MIDIAN ELECTRONICS

VPU-15 Series

Voice Inversion Scrambler with Midian's Kryptic Signaling

Technical Reference Manual

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Supports VPU-15 Firmware Versions: 4.93 & Higher

Supports VPU-15 (MOT-PRO & COM) Firmware Versions: 2.95 & Higher

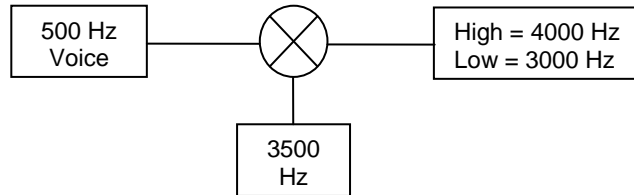## TABLE OF CONTENTS

ABOUT THE VPU-15 SERIES

Security: Midian's VPU-15 is an entry level voice inversion scrambler. The VPU-15 has 37 different inversion frequencies and can have 4 of these frequencies programmed into the scrambler.
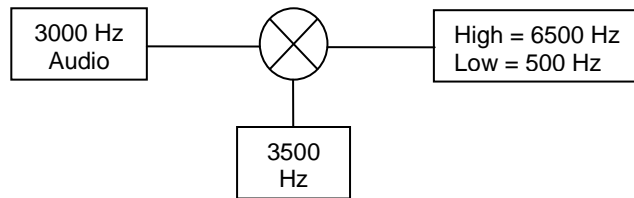
Signaling:

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 VOICE INVERSION SCRAMBLING

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.

```
┌──────────┐         ⊗          ┌──────────────────┐
│ 500 Hz   │────────────────────│ High = 4000 Hz   │
│ Voice    │         │          │ Low = 3000 Hz    │
└──────────┘         │          └──────────────────┘
                ┌─────────┐
                │  3500   │
                │   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.

```
┌──────────┐         ⊗          ┌──────────────────┐
│ 3000 Hz  │────────────────────│ High = 6500 Hz   │
│ Audio    │         │          │ Low = 500 Hz     │
└──────────┘         │          └──────────────────┘
                ┌─────────┐
                │  3500   │
                │   Hz    │
                └─────────┘
```

In addition to securing communications, the VPU-15 incorporates a number of features to support fleet management. Among these is Automatic Number Identification (ANI). Each time a user keys the radio, the VPU-15 transmits a programmable 4-digit ID. 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 VPU-15 status reporting feature consists of a 4 digit code which may be entered by the operator if the VPU-15 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.

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 ANI 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 ANI. This input is only needed if using the Kryptic signaling features of the VPU-15.

The following is an explanation of the programmable features and parameters of the VPU-15.

Encode/Decode Tab

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 VPU-15 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 VPU-15 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 VPU-15 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:

Select from the 37 offered codes in the drop down list. This code must be the same between all scramblers in order to communicate with one another.

Security Code #2:

Select from the 37 offered codes in the drop down list. This code must be the same between all scramblers in order to communicate with one another.

Security Code #3:

Select from the 37 offered codes in the drop down list. This code must be the same between all scramblers in order to communicate with one another.

Security Code #4:

Select from the 37 offered codes in the drop down list. This code must be the same between all scramblers in order to communicate with one another.

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.

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.

Auto Descramble (RX):

Auto Descramble:

If selected, the scrambler will automatically descramble scrambled audio. The scrambler will continue to descramble until the programmed time has expired 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 ANI packet from another VPU-15.

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 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 ANI data bursts.

    Mute Initial Data Burst in Scramble Mode:

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

    Always Mute Initial Data Burst:

If selected the scrambler will mute the 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.

Key-Up Delay:

Front-Porch Time:

This sets the amount of time from when the user keys the radio until the ANI is 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 ANI 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 ANI has passed and they can now talk.

Miscellaneous:

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.

The following features are only available if the VPU-15 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 VPU-15 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.

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).

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 VPU-15 (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 VPU-15 in scramble mode.

7. With the VPU-15 in the clear mode, adjust the TX output pot for the documented level from step 2.

Simplex:

It will be necessary to program the "Front Porch Time" on the VPU-15 long enough for the CTCSS or DCS signaling to be decoded by the receiving radio prior to the ANI being transmitted by the scrambler.

Repeater:

If the repeater audio levels are not properly aligned it is possible the ANI 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 VPU-15 long enough for the ANI to be decoded by the CAD-300. Time should be given for CTCSS or DCS signaling to be decoded and for the repeater to rise prior to the ANI being transmitted by the scrambler.

Trunking Systems:

Midian's VPU-15 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 VPU-15 will go through the programmed "Front Porch Time" and send the ANI. If a channel is not acquired within 5 seconds the PTT will need to be reset. If ANI is not being used this input does not need to be connected.

Voted Systems:

When using the VPU-15 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 VPU-15 to "Preamble".

If the ANI is not being used in the VPU-15 then scan and re-scan can be used.

HF SSB:

The VPU-15 can be used in HF SSB systems, however, the reliability of the Kryptic signaling will be negatively affected and will not be 100%.

OTAR:

Midian's VPU-15's security codes can be reprogrammed over the air using the OTAR feature of the CAD-300 or DDU-300. Not all 37 inversion codes available in the VPU-15 can be done over the air. The following is a list of the inversion frequencies supported by OTAR and the code that should be entered in the CAD or DDU for OTAR.

#	Freq. Range	Actual	Code
11*	2617 - 2647	2632	00000001
14*	2713 - 2743	2728	00000002
18*	2853 - 2883	2868	00000003
21*	2968 - 2998	2983	00000006
22*	3008 - 3038	3023	00000004
23*	3050 - 3080	3065	00006490
24*	3092 - 3122	3107	00003480
25*	3136 - 3166	3151	00003470
26*	3181 - 3211	3196	00002460
27*	3227 - 3257	3242	00002450
28*	3275 - 3305	3290	00005440
29*	3324 - 3354	3339	00005430
30*	3375 - 3405	3390	00005420
31*	3427 - 3457	3442	00004410
32*	3481 - 3511	3496	00004400
36*	3714 - 3744	3729	00000009

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 VPU-15 '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 VPU-15 mode or dual mode.

Decode & De-scrambling Problems:

The following are potential causes and solutions for the problem:

Mismatched Inversion Frequency:

Another common problem resulting in a failure to de-scramble is that the transmitting and receiving scrambler are not using the same inversion frequency. If the both units are in scramble mode and the scramblers do not communicate it is likely the inversion frequencies are different. The VPU-15 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.

Another way that inversion frequencies often become mismatched is that users attempt to 'clone' scramblers. When the configuration of a scrambler is read, the scrambler reads back inversion frequency 3275-3305. This prevents someone who has stolen a scrambler from learning the inversion frequency. Let's say an attempt is made to clone a working scrambler with 3714-3744. First, the unit with frequency 3714-3744 is read. Then, a new unit is programmed immediately thereafter. The new unit will end up programmed with a security key of 3275-3305. 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 Mode:

The VPU-15, when used with another VPU-15, can automatically detect scrambled/clear audio when using Midian's Kryptic ANI. There are the "Send ANI in Scramble Mode" box and "Send ANI in Clear Mode" box in the programming. If these boxes are checked then a mode status bit is attached to the ANI. The receiving scrambler will automatically changes modes if the Automatic Detection feature is enabled. Otherwise the operator must manually change modes using the mode switch.

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 VPU-15 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 VPU-15 power supply. If this does not work, a modification to the VPU-15 may be required. Contact Midian in this case.

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