



# **TVS-2 Series**

**Hopping Code Voice Scrambler**

## **Technical Reference Manual**

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**Supports TVS-2 Firmware Versions:** 4.93 & Higher

**Supports TVS-2 (MOT-PRO & COM) Firmware Versions:** 2.95 & Higher

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## REGULATORY INFORMATION

Midian's TVS-2 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 TVS-2 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 of the TVS-2 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.

When being exported outside of the United States or Canada, Midian's end-user form must be completed and sent to Midian prior to shipment. The Export Classification Control Number (ECCN) for the TVS-2 is 5A992. The license exception ENC is available for the TVS-2, except in cases listed above.

## ABOUT THE TVS-2 SERIES

**Security:** Midian's TVS-2 is a high-level rolling code scrambler that uses hopping type rolling code encryption for higher security rather than sweeping code type. See the following section for differences between hopping and sweeping. The following security levels are user-programmable in the TVS-2:

**L4** (13-25 Hops Per Second) – This results in the highest in analog encryption, but the audio quality is reduced.

**L3** (6-12 Hops Per Second) – This results in very high security, with good quality audio. This is the default security setting for the TVS-2.

**L2** (1.2-2.4 Hops Per Second) – This results in a medium level of security, with very good audio quality.

**L1** (0.6-1.2 Hops Per Second) – This results in a lower level of security, with excellent audio quality.

**Voice Inversion** – The TVS-2 can be downgraded to the VPU-15. The VPU-15 provides basic security with excellent audio quality.

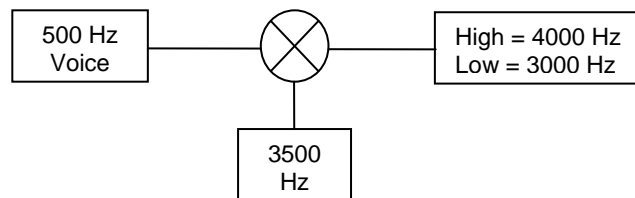
The TVS-2 is capable of +40 Trillion possible security codes. This entails a 4-digit System ID controlled by Midian and an 8-digit Security Key that is user-programmable. The 8-digit Security Key can contain the characters 0-9 and A-F.

### **Signaling:**

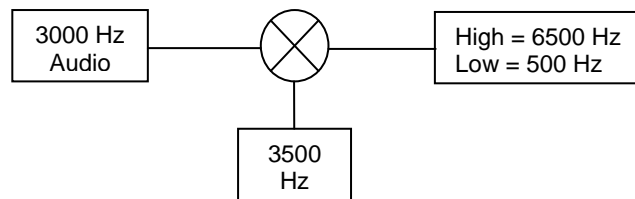
The scrambler is capable of features such as ANI, ENI, Deadbeat Disable, Spy, and more when using Midian's Kryptic Signaling format with the CAD-300 or DDU-300.

## ABOUT ROLLING CODE VOICE SECURITY

Rolling code voice security is based upon the theory of voice inversion. Voice inversion scrambling mixes the frequency of the voice with an inversion frequency. During the mixing process the scrambler creates a sum and a difference. For example if the speaker's voice was a constant 500 Hz and the inversion frequency was 3500 Hz, the scrambler would create a sum of 4000 Hz and a difference of 3000 Hz.



The scrambler has a low pass filter which filters the 4000 Hz and passes the 3000 Hz. The 3000 Hz is transmitted over the air as scrambled audio. On the receiving scrambler the 3000 Hz is then mixed with the 3500 Hz inversion frequency again creating a sum and difference. The sum is 6500 Hz and the difference is 500 Hz. The 6500 Hz is again filtered out and out comes the 500 Hz voice.



Rolling code voice scramblers work in the same manner as above, but rather than remaining at one fixed inversion frequency the rolling code scrambler is constantly changing inversion frequencies. There are two main types of rolling code voice scramblers, hopping code and sweeping code.

### Hopping Code Type:

Hopping code scramblers change the inversion frequency no more than 25 times per second. However, each inversion frequency change is significant. Midian's TVS-2 is a hopping code scrambler with each of its hops being at least 300 Hz in length. Because each hop is several hundred cycles in length there is no residual inversion tone to track.

### Sweeping Code Type:

Sweeping code scramblers will claim hundreds of "hops" per second. However, each of their "hops" are approximately 1 cycle in length, so it takes hundreds of "hops" to equal a single hop of Midian's TVS-2. Additionally because the change in inversion frequency is so minute this type of scrambling has been broken by tracking the residual inversion tone.

## SYNCHRONIZATION

Because the inversion tone is hopping at random intervals to random frequencies, both the sending and receiving scramblers must be perfectly synchronized in time. To achieve synchronization, the transmitting scrambler sends a sync packet which is a burst of digital data that the receiving scrambler uses as a signal to begin hopping. In addition, the packet contains a random number indicating where in the hopping sequence to start.

The sync packet must be sent at the beginning of every transmission. Technically, once the scramblers are synchronized, there is no need to send additional sync packets. However, radio is an unreliable medium for transmission of digital data, and therefore the TVS-2 can be programmed to send additional sync packets periodically in case the initial packet was somehow missed. Typically, this re-sync interval is set for 3 seconds. The re-sync packets are only 90 ms and are not heard by the user of the receiving radio. This is because the receiving scrambler knows when the next sync packet is due to arrive and it briefly mutes the receive audio during the packet time.

It cannot be stressed enough how important sync is to proper scrambler operation.

## PRODUCT FEATURES

In addition to securing communications, the TVS-2 incorporates a number of features to support fleet management. Among these is Automatic Number Identification (ANI). Each time a user keys the radio, the TVS-2 transmits a programmable 4-digit ID along with the synchronization information in the initial packet. This ID can be decoded using the **CAD-300**, a PC-based computer aided dispatch system, the **DDU-300** desktop decoder or the **TRC-300**, a tone remote controller. In addition to decoding ANI, the CAD-300/DDU-300/TRC-300 offers the dispatcher the following fleet management features:

**Selective Call** – Allows the dispatcher to cause a unit or group of units to ‘ring’. This is used to alert the radio operator of an upcoming message. It also may be used in conjunction with the Advanced Mute Functions (see below).

**Deadbeat Disable** – Allows the dispatcher to disable or ‘kill’ a unit. This is used to prevent a lost or stolen unit from being used.

**Query** – Also known as radio check, this allows the dispatcher to determine the current status of a unit and if it is operating.

**Spy** – Allows the dispatcher to remotely key-up a unit for a brief time and listen to what is happening at the unit location. This may be used to help determine why a unit is not responding to calls.

**Over the Air Re-programming (OTAR)** – Allows the dispatcher to remotely change the security key or keys in one or more units. This may enhance security or be used to change the key should it be compromised. Security keys 1-4 may be changed using OTAR.

**Advanced Mute Functions** – Allows the dispatcher to selectively mute and un-mute one or more units. This is typically used by taxi fleets because it allows the dispatcher to control which driver receives a call.

**Status Reporting** – The TVS-2 status reporting feature consists of a 4 digit code which may be entered by the operator if the TVS-2 is equipped with a keypad. Any status code beginning with a “9” is considered an emergency. An emergency status message can be sent without using a keypad by grounding the emergency input for about 2 seconds.

## HARDWARE INPUTS & OUTPUTS

### **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 packet.

### **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. When configured as common, the output is asserted from the time PTT IN goes active until the time the complete initial packet has been sent. After that PTT OUT 'lets go' 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. Breaking of the PTT path is required only if it is desired to use the deadbeat disable feature of the scrambler. This feature allows the radio to be disabled remotely if it is lost or stolen. PTT OUT will not be asserted when in the disabled state, preventing use of the radio.

The PTT OUT connection also allows the scrambler to transpond when called, send status messages, send emergency ANI, and key-up the radio in response to a spy command. If none of these features are to be used, and if it is acceptable for partial packets to be transmitted on a momentary PTT, then connecting PTT OUT is not necessary.

### **COR:**

The COR Input has several uses. First of all it can mute the audio of the radio so that the incoming sync packet is not heard in the radio's speaker. If programmed the scrambler can revert from scramble to clear mode after a programmed amount of time. The Busy channel lockout feature requires COR. Finally the Advanced Mute Functions require COR for proper use.

### **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 LED Output:**

This output can be connected to the anode of an LED to indicate scramble or clear mode.

### **Emergency Input:**

Grounding 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. After 5 seconds the PTT will need to be reset. Once the channel is acquired the scrambler will key-up and transmit sync and/or ANI.

## PRODUCT PROGRAMMING

The following is an explanation of the programmable features and parameters of the TVS-2.

### Encode/Decode Tab

#### ANI Length:

This is selectable for 3 or 4-digits. This should be left at 4-digits except when compatibility is needed with the older 3-digit ANI TVS-1 and TVS-2U/M Series.

#### Decode Options:

##### ANI/Primary Decode #1:

This sets the 4-digit ANI, as well as the ID that would be dialed by the dispatcher or another scrambler to selectively call the individual unit. The unit will transpond with decode address #1 only.

##### Secondary Decode #2:

This 4-digit ID is typically used for group call or all call. Using this feature allows the dispatcher to call multiple units simultaneously.

##### Secondary Decode #3:

This 4-digit ID is typically used for group call or all call. Using this feature allows the dispatcher to call multiple units simultaneously.

#### Number of Rings:

This sets the number of times the scrambler will ring when it is selectively called by the dispatcher or another unit. This register is programmable for 0-9. If the unit is set to "0" it will not ring. Decode #1 will ring with a "--", decode #2 "...", and decode #3 "...".

#### Encode Options:

##### Send ANI in Scramble Mode:

If selected the TVS-2 will send the ANI programmed in the ANI/Primary Decode #1 field when the radio is keyed up in scramble mode. If ANI is not being used, uncheck this box. For audio quality purposes Midian recommends checking this box (see Troubleshooting section).

##### Send ANI in Clear Mode:

If selected the TVS-2 will send the ANI programmed in the ANI/Primary Decode #1 field when the radio is keyed up in clear mode. If ANI is not being used, uncheck this box.

**ANI Repeat Timer:**

Select a time for 0-60 seconds. Once the user has keyed up the radio and sent an ANI, the scrambler will not send another ANI until the ANI Repeat Timer has expired. This feature is only valid in clear mode. The timer will reset itself each time the radio is keyed. (This prevents repetitive and irritating ANI's on numerous transmissions.)

**Security Keys Tab****Total Number of Active Codes:**

The TVS-2 can have up to 4 different security codes programmed into it. A button on the radio can then be assigned to toggle between these codes. Certain codes can be assigned to certain scramblers. For example, all users in the system can use Security Code #1; supervisors can also have Security Code #2, and Security Code #3 for use with another department.

**Key Codes:****Security Code #1:**

This is an 8-digit security code. This code must be the same between all scramblers in order to communicate with one another. The characters that can be used in this field are 0-9 and A-F.

**Security Code #2:**

This is an 8-digit security code. This code must be the same between all scramblers in order to communicate with one another. The characters that can be used in this field are 0-9 and A-F.

**Security Code #3:**

This is an 8-digit security code. This code must be the same between all scramblers in order to communicate with one another. The characters that can be used in this field are 0-9 and A-F.

**Security Code #4:**

This is an 8-digit security code. This code must be the same between all scramblers in order to communicate with one another. The characters that can be used in this field are 0-9 and A-F.

**Scrambler Tab****Power-Up Mode:****Clear:**

If checked the TX mode of the scrambler will power up into Clear mode.

**Scramble:**

If checked the TX mode of the scrambler will power up into Scramble mode.

**Synchronization:****Resync Time:**

This is programmable for 0-9 seconds. If 0 is selected synchronization will only be sent on PTT. Otherwise it will send it every number of seconds from 1-9 seconds. The reason for this feature is if someone in the system powers up or comes on channel in the middle of a conversation that user will be brought into the conversation. If using this feature the recommended value is 3 or 4 seconds.

**# of Self-Resyncs After Loss of Sync:**

This sets the number of resync packets that can be missed before the TVS-2 will revert back to clear mode. The recommended value is 2 in the event of a fading signal.

**Security:****Erase Security Keys When Disabled:**

If selected, the security keys programmed into the scrambler will be erased when a unit is disabled using the Deadbeat Disable command from the CAD-300/DDU-300/TRC-300. Re-enabling the scrambler will not restore the erased security keys.

**Hop-Rate:**

**L4** – Double (13-25 Hops Per Second) – This results in the highest in analog encryption, but the audio quality is reduced.

**L3** – Normal (6-12 Hops Per Second) – This results in very high security, with good quality audio. This is the default and recommended security setting for the TVS-2.

**L2** – Slow (1.2-2.4 Hops Per Second) – This results in a medium level of security, with very good audio quality.

**L1** – Very Slow (0.6-1.2 Hops Per Second) – This results in a lower level of security, with excellent audio quality.

**Auto Descramble (RX):****Auto Descramble:**

If selected, the scrambler will automatically descramble scrambled audio. The scrambler will continue to descramble until the programmed number of re-sync packets have been missed or if stop auto descramble on loss of COR has been enabled for the programmed time.

**Descramble or not Depending on Selected Mode:**

If selected the scrambler's RX mode is controlled by a switch. Therefore if the scrambler's RX mode were in clear the user would have to switch over to scramble mode manually to receive scrambled audio.

**Stop Auto Descramble:**

If selected the Auto Descramble feature will quit after loss of carrier. This will allow the unit to once again receive clear audio.

**Milliseconds After Loss of Carrier:**

This sets the amount of time in milliseconds that the Stop Auto Descramble feature will wait after a loss of carrier to revert back to clear mode. Allow a few hundred milliseconds so the unit does not reset on fading audio.

**Auto Scramble (TX):****Autoswitch to Scramble Mode Upon Receipt of Sync:**

If selected the scrambler will transmit in scramble mode upon receipt of a scrambled signal.

**Scramble or not Depending on Selected Mode:**

If selected the scrambler's TX mode is controlled by a switch. Therefore if the scrambler's TX mode were in clear the user would have to switch over to scramble mode manually to transmit scrambled audio even after receiving a scrambled sync packet from another scrambler.

**Input/Output Tab:****PTT:****PTT In Active Polarity:**

This should match the polarity of the radio's PTT In when it is active. This can be set to either High (+5V) or Low (0V).

**PTT Out Active Polarity:**

This should match the polarity of the radio's PTT Out when it is active. This can be set to either High (Float) or Low (0V).

**PTT In/Out Common:**

If selected the PTT is controlled by the radio and not the scrambler. It is necessary to have this unselected if using features such as Deadbeat Disable, Time-Out Timer, Penalty Timer, etc.

## **Auxiliary Output:**

### **Squelch Out:**

If selected, this output will keep the radio quieted until the scrambler is selectively called.

### **Disable Out:**

If selected, this output will go low when the scrambler is disabled using the Deadbeat Disable feature.

### **Call LED:**

If selected, this output will go low upon receiving a call. It will return to a high when PTT is pressed.

### **Squelch Polarity:**

This should match the active squelch polarity of the radio. This can be set to either High (Float) or Low (0V).

## **Mode Input:**

### **Mode Switch Type:**

Select either Edge (Momentary) or Level (Latched).

### **Mode Switch Polarity:**

Select High (+5V) or Low (0V). This should match the polarity of the radio's switch.

## **Miscellaneous:**

### **COR In Polarity:**

This should match the COR polarity of the radio when it is active. This can be set to either High (Float) or Low (0V).

### **Audio Enable Out Polarity:**

Select the output polarity that is used to turn on the speaker amp in some radios. This will allow you to hear rings and courtesy tones.

### **Trunking Delay In Polarity:**

This should match the polarity of the strobe that the radio gives when an LTR channel is acquired. Select High (+5V) or Low (0V). When activated the scrambler will go through the key-up period and transmit the sync and ANI.

## **Keypad:**

### **Disabled:**

If selected, no keypad functions are available.

### **Row/Col to Ground:**

If selected, keypad functions are available using a Row/Column to ground keypad.

### **Scanned Type:**

If selected, keypad functions are available using a scanned type keypad.

### **2-Line Binary:**

If selected, two of the keypad lines become binary key code select inputs and the keypad functions are disabled.

## **Advanced Tab:**

### **Standard Mute Functions:**

#### **Do Not Mute:**

If selected the scrambler will not mute any sync and ANI data bursts.

#### **Mute Initial Data Burst in Scramble Mode:**

If selected the scrambler will mute the initial sync and ANI data bursts in the scramble mode. This feature requires COR input.

#### **Always Mute Initial Data Burst:**

If selected the scrambler will mute the initial sync and ANI data bursts in clear and scramble modes. This feature requires COR input.

### **Advanced Mute Functions:**

#### **Un-Mute After PTT:**

If selected, the scrambler will un-mute when PTT is pressed.

#### **Un-Mute When Called:**

If selected, the scrambler will un-mute when selectively called.

#### **Re-Mute When Another Unit is Called:**

If selected, the scrambler will mute the radio when another scrambler is called.

**Enable Busy Lockout When Muted:**

If selected, the Busy Lockout feature will be available when the radio is muted.

**Miscellaneous Tab:****Power-Up Lockout:****Enable Password:**

If selected, the user will have to enter a password to utilize the radio upon power up. Until the password is entered the radio will not transmit or receive. A keypad is required to utilize this feature.

**Password:**

The password must be 4-digits in length. Program this to 0000 to disable.

**Time-Out Timer:****Enable Time-Out Timer:**

The Time-Out Timer, if selected, limits the time that a user can talk. If the user exceeds the programmed period of time, the scrambler will stop the radio from transmitting.

**Time-Out Time:**

Sets the number of seconds a user can talk before being kicked off the channel. Note: If using with the Penalty Timer feature, the time in seconds for the Time-Out Timer is limited to 30 or 60 seconds.

**Enable Penalty Timer:**

This feature is used with the Time-out Timer. After the unit times out the user will be unable to re-key for the programmed amount of time.

**Penalty Time:**

This sets the number of seconds after the unit times out, that the user is unable to key the radio.

**Key-Up Delay:****Front-Porch Time:**

This sets the amount of time from when the user keys the radio until the sync packet and ANI are sent. This time is used to allow CTCSS to go out and raise the repeater.



**Front-Porch Type:**

Select from Carrier or Preamble. During the key-up delay using carrier type the scrambler is idle as it waits for CTCSS to go out and open the repeater. During the key-up delay using preamble type the scrambler generates a preamble tone for a voter to lock onto the signal before sync is sent.

**Enable Go-Ahead Beep:**

If selected the scrambler will emit a courtesy tone to notify the user that the key-up delay and sync time has passed and they can now talk.

**Miscellaneous:****Enable Programming Via Keypad:**

Do not enable this feature.

**Spy Period:**

This sets the period from 0 – 90 seconds in 10-second increments that the scrambler will key the radio when the Spy feature is activated.

## 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 (1-4 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.

### **ANI:**

When the PTT Input is taken to ground, the scrambler will transmit the unit's ANI as programmed into the ANI/Primary Decode #1 field in the KL-3 software.

### **ENI:**

When the Emergency Input is taken to ground, the scrambler will transmit the unit's Emergency ANI. This is the ANI with a status bit attached for the emergency indication.

## KEYPAD OPERATION

The following features are only available if the TVS-2 is connected to a supported keypad and the scrambler is programmed to accept the keypad inputs. A single beep will be heard when a digit 0-9 is pressed and a double beep at the execution of a function. To clear a mistaken entry, press the # key.

### **Password:**

If this feature is enabled, when the scrambler is powered on it is required that the correct 4-digit password be entered on the radio's keypad followed by \*8 (i.e. 1234\*8). If successfully entered 3 beeps will be heard and the radio and scrambler will operate normally. If after 5 attempts the scrambler does not receive the correct password the radio and scrambler will be permanently disabled. To restore the scrambler and radio to operation it will be necessary to enable the scrambler via the CAD-300 or DDU-300 or to reprogram the scrambler with the KL-3. If the "Erase Security Keys When Disabled" feature is enabled the security keys will be erased after the fifth failed attempt.

### **Selective Calling:**

To selectively call another radio equipped with a TVS-2 scrambler enter the 4-digit ANI of the radio to be called followed by \*1 (i.e. 1234\*1).

### **Mode Select:**

Entering \*0 on the keypad will toggle the mode between scramble and clear.

### **Code Select:**

To change codes between codes 1-4, enter \*4 for code 1, \*5 for code 2, \*6 for code 3, and \*7 for code 4.

### **Changing Security Codes:**

It is possible to reprogram security codes 1-4 via the keypad. Enter the new 8-digit security code followed by \*4 for code 1, \*5 for code 2, \*6 for code 3, and \*7 for code 4.

### **Status & Location:**

The CAD-300 offers one status field and 2 location fields. By entering 2-digits for the status and 2-digits for the location (grid) followed by \*2, the unit will send the unit ID followed by the status and location (i.e. 12349068, wherein 1234 is the ID, 90 is the status, 6 is location 1 and 8 is location 2).

## SCRAMBLER ALIGNMENT

### Setting the RX & TX Levels:

1. For a level reference take a signal measurement at the input and output of the RX audio path's breaking point component in the radio by modulating the receiver with a full quieting signal and at full modulation of a 1 KHz tone. That's 5 kHz for a wide band radio and 2.5 kHz for a narrow band radio.
2. For the TX signal level speak normally into the microphone while monitoring the TX breaking point in the radio. For a higher level, say "FOUR" and document the levels. If it is possible to inject a 1 kHz tone into the microphone stage, set that as 3 kHz for wide band or 1.5 kHz for narrow band as a reference while monitoring the TX modulation on the service monitor.
3. To set up the RX level correctly on the TVS-2 (after installation into the radio), modulate the radio receiver at full quieting with a 1250 Hz tone at 1.0 to 1.2 kHz for wide band or 0.4 to 0.6 kHz for narrow band.
4. To adjust the RX input pot, monitor with a DC scope at IC-6 Pin 7 until it triggers at the step 3 levels.
5. Adjust the RX output pot to match the reference level documented from step 1.
6. For the TX levels, set the TX input pot so that the level at IC-9 Pin 1 is just below clipping by speaking loudly into the microphone with the TVS-2 in scramble mode.
7. With the TVS-2 in the clear mode, adjust the TX output pot for the documented level from step 2.

## SYSTEM SET-UP

### **Simplex:**

It will be necessary to program the “Front Porch Time” on the TVS-2 long enough for the CTCSS or DCS signaling to be decoded by the receiving radio prior to the synchronization being transmitted by the scrambler.

### **Repeater:**

If the repeater audio levels are not properly aligned it is possible the synchronization packet could be affected. Flat audio should be used. Do not use pre-emphasis or de-emphasis. To correct this follow the following procedure:

1. Connect the microphone to the repeater's TX radio.
2. While monitoring the TX signal with a service monitor set the TX modulation for 4.8 – 5.0 kHz of deviation in a wide band system or 2.3 – 2.5 kHz in a narrow band system. This should be done while speaking loudly into the microphone with a constant voice.
3. Adjust the RX repeat audio using 1.5 – 2.0 kHz deviation of a 1 kHz tone at the RX input with a strong RF signal and adjust the repeat level to the transmitter for the same level of 1.5 – 2.0 kHz while monitoring the TX signal with a service monitor. For a narrow band system use 0.75 – 1.0 kHz deviation.
4. Ensure that compression and expansion are turned off in the repeater. Do not turn off de-emphasis or pre-emphasis.

It will be necessary to program the “Front Porch Time” on the TVS-2 long enough for the sync packet to be decoded by the receiving radio. Time should be given for CTCSS or DCS signaling to be decoded and for the repeater to rise prior to the synchronization being transmitted by the scrambler.

### **Trunking Systems:**

Midian's TVS-2 has a trunking delay input. Connect this input to a point in the radio that will give the scrambler a strobe upon acquisition of a channel. This can either be high or low. Program the “Trunking Delay Polarity” to the active state of the strobe. Upon indication that the channel has been acquired the TVS-2 will go through the programmed “Front Porch Time” and send the synchronization. If a channel is not acquired within 5 seconds the PTT will need to be reset.

**Voted Systems:**

When using the TVS-2 in a voted system please observe the following:

1. The voting receivers should be programmed to “Scan and Lock”, not “Scan and Re-Scan”.
2. Set the “Front Porch Type” on the TVS-2 to “Preamble”.

Some voting systems regard frequencies above a certain frequency (i.e. 2700 Hz) as noise. With inversion and rolling code scramblers the voting comparator may treat the inverted voice as noise.

**Simulcast Systems:**

Midian's TVS-2 currently does not support operation with Simulcast Systems. Call for more information.

**HF SSB:**

Midian does not recommend the TVS-2 to be used on HF SSB systems for several reasons. Due to the nature of SSB modulation the signal fades in and out. Depending on the strength of the signal at the time the sync is received by the TVS-2 will determine whether or not the sync will be decoded. A radio 30 miles away might decode, but a radio 30 feet away might not. If the TVS-2 is used in an SSB system Midian recommends that either L1 or L2 hop rates are used for audio quality purposes. For HF SSB systems Midian recommends using Midian's VS-1200 frequency domain scrambler.

## TVS-2 OPTIONS

### Dual Mode:

Midian can enable the TVS-2 to be capable of sharing the security keys between rolling code and voice inversion. Reasons for this can be if a system is being upgraded from voice inversion to rolling code or if a system using rolling code needs to be compatible with voice inversion. This feature needs to be specified when ordering.

Programming of a dual-mode unit is the same as that of standard TVS-2 models with one exception. Normally, the TVS-2 supports up to four 8-digit security keys that all apply to rolling code mode. In the dual-mode model, the security keys control which type of scrambling is used as well as setting the security code or inversion tone.

If the first four digits of a security key are all 0, this code will be considered single inversion, and the unit will go into single inversion mode. Codes with any non-zero value in any of the first four digits will be considered an 8-digit security key, and cause the unit to go into rolling code mode.

Not all codes of the form 0000XXXX are valid, and the XXXX does **not** represent the inversion tone in Hz. The following chart lists the 37 legal codes and their corresponding inversion tones. Any code beginning with 0000 not appearing in the chart is not valid and should not be entered or the unit may be made unusable.

#	Freq. Range	Actual	Code	#	Freq. Range	Actual	Code
1	2340 – 2370	2355	0000F5F0	20	2929 - 2959	2944	000074C0
2	2365 – 2395	2380	0000F5E0	21*	2968 - 2998	2983	000074B0 00000006
3	2391 – 2421	2406	0000F5D0	22*	3008 - 3038	3023	000064A0 00000004
4	2417 – 2447	2432	0000F5C0	23*	3050 - 3080	3065	00006490
5	2443 – 2473	2458	0000F5B0	24*	3092 - 3122	3107	00003480
6	2471 - 2501	2486	0000F5A0	25*	3136 - 3166	3151	00003470
7	2499 - 2529	2514	0000F590	26*	3181 - 3211	3196	00002460
8	2527 - 2557	2542	0000B580	27*	3227 - 3257	3242	00002450
9	2557 - 2587	2572	0000B570	28*	3275 - 3305	3290	00005440
10	2586 - 2616	2601	0000A560	29*	3324 - 3354	3339	00005430
11*	2617 - 2647	2632	0000A550 00000001	30*	3375 - 3405	3390	00005420
12	2648 - 2678	2663	0000D540	31*	3427 - 3457	3442	00004410
13	2680 - 2710	2695	0000D530	32*	3481 - 3511	3496	00004400
14*	2713 - 2743	2728	0000D520 00000002	33	3536 - 3566	3551	000013F0
15	2747 - 2777	2762	0000C510	34	3593 - 3623	3608	000003E0
16	2782 - 2812	2797	0000C500	35	3653 - 3683	3668	000003D0
17	2817 - 2847	2832	000094F0	36*	3714 - 3744	3729	000003C0 00000009
18*	2853 - 2883	2868	000094E0 00000003	37	3777 - 3807	3792	000003B0
19	2890 - 2920	2905	000084D0				

**Freq. Range:** This is the range of inversion frequencies compatible with this code.

**Actual:** This is the actual inversion frequency selected by this code.

**Code:** This is the value to enter in the *Security Code* field on the TVS-2 'Security Keys' screen.

**\*:** This indicates that this is a code that can be changed via OTAR using a CAD or DDU-300.

Note that only codes with numeric characters can be changed via OTAR. Codes with hex codes cannot be changed.

Changing between security codes operates the same whether in TVS-2 mode or dual mode.

### **Programming Parameters in Dual Mode**

The TVS-2 line offers a number of different configuration options via the KL-3UP programming software. When in rolling code mode, these options work just as if the dual-mode unit were a standard TVS-2. For example, in rolling code mode, the unit can usually automatically de-scramble incoming scrambled audio if the *Auto Descramble* option is enabled. This is not the case for single inversion mode however.

When in single inversion mode, a number of the configuration options are changed to hard-coded settings that cause the unit to behave like a 'dumb' single inversion scrambler. For example, most single inversion scramblers do not send a signal that indicates the audio is scrambled. Therefore, the 'Auto-Descramble' option is disabled in single inversion mode. The user must place the unit into scramble mode to hear incoming scrambled audio. Also, the ANI and other advanced features, such as deadbeat disable and over the air reprogramming (OTAR) are disabled in the single inversion mode.

The following settings are disabled when in single inversion mode:

- Send ANI in Scramble Mode
- Send ANI in Clear Mode
- Auto-descramble
- Stop Auto-descramble
- Standard Mute Functions
- Advanced Mute Functions\*
- Key-up Delay
- Go-ahead Beep

Upon switching from single inversion mode to rolling code mode, the settings programmed via the KL-3UP are restored.

\* The Advanced Mute Functions must not be used at all, even in rolling code mode.



### **Decode & De-scrambling Problems:**

Often, a failure to de-scramble scrambled audio is because the receiving scrambler does not decode sync. There is a simple test to determine if this is the case. First, the scramblers should be set up with the default 3-second re-sync interval. Listen for at least three of the re-sync packets in the receiving radio. If they are heard, then there is a complete failure to decode sync. If only the first of the re-sync packets is heard, then the unit is able to decode sync, but is probably missing the initial packet. If none of the re-sync packets are heard, then it is not a decode problem.

The following are potential causes and solutions for the problem:

#### **Insufficient Front Porch Time:**

One of the most common problems is that a receiving unit does not de-scramble the beginning of a transmission because the initial packet is not decoded. The most common cause of this problem is insufficient key-up delay. This is especially true in systems using repeaters and CTCSS.

EIA specifications state that a receiver should decode a 100 Hz CTCSS tone within 250 ms. Lower frequency CTCSS tones may take even longer. Therefore, assume that it will take any repeater in the system at least 250 ms before it will key the transmitter. The receiving radios equipped with scramblers will also require about 250 ms to decode CTCSS before passing receive audio to the scrambler. That is a total of 500 ms which must elapse between the time the transmitting radio keys-up and the time that the receiving scrambler can 'hear' sync.

In the above scenario, if the scramblers were set up for a 400 ms key-up delay, the initial packet would not be heard by the receiving scrambler. The net result is a failure to de-scramble until the next re-sync. Matters are made worse if multiple repeaters and/or voters are added to the mix. The bottom line is, if the initial packet is being missed, then the key-up delay more than likely needs to be increased. Here are some guidelines for key-up delay settings:

Simplex operation: 300-400 ms.

Single repeater: 500-600 ms.

Multiple repeaters: add 200-300 ms per repeater.

#### **Mismatched Security Keys:**

Another common problem resulting in a failure to de-scramble is that the transmitting and receiving scrambler are not using the same security key. If the unit is decoding sync, as evidenced by re-sync packets being muted, then a security key mismatch is likely the problem. The TVS-2 can be configured to have up to four 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 all 0's. 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 00000000. 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.

### **Mismatched Factory Configuration:**

If the keys are matched and sync is being decoded but communication is still not possible, it may be the result of a mismatched factory configuration or mislabeled product. As stated earlier, there are two factory- configured parameters: system ID and backward compatibility. If either of these are mismatched, communications will not be possible. Contact Midian if this is suspected.

### **Mismatched Mode:**

Normally, the TVS-2 expects to receive clear audio. It will automatically de-scramble scrambled audio when an initial packet indicates that the audio is scrambled. Some users prefer to override the automatic de-scramble feature by checking the box next to Descramble or not Depending on Selected Mode. This will result in either: clear audio sounding scrambled when the mode is set to scramble mode; scrambled audio not being de-scrambled when the mode is set for clear.

### **Mismatched Re-sync Interval:**

All TVS-2's in a system must be programmed with the same re-sync interval and Front Porch Time for correct operation.

### **Channel Bandwidth Mismatch:**

Many radios are configurable for both wide (25 kHz) and narrow (12.5 kHz) channel bandwidth. The TVS-2 will work on both wide and narrow band channels. However, if radio set for narrow band transmits to a radio set for wide band, decode failure will result. All radios on a given frequency must have the same channel bandwidth setting for proper operation of the TVS-2.

### **Packet Integrity Issues:**

If the TVS-2 is failing to decode sync, it could be because the integrity of the sync packet is not retained through all of the radio system components. Often, a misadjusted repeater system may sound okay to one's ear, but is in fact destroying the sync packet. Even the de-emphasis circuit in some radios can severely distort the packet. The more equipment the audio is required to pass through, the greater the chance for sync packet degradation.

## **Audio Quality Issues:**

### **“Warbly” Audio:**

A small amount of warble is to be expected in the recovered audio due to the code hopping nature of the TVS-2. However in some cases it may be excessive, particularly just after key-up and before the first re-sync. Fortunately, this initial warble can be minimized through scrambler programming. First, make sure that the box labeled Send ANI in Scramble Mode is checked. Synchronization timing was optimized with the scrambler in this configuration. It has also been determined that the choice of security key can influence how often the initial warble is heard. Try several different security key codes to find one that results in less warble.

## **Operational Problems:**

### **Will Not Transmit Scrambled:**

If the selected transmit mode is scrambled and the transmitted audio is clear, it could be a power supply problem. On some radios, the power supply voltage drops when PTT is pressed due to the sudden current drain. The voltage regulator on the TVS-2 detects this and issues a reset pulse to the microprocessor causing it to come up in clear mode. One work-around for this problem is to place a large value capacitor in parallel with the TVS-2 power supply. If this does not work, a modification to the TVS-2 may be required. Contact Midian in this case.

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