# VE2EMM Doppler I
## Alternate Firmware Operation Manual - “Enhanced” mode

This quick reference covers the basics of operation for a VE2EMM “Doppler I” running the KA7OEI Enhanced firmware *(Versions 4S or higher)*. This manual presumes the installation of three buttons.

This software has an “Enhanced” mode *(described in this document)* where many features have been added - but it also has a “Simple Mode” with limited functionality intended for use with VE2EMM Doppler I units with minimal hardware modification - *see the link to the manual for the “Alternate Firmware” in the “Additional Information” section at the end of this document for more information about this mode.*

## Initial firmware set-up

The new firmware ***may*** be in “simple” mode - one that is *(mostly)* compatible with the unmodified VE2EMM board. If you ***do not*** see the LEDs on the compass rose “spin” 2 or 3 times on power-up, turn off the unit, remove ***any*** source of audio and then back on again ***while holding all three buttons down***. This should put the unit into the “configuration” setting of the “enhanced mode” with two or three LEDs blinking, depending on whether you have single or dual-color LEDs installed.

### Important note if using single-color LEDs

This firmware is capable of using two-pin dual-color LEDs *(one direction for red, the other for green)* for a three-color *(red, green, yellow)* display. If you are upgrading an existing VE2EMM Doppler I unit with single-color LEDs, ***do the following to put it in “single color” mode:***

- Turn off the unit.
- Using a resistor of between 220 ohms and 1k, temporarily connect it between pin 27 of the microcontroller and ground.
  - Orient the circuit board so that pin 1 of the microcontroller *(the one with 28 pins)* is upper-left: Pin 1 is indicated with a dimple or notch. Pin 28 is across from pin 1 *(upper-right)* and pin 27 is next to it, closer to you.
  - I typically use a clip lead to ground and hold the resistor on pin 27.
- Power up the unit. Once the display activates, remove the resistor connection and turn it off again.
- If you are using single-color LEDs, power up the unit again without the resistor in place: You should see the compass rose spin ***three*** times in quick succession if it’s in “single color” mode.
  - If you see it spin once - pause and spin again, it’s ***not*** in single-color mode and you should re-try the above procedure, verifying the resistor value, ground connection and pin to which the resistor was temporarily connected.
- If you later install dual-color LEDs, use this same procedure to toggle out of single-color mode - see the section “Upgrading to 2 color LEDs” at the end of this document.

## Antenna set-up:

### A note about "Radio configuration"

Three different "radio" configurations may be stored in the firmware and each of these have store drive polarity, rotation direction and direction calibration.

A configuration is selected by holding button 1, 2 or 3 down while powering up the unit. Subsequently, when the unit is powered up the current radio configuration is indicated by 1, 2 or 3 LEDs being displayed ***just prior*** to the "spin" of the compass rose display.

> **If you change radio configuration, be sure to properly set rotation direction and polarity before you proceed any further!**

### Drive polarity

As this firmware may be used with different arrays and antenna switchers, it's important that you know the rotation direction and drive polarity. The simplest drivers apply the 5 volt pulse directly from the microcontroller to forward-bias the switching diode and will likely use "positive" switching *(e.g. a 25% duty cycle positive pulse)*. More complicated drivers - such as those that use RS-232 port drivers to apply both positive and negative voltages to better turn the diodes on-off - may invert the signal - and these may use "negative" switching from the microcontroller *(e.g. 75% "on" duty cycle)*. The orientation *(polarity)* of the switching diodes must also be considered.

***Whatever configuration you need, it is important*** that the drive circuitry turns each antenna <u>**ON**</u> with a **25% duty cycle**.

### To change the antenna switching polarity:

- Enter the "configuration" mode *(hold buttons 1, 2 and 3 while powering up - the LEDs will flash in a triangular pattern)*. Release the buttons when the display starts spinning
- Do a "long press" *(more than 2 seconds)* of button #2: The east and west LEDs will blink.
- If the LEDs flash **ON** briefly, this is POSITIVE switching *(25% "on" time at the microcontroller).*
- If the LEDs flash **OFF** briefly, this is NEGATIVE switching *(75% "on" time at the microcontroller).*
- Remember: You drive circuitry may invert the polarity of the pulses.
- Do a short press of button 1 to toggle polarity.
- After a few seconds of no button pressing, it will revert back to the configuration *(e.g. blinking triangle.)*
- To exit the configuration, simply power-cycle the unit.
- **It is recommended that you mark the unit with the switching polarity for future reference.**

If you are unsure of the required polarity drive for your antenna unit, do the following with the antenna unit connected, with all four antennas installed.

- Enter the "configuration" mode using buttons 1, 2 and 3 as described above. The LEDs should blink in a triangular pattern.
- Enter the "Antenna Test" mode by briefly pressing button 3.

- Using a receiver with a signal level meter, find a signal that is ***NOT*** full-scale and/or slightly noisy.
- Press button #1 several times:  You will note the sequence of the "North" LED flickering *(all antennas "off")*, North LED solid *(antenna #1 ON)*, North and East antenna ON *(antenna #2 on)* and so on with antenna #4 indicated by all four cardinal points being illuminated *(they may be flickering due to multiplexing.)*
- If the polarity is correct, the signal will be weak or disappear when ***NO*** antennas are selected *(North LED flickering)* but the signal level will be much higher and equal when ***any*** of the four antennas are selected.
  - Note:  If the signal source is distant and possibly affected by multi-path, signal levels may be different between antenna, but a slight movement of the signal source or the antenna array in any direction should change it.
- If the signal level does ***not*** drop significantly when ***NO*** antennas are selected, change the polarity of the drive signal and re-check.
- This "Antenna test" utility may be used to verify the operation of each of the four antenna's RF switches:  If you get completely nonsensical readings after calibration and checking the rotation direction *(see below)* verify that each of the antennas can be turned "on" and "off" by selecting them one at a time.
  - ***Such damage is mostly likely to happen if one inadvertently transmits into the antenna array.***
- The "test" antenna selected in this mode *(which can include "none")* ***<u>IS</u>*** the antenna that will be selected if, during operational mode, one stops rotation by briefly pressing button #3.
  - It's ***strongly*** suggested that an antenna be selected *(rather than "none")* in this mode so that when you stop antenna rotation, you can hear the signal being monitored via the DF unit's receiver's audio.

**Direction of rotation**

The direction of rotation is a matter of how the cables/antennas are labeled and it can be CW *(clockwise)* or CCW *(anti-clockwise).*  If the displayed bearing moves in the direction opposite of the signal source, set the rotation opposite to its current setting.

**To change the direction of rotation:**

- Enter the "configuration" mode *(hold buttons 1, 2 and 3 while powering up - the LEDs will flash in a triangular pattern)*.  Release the buttons when the display starts spinning
- Do a "short press" *(less than 1 second)* of button #2:  Two LEDs will chase each other in the direction of rotation.
- Do a short press of button 1 to toggle direction.
- After a few seconds of no button pressing, it will revert back to the configuration *(e.g. blinking triangle.)*
- To exit the configuration, simply power-cycle the unit.
- **It is recommended that you mark the unit with the rotation direction for future reference.**

## Audio level set-up

During normal operation, you will hear the 500 Hz "switching" tone on any received signal - this being imparted on that signal by the electronic "rotation" of the four antennas:  It is this signal that conveys the bearing information.

The audio level from the receiver should be set at a level well below distortion of the amplifier - even when modulation is present - which is atop the switching tone. It should be noted that when signals are weak, noise may also be present, increasing the overall audio level and peaks.

While occasional "overload" indications on audio peaks are fine, it's better to have "slightly low" audio level rather than "too high". There are two ways that the audio level may be represented:

**Audio level meter:**

- In normal operation mode, a quick press of **Button #2** will show up to eight LEDs lighting up CCW *(left)* from the "North" LED, representing audio levels zero through eight. A setting of between four and eight LEDs is suggested for peak audio.
- If the LED just below the "West" LED illuminates, an audio overload is being detected. It is permissible for this to light on occasional audio peaks.

**Audio level indication using compass rose flashing:**

Audio level may also be indicated by blinking the display if the level is too high *(fast blinking)* or too low *(slow blinking)*: You may still use Button #2 to display the audio level in this mode. This mode is off by default and may be enabled as follows:

- Enter the "configuration" mode *(hold buttons 1, 2 and 3 while powering up - the LEDs will flash in a triangular pattern)*. Release the buttons when the display starts spinning
- Press and hold buttons 1 *and* 2 for about 2 seconds: This will toggle the setting.
- If the display shows three LEDs at north flashing, it is in the mode where the display will flash depending on the audio level *(e.g. fast blinking = too-high audio, slow blink = too-low level.)*
- If the display shows the three LEDs at north ***NOT*** flashing, it is in the mode where the display will ***not*** flash depending on the audio level.
- After a few seconds, it will return to the configuration mode *(e.g. blinking triangle)*.
- To exit the configuration, simply power-cycle the unit.

## Direction calibration

If this unit is to be used in a vehicle, it's typical for "straight ahead" to be represented by "North" on the compass rose. To calibrate, the following is suggested:

- Tune in a signal from a ***known*** location. The view of the transmitter should be clear of obstructions and multi-path reflections. It's preferred to use a signal with no modulation *(e.g. someone standing some distance away in front of the vehicle with a radio)*.
- Adjust the audio appropriately, avoiding "overload" indications.
- The display should show a bearing: It may "wobble" a bit if modulation is present: This is normal.
- If a "zero" degree *(North)* indication is not shown, an "Auto Calibration" may be done:
  - In the normal operation mode, press and hold **Buttons 1 and 2** for about 2 seconds.
  - This will calibrate the unit such that the current bearing is now "North".
- If you have recently set up the unit, turn the vehicle left or right: If the bearing goes in the opposite direction, you must reverse the rotation as described earlier and re-calibrate.

**Important note about inexpensive radios:**

- **Many inexpensive Chinese radios are *<u>NOT</u>* suitable for use in this direction-finding system.**
  - Many of these radios use a “radio on a chip” that process the audio in unpredictable ways, resulting in varying phase and delay, making them ***unsuitable*** in this application.
  - Some modern “digital” radios may also be unsuitable - even if configured for “analog” operation.
  - It is ***STRONGLY*** recommended that an “old school” analog radio be used!
- Different radios will have different amounts of delay/phasing in their audio path and this ***will*** affect calibration. If you change radios, you will need to recalibrate the direction.
- If you move the unit to a different vehicle, the change in environment may skew the readings, requiring recalibration.
- If you add/delete an antenna from a given vehicle, this may affect readings, requiring recalibration.
- If you routinely use ***different*** radio and/or vehicle combinations, you may wish to utilize the “Radio Configuration” settings described earlier.

**Manual calibration**

In a vehicle, “Auto Calibration” will almost always be used, but in a situation where the array cannot be oriented such that “North” is in the direction of the test signal *(e.g. in a fixed/home installation)* the bearing may be manually adjusted.

- In Normal mode, press and hold button 1. The current bearing will freeze.
  - If no other buttons are pressed, the unit will return to normal operation after 2 seconds.
- Pressing button #2 will decrement the calibration by 11 degrees *(1 LED)*
- Pressing button #3 will increment the calibration by 11 degrees.
- While in this mode, a ***brief*** press of button #1 will put it in “fine” calibration mode, where:
  - Pressing button #2 will decrement the calibration by 1 degree
  - Pressing button #3 will increment calibration by 1 degree.
  - Pressing button #1 - or waiting several seconds with no button presses - will exit.

## Additional configuration options

There are ***three*** types of bearings that may be displayed:

- **“Bad” bearings**. On a dual-color display, these are shown in red and are considered to be of poor quality. These will be displayed on noise or in severely degraded signals *(noisy, multi-path)*. These bearings - while likely not conveying useful bearing data - may still provide insight as to the quality and nature of the signal being monitored. On a dual-color LED system, these are represented in Red.
- **“Current” bearings**. These are the “raw” bearings. Lacking statistical processing, they can be quite “noisy” of either the transmitter or receiver is in motion and distortion/multi-path is present. On a dual-color LED system, these are represented in Green.
  - While noisy, this information may be useful to the experienced operator to note trends or to determine the likely “quality” of the bearings in terms of being subject to reflections.

    - On a single-color LED system, these cannot be represented as a separate color and will be displayed as a second bearing - but as these are “noisy” compared to the “averaged” bearings, they may be visually distinguished.
- **“Averaged” bearing.** Internally, the raw data is represented as a pair of vectors, the signs and amplitudes trigonometrically representing the bearing. The “Average” bearing sums the vectors of the past several “current” readings and in so doing, “good quality” bearings are weighted more highly than “poor quality” bearings. On a dual-color LED system, these are represented in Yellow.
    - Under “noisy” conditions *(weak signal, multi-path)* the “Averaged” bearing is more likely to indicate the general direction and will be much more stable than the “Current” bearing.

**Turning on/off “Bad” bearings:**

**Note:** “Bad” bearings cannot be displayed on a unit with single-color LEDs.

- Enter the “configuration” mode *(hold buttons 1, 2 and 3 while powering up - the LEDs will flash in a triangular pattern)*. Release the buttons when the display starts spinning.
- Briefly press Button #1 to toggle “bad” bearings on/off.
    - When “bad” bearings are enabled, the “south” LED will flash.
    - When ‘bad” bearings are disabled, the two LEDs on either side of the “south” LED will flash.
- After a few seconds, it will return to the configuration mode *(e.g. blinking triangle)*.
    - To exit the configuration, simply power-cycle the unit.

**Turning on/off “Current” bearings:**

**Note:** As noted above, the “Current” bearings will be the same color as the “averaged” bearings on a single-color display, but may be distinguished by the fact that they will be more “noisy” than the averaged bearings so you ***may*** wish to disable the “current” bearings to reduce visual clutter.

- In normal operational mode, press and hold buttons 2 and 3 for at least 2 seconds.
- If the 2 LEDs on either side of “north” flash *(and NOT the “north” LED)*, the display of the “current” bearing is disabled.
- If the “north” LED flashes, the display of the “current” bearing is enabled.
- After a few seconds, it will return to normal operation.

# Detailed configuration information

## Operate mode:

**"Operate" mode is the normal mode where the display shows the bearings. In this mode, the buttons are used to show status and configure settings.**

**Note:** When in "Operate" mode, by default, the LEDs on the four cardinal points (North, South, East and West) will blink briefly once every 3/4 of a second or so. This allows visual orientation of the unit in the dark. *This feature may be disabled/enabled using the "Disable/enable cardinal point blinking" function in the configuration mode - see below.*

- **Button 1** ***(Shortpress):*** **Display quality.** Green LEDs, displayed CCW from "North" with the number of LEDs indicating quality of the **integrated** *(not averaged)* bearing.
    - Flashing red and with a single green LED indicates quality of zero. Automatically times out if no button pressed, but may be extended by pressing and/or holding of button 1 (once it is displaying the quality) before it times out and returns to normal operation. *This mode does not stop antenna rotation.*
        - Moving CW from the "South" LED is the quality of the **averaged** signal.
    - A single red LED at approximately the "East" position indicate an audio overload condition.
- **Button 1** ***(Longpress):*** **Calibrate direction.** Green indicates current calibration setting while yellow shows the corrected direction. ***Note that calibration direction is stored separately with each of the 4 possible radio presets.***
    - Button 2 (shortpress) decrements by 11 degrees (1 LED)
    - Button 3 (shortpress) increments by 11 degrees (1 LED.)
    - "Fine" calibrate mode: Button 1 (short) will switch to "fine" calibration mode with green showing current calibration and yellow showing corrected direction:
        - Button 2 (shortpress) decrements by 1 degree
        - Button 3 (shortpress) increments by 1 degree.
        - Button 1 (shortpress) exits.
    - Either mode is exited after a short period with no buttonpresses.
    - If using only single-color LEDs, only the "Green" *(calibration)* value will be indicated rather than the corrected direction which can make precise setting a bit awkward.
        - If using in a vehicle, calibration is normally done using the "Auto Calibrate" function *(Button 1 and 2 longpress)* to set "directly ahead".
- **Buttons 1 and 3** ***(Longpress):*** **Toggle dim/bright mode.** When this is done, the East/West LEDs will blink green/yellow respectively at the new brightness setting. NOTE: Cardinal point blinking does ***not*** change brightness.
- **Buttons 1 and 2** ***(Longpress):*** **Auto-calibrate.** The "north" direction is automatically set to that of the present *averaged* direction. *This mode does not stop antenna rotation.*

        - This is used primarily when the DF unit is used in a vehicle:  The vehicle ***must be*** oriented such that a ***known*** ***<u>good</u>*** signal source - without multipath is **<u>straight ahead</u>**.
        - This setting is stored for each, individual radio configuration.
- **Button 2** ***(Shortpress):*** **Display audio level.** The audio level is displayed using 1-8 LEDs. Yellow LEDs *(if dual-color LEDs are used)* displayed CCW from "North" with the number of LEDs indicating the level.
    - Flashing red and yellow LEDs at the "north" position indicate quality of zero. Automatically times out if no button pressed, but may be extended by pressing and/or holding of button 1 before it times out.  *This mode does not stop antenna rotation.*
    - A single red LED at approximately the "West" position indicates an audio overload condition.
- **Button 2** ***(Longpress):*** **Adjust averaging.** Averaging indicated by number of green LEDs illuminated from 2 to 32.  *This mode stops antenna rotation!*
    - Button 1 (shortpress) decreases averaging
    - Button 3 (shortpress) increases averaging.
    - **Integration adjust mode:**  Another press of Button 2 (shortpress) switches to integrate adjust mode with the number of integrations indicated by the number of red LEDs, from 1 to 32.  ***(Note:  This setting may be difficult to use if only single-color LEDs are used on the display.)***
        - Button 1 (shortpress) decreases integration.
        - Button 3 (shortpress) increases integration.
        - Button 2 (shortpress) exits to normal operation.
    - Either mode is exited after a short period with no buttonpresses.
- **Button 3** ***(Shortpress):*** **Toggle stop/start rotation.** Stopping rotation is useful for wanting to listen to signal without the switching tone - particularly useful when the signal is very weak or if you are trying to hear something on modulated onto the signal.
    - ***When rotation is stopped, the display is frozen and the cardinal points will blink quickly - even if the blinking of cardinal points has been disabled.***
    - When rotation is stopped, the antenna selected in the "Test Antenna" configuration setting will be used.
        - Note that the "test antenna" setting could be set to "None" *(no antennas)* which may result in the receiver being "deaf" if no antenna is selected and rotation is stopped.
- **Button 3** ***(Longpress):*** **Adjust quality threshold.** Quality level is display in green with a quality of zero indicated by flashing red LED. The LED (green or yellow) increasing quality displayed CCW from "North." If displayed in green, ONLY current bearing is used for gating, if displayed in yellow, BOTH the current and averaged bearing are gated.  *This mode stops antenna rotation.*
        - Button 1 (shortpress) decrements quality threshold.
        - Button 2 (shortpress) increases quality threshold.
        - **Important:**  It's not recommended to set the quality threshold much higher than 4 or so as this may exclude too many bearings to get a general direction of the

        signal - particularly in areas where the signal is weak/noisy/multipathy.  A setting of 2 or 3 is suggested.

    - Button 3 (shortpress) changes to "Audio threshold adjust" mode.
    - **Audio level threshold adjust mode:** Another press of Button 3 (shortpress) switches to Audio threshold adjust with a threshold of zero (disabled) indicated by a flashing red LED with a yellow LED, with increasing level displayed "CCW" from "North" in yellow.
        - Button 1 (shortpress) decrements threshold level
        - Button 2 (shortpress) increases audio threshold.
        - Button 3  (shortpress) exits.
    - Either mode is exited after a short period with no button presses.
- **Buttons 2 <u>and</u> 3 *(Longpress):* Turn on/off the display of the "Current" (green) bearing.** When the "current" *("integrated")* bearing is turned off, the "North" point will be flanked by a yellow and red blinking LED.  When the "current" bearing is turns on, the "North" point will be a blinking green LED, indicating that "current" (green-colored) bearings are to be displayed.  One might turn off the display of the "current" bearing for several reasons:
    - If using a single-color LEDs *(e.g. NOT dual-color)* it may be difficult to distinguish the "Integrated" *(a.k.a. "current")* from the "Averaged" bearing.  As noted elsewhere, the "averaged" bearing is the more useful of the two.
    - De-clutter the display.  If the signal has a lot of multipath, the constantly-moving green LED may make the display a bit more difficult to read.  Turning it off leaves only the "average" bearing on the display.
    - Increase brightness.  When the "current" bearing is turned off, the brightness of the green LED that would be displayed is combined with the yellow LED.  This causes the color to shift a bit toward the green, but it also makes the LED noticeably brighter.
- **Buttons 1, 2 <u>and</u> 3 *(Longpress):* Enter "Configuration" mode".** Restart the software and enter config mode.  ***Note:  Release the buttons as soon as the display changes!***

## *Comments on normal operation:*

- If the audio level or quality factor is too low, bearings displayed in ***RED*** *(if "bad" bearings are enabled and dual-color LEDs are used)* will appear and neither the "current" bearing *(displayed in green if dual-color LEDs are used)* or the "averaged" bearing *(displayed in yellow if dual-color LEDs are used)* will be updated.

## *Selecting 1 of 4 radio presets:*

Configurations for up to 4 different radios may be stored, allowing multiple radios and/or antenna switching systems to be used without need to recalibrate. The radio configuration to use is selected by **pressing and holding buttons 1, 2, 3, or 4 while turning on the power**, selecting radio #1, 2, 3 or 4 respectively, and storing this selection in nonvolatile memory.

When the unit powers up, the display will show, by the number of LEDs, which radio configuration is being used. *Note that the LEDs depicting the radio selection is shown both at the top and the bottom of the display - that is there will be 2 LEDs on the top, and 2 on the bottom to indicate the selection of radio #2.* Of course, if the 4th button was not installed, you will, not be able to select configuration #4. The configuration data saved includes:

- **Direction calibration:** With a fixed station, this would probably be True North but in a vehicular installation, this usually refers to a "Straight Ahead" bearing.
- **Antenna rotation direction:** CW or CCW. Depending on one's labeling and the order that antenna cables are connected, one may need to select antenna rotation direction.
- **Antenna polarity:** Positive or negative drive. If you have different antenna switching units, you may need to have different settings to use them.

# Configuration mode:

**Note:** When in configuration mode "idle" display, three LEDs will blink in a **<u>triangular</u>** pattern and no other LEDs will be lit unless an option has been activated. After setting a configuration, the new configuration will be displayed for a couple of seconds and then the display will revert back to the "triangular blink pattern" at which time more changes may be made.

- **Configuration mode may be entered by holding down buttons 1, 2 and 3 while turning the power on. Release the buttons as soon as the display changes.**
- **Settings are saved to nonvolatile memory as soon as they are changed.**
- **Press and hold buttons 1, 2 and 3 to exit the configuration mode, release the buttons as soon as the display changes! You may also toggle power to the unit to restart in normal operational mode.**

### Options:

- **Button 1 *(Shortpress):* "Bad" bearing display.** Toggle enable/disable of the display of "bad" bearings (displayed in RED.) When the red "bad" bearings are to be displayed, the SOUTH LED will flicker red. When the display of "bad" bearings are disabled, the two LEDs will flicker on either side of the the SOUTH LED.  This may be done to if the red "bad" LED causes too much visual "clutter."

- **Button 1** ***(Longpress)*****:**  **Flip display** (e.g. "mirror" mode.)  The display "spins" in the direction of increasing degrees, that is, it spins Clockwise for a "normal" display and CounterClockwise for a "flipped" display - perhaps a reflection off a mirror/windshield.  *Note that "flip" mode does* ***not*** *affect the way any of the configuration menus are displayed.*
  - ***Buttons 2 or 3*** *(shortpress):*  Toggle direction
- **Button 2** ***(Shortpress):***  **Antenna rotation direction.** Two LEDs chase each other in antenna rotation direction. ***Note that antenna rotation is stored separately with each of the 4 possible radio presets.***
  - ***Buttons 1 or 3*** *(Shortpress):*  Toggle rotation direction.
- **Button 2** ***(Longpress):***  **Select antenna drive polarity.** Green/Red on East/West cardinal points with duty cycle indicating drive polarity.  Briefly pressing button #1 toggles setting.  ***Note that antenna drive polarity is stored separately with each of the 4 possible radio presets.***
  - Positive drive:  A quick "on" flash indicates that an antenna is turned on when voltage is present on the antenna drive pin.
  - Negative drive:  A quick quick "off" flash indicates that an antenna is turned off when there is zero voltage present on the antenna drive pin.
  - ***Buttons 1*** *(shortpress):*  Toggle polarity.
- **Buttons 1 and 2** ***(Longpress):***  **Audio level blinking.**  Toggles enabling of the display blinking according to the audio level.  When enabled, the display will blink slowly (once-per-second) when the audio is too low and it will blink quickly (three times per second) if the audio level is too high.  *Cardinal point blinking is independent of this function.*  This function is most useful when using the ***"Single Color"*** mode (just one color of LEDs installed) to indicate whether the audio is too high or, too low.
  - The three LEDs on the top (north) of the display will flash on/off  when in "Blink for audio" level mode.
  - The three LEDs on the top of the display will ***NOT*** flash when in the mode in which audio level is indicated only by a short-press of button 2.
- **Button 3** ***(Shortpress):***  **Select test antenna:** When this command is executed, or when rotation is stopped *(see the "stop rotation" command below)*  1, 2, 3 or 4 LEDs *(on cardinal points)* depicts whether antenna 1, 2, 3 or 4 turned on at that time.   ***The default is NONE***.
  - ***Button 1*** *(shortpress):*  Decrements antenna number.
  - ***Button 2*** *(shortpress):*  Increments. antenna number.
  - Antenna #1 is indicated by only the "North" LED illuminated, #2 is with "North" and "East", #3 is with "North", "East" and "South" and #4 is with all four points illuminated. *(Note that the display will flicker as more LEDs are illuminated.)*
  - **Note:**  If set to "None", note that when antenna rotation is stopped in "Operation" mode *(via a shortpress of button 3)* there will be no antenna connected to the receiver and what may be heard would be via leakage of the switching diodes.  If you wish to be able to hear with the rotation stopped, select at least one antenna.

    - A selection of "none" *(no antenna selected)* is indicated by a flashing LED on the North point. This function is useful for testing an antenna array and its switcher board.
    - This function may be used to check the antennas/array:
        - In a location without multipath, the signal level will be the same when any of the four antennas is selected - but decrease when "None" is selected.
        - Note that many FM receivers have S-meters that do not accurately convey signal strength so it's possible that even a weak signal may show "full scale". It is recommended that an inline step attenuator be used to reduce the signal from a known-good antenna to mid-range on the radio's S-meter and then select each antenna, in turn to observe that each selected antenna has the same signal strength and that signal levels drop significantly when "None" is selected.
- **Button 3 *(Longpress):* Configure the "average clear" time.** "Off" is indicated by a flashing red LED on the South point, a yellow indicates a time of "0" seconds, and the selected time increments going CW from south in 1/4ths of a second per LED, with the available times being 1/4 *(1 LED)*, 1/2 *(2 LEDs)*, 3/4 *(3 LEDs)*, 1 *(4 LEDs)*, 2.5 *(10 LEDs)* and 5 seconds *(20 LEDs)*. The "average clear" function resets the contents of the "running average" after the signal disappears. If set to "0" *(the yellow LED)* it clears it the instant that the signal goes away, while the timed settings wait for that period of time to pass before the signal is cleared.
    - ***Button 1*** *(shortpress):* Decrements time setting.
    - ***Button 2*** *(shortpress):* Increments time setting.
    - **If using a single-color LED display.** The use of a single-color LED display makes this configuration more difficult to use, so the sequence is as follows.
        - Press Button 2 *(shortpress)* to increment setting: The number of LEDs will increase and at a setting of 5 seconds, 20 LEDs will be illuminated.
        - The following is the sequence for ***subsequent*** presses:
            - Single LED *(South)*: "Average Clear" is disabled - which would be represented by a Red LED. *(The LED may be slightly dimmer)*
            - Single LED *(South)*: "Average Clear" is enabled, but occurs the instant the signal goes away - which would be represented by a Yellow LED.
            - Single LED *(South)*: "Average Clear is enabled and occurs 1/4 second after the signal goes away - which would be represented by a Green LED.
            - Two LEDs *(South and the next CW to it)*: "Average Clear is enabled and occurs 1/2 second after the signal goes away.
            - From here, the number of LEDs increases as described above.
- **Buttons 2 and 3 *(Longpress):* Cardinal point blinking.** Toggles enables/disables the cardinal point blinking. When the cardinal point blinking is enabled, the 4 cardinal points will display as blinking. If the cardinal points are disabled, they will be turned on continuously (non-blinking.)
- **Buttons 1, 2 and 3 *(Longpress):*** From this "configuration mode idle display" this "reboots" the unit, allowing exit of the configuration mode. ***Release the buttons as soon as the display changes!***

## Additional configuration options:

There are additional configuration options possible and these are. These are activated by grounding the appropriate pin, through a resistor with a value of 220 to 1k ohms, when the unit is powered up.:

- **RB7** (Pin 28): **Rotate the display 180 degrees.** This option simply turns the display upside-down. This is useful if, for whatever reason, the display has been mounted inverted.
- **RB6** (Pin 27): **Toggles "One-Color" mode.** If you have already built a Doppler I, performed the above modifications, but have ***not*** replaced the LEDs with the dual-color devices, you can use this function to cause all parameters to be displayed as ***one*** color.
  - If this setting is activated, you will also want to disable the "bad" bearings *(done by a "shortpress" of buttons 1 in the Configuration mode)* and the "current" bearings *(done by a "longpress" of buttons 2 and 3 in the "Operate" mode)* as well as activating the "Audio Level Blink" mode *(done by a "longpress" of buttons 1 and 2 in the Configuration mode)* to avoid confusion caused by displaying several different types of data with the same color.
- **RB5** (Pin 26): **EEPROM RESET and *enter SIMPLE mode.*** This also restores default settings and calibrate the audio detector. ***If this function is performed, remove all audio from the input to allow proper audio level meter calibration!***
  - This will cause all configuration to be set to the defaults.
  - This function also initiates a re-calibration of the audio detector. This function looks at the audio level detector input and calibrates the current audio level reading as "zero" so <u>it is important that audio ***not*** be present on the input</u>. If audio is detected on the input, all LEDs will briefly display RED and a "canned" default value will be used instead. This "audio calibrate" function is used to accommodate different voltage drops across the audio detector diode.
  - To exit SIMPLE mode, press and hold buttons 1, 2 and 3 for several seconds: This will enter "Config" mode. *Once SIMPLE mode is exited, it is **not** possible to return to SIMPLE mode without doing an EEPROM RESET.*

- **Important note for users VE2EMM using the *original* antenna switching unit and configuration:**
  - When an EEPROM RESET is done, users of the original Doppler I firmware need to be aware that two parameters need to be changed in order for it to work properly with the antenna switching unit originally described on the VE2EMM site.
    - Antenna rotation needs to be switched to Clockwise (CW) mode. This is done with a shortpress of button 2 in the configuration menu *(see above.)*
    - Antenna switching polarity needs to be changed to Negative mode (that is, the LEDS blink ***off*** briefly.) This is done with a longpress of button 2 in the configuration menu *(see above.)*

### Serial data/4th button:

There are provisions for adding a 4th button. This not only allows a 4th radio preset, but it permits the configuration of the transmission of serial data - say, to a host computer to display bearings/quality on a moving map display such as Robin Lovelock's "GPSS" program: http://gpss.co.uk/ - or possibly others. See the "Manual for the Alternate Doppler 1 Firmware" page linked below for more details.

## Upgrading to dual-color LEDs

As originally designed, VE2EMM used "single color" LEDs - typically 31 LEDs being red with a single green LED at the "South" or "North" to allow visual orientation in the dark. This "alternate" firmware allows the use of bi-directional red/green LEDs *(those with two leads)* to permit the display of red, green and yellow. Suitable dual-color LEDs include:

- For 3MM diameter, T1 LEDs: DigiKey P.N: 160-1058-ND which are Liteon P/N: LTL-14CHJ. *These are the same size as the originally-recommended LEDs.*
- For 5MM diameter T1-3/4 LEDs: DigiKey P/N: 160-1038-ND which are Liteon P/N: LTL-293SJW. *These are larger than the original LEDs and would require re-drilling holes if you sized them for the originals.*

If you choose to change these LEDs, the following procedure is **STRONGLY** recommended:

- **BEFORE** changing any LEDs, switch out of "single color" mode by grounding processor pin 27 via a 220-1k resistor and applying power. When in 2-color mode, you will see the display do a "spin" - pause briefly - and do another spin: This pause in the spin is due to the single-color LEDs not illuminated when reverse polarity is applied.
- Once "dual-color" mode is enabled, remove **ONE** LED and ***temporarily*** tack a dual-color LED in its place.
- Apply power and watch the color of the dual-color LED that you just installed: As the three spins occur, the sequence should be **GREEN - RED - YELLOW**.
  - If you see this sequence in the correct order, install the remaining LEDs with this same pin orientation *(e.g. the same pin length toward the outside of the circle).*
  - It's suggested that you re-check the color sequence occasionally as you proceed with the LED replacement to avoid mistakes.
  - If you see the sequence **RED - GREEN - YELLOW** the reverse the leads of the dual-color LED and re-check.

## Additional information

Refer to the following web pages for more detailed information:

**https://www.ka7oei.com/emm1.html** - The **"Manual for the Alternate Doppler 1 Firmware"** - plus information on hardware modifications, including adding the 4th button and serial output port.

**https://www.ka7oei.com/mtdop1-e_1.pdf** - This is a version of the ***original*** documentation for the VE2EMM "Montreal Doppler I" by Jacques Brodeur, VE2EMM (SK). This includes a description of the hardware and software, parts lists, board layout, and source code of the original firmware.

There are also the KA7OEI ARDF pages: **https://www.ka7oei.com/ardf_pages.html**