Virtual Pocket

Pocket HARMONIZER®

VP Harmonizer Version 1.05
Press ENTER...

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Introduction and Installation

by BlueSwarf LLC

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Part I
1 Introduction

The Pocket Harmonizer is a Windows Mobile version of MLI’s full Harmonizer product. It uses the exact same detection and decision algorithms. Technology contained in the Harmonizer is protected by some or all of US patents, 5,170,358 and 6,085,121; and International Pub. No. 99/15310 along with other patent pending technology and trade secrets.

It is a digital based application to simply and quickly identify chatter and suggest alternative spindle speeds. Like the full Harmonizer it is an iterative technique to find a stable rpm. It can also suggest that the cut is too deep or aggressive. So, after a minimal set of attempts changing spindle speed, harmonizer suggest reducing the depths of cut.

The Virtual Pocket Harmonizer or VPH is a Windows based PC version (see Figure 1 below) that is identical in function and form to the Pocket Harmonizer. Many users treat it as a simple pop-up applet to run with their Windows hosted controllers or on their laptop computers. Files of either application can be read by the full Harmonizer.

This manual explains the function of the Harmonizer and provides an example of how to detect and correct a chatter situation.

1.1 Why use Virtual Pocket Harmonizer or VPH

The Virtual Pocket Harmonizer is an inexpensive tool to aid Machinists, Programmers, and Engineers in selecting stable parameters to eliminate chatter and improve quality and throughput. It uses the chatter frequencies to recommend “sweet spot” rpm’s with minimal effort.
1.2 Requirements

Computer Requirements are as follows.

**Virtual Pocket Harmonizer**
- Windows 2000 or higher
- Audio enabled PC
- Internal or external microphone for PC
- Set the default audio recording device to the desired input.

1.3 Installation

To install the Virtual Pocket Harmonizer (VPH) you will need to do the following:

For the Virtual Pocket Harmonizer:
1. Unzip the file `DataCollector2014.zip`
2. You will be guided through the installation steps and the application will be installed on your PC.
3. Start the Pocket Harmonizer on your PC by clicking on the Virtual Pocket Harmonizer ICON.
4. The following welcome screen, Fig. 2, will appear, press **Enter**.
5. The Passcode Screen provides a **Software Key** and requests a **Passcode** shown below in Fig. 3 and 4.
6. Go to [http://www.blueswarf.com/activation](http://www.blueswarf.com/activation) and enter the software key. You will receive a Passcode.
7. Once you have received the Passcode, enter it using the keypad. *Only three attempts are allowed* to enter the Passcode. After three failed attempts the Pocket Harmonizer will not launch and the application will then have to be uninstalled and reinstalled to reattempt the entry of the Passcode.
Once the passcode is entered the Pocket Harmonizer will display the spindle speed entry screen, Figure 5, shown after the VPH installation instructions.

**NOTE:** The software operates with either using the mouse to click the keypad or by using the equivalent keys on the keyboard.
2 Operating Instructions

The following is a step by step explanation for operating the Virtual Pocket Harmonizer

2.1 Basic Operation

NOTE: The key pad will be eliminated from the figures so only the display of the Harmonizer will be shown in this and following sections.

Operation of the Virtual Pocket Harmonizer can be done in **SIX steps**.
1. Enter the current spindle speed
2. Enter the maximum spindle speed
3. Enter the number of effective cutting edges
4. Enter the desired recording length
5. Select the Threshold method
6. Make the recording.

Subsequent operation of the Harmonizer uses many of the above inputs so they are input only once. The next set of screen shots shows in detail the step-by-step procedure.

1. Enter the Current Spindle speed which is the current speed (rpm) during cutting while the recording is going to be made.

![Current Spindle Speed (rpm): 10000](image1)

2. Enter the Maximum Speed that you are willing to allow for a suggested spindle speed.

![Max. Spindle Speed (rpm): 10000](image2)

3. Enter the number of "effective" cutting edges (flutes, inserts) and press enter.

![Effective Cutting Edges](image3)
4. Enter the desired Recording Length (seconds) and press enter.

5. Select the Threshold Setting Method (most common is 1) and press enter.

6. Ready to run. Wait for the tool to start cutting and press enter to begin the recording.

The Harmonizer will record the cutting sound and then analyzes the signal. It is best to start the recording as the tool enters the cut or soon thereafter or in the area of the cut that is of most interest. The recording screen is shown below during recording. Note the Indicator Light is **YELLOW** to indicate it is recording. After recording is complete Pocket Harmonizer analyzes the signal as shown on the right while reporting the spindle speed detected or previously set and the threshold setting being used.
After the analysis is complete it will either (a) report that chatter is found like the screen shot below left with a red indicator light or (b) report that no chatter was present (shown later). The reported spindle speed is slightly different here because the option "auto-tune" has been set to allow the Harmonizer to detect as best it can the actual spindle speed during the sample. This is needed to best adjust the harmonic filters used by the Harmonizer. After pressing enter will suggest the next alternative spindle speed as shown below right.

The adjustment in spindle speed can be made and if no chatter is found it will look like below with a green indicator light (a similar screen is displayed if no chatter is found on the initial recording, both will have adjusted spindle speeds if the "auto-tune" function is activated, see Options Section of this manual). The user can either attempt a deeper cut or is free to adjust the chip load (feed rate) within the manufacturer's ranges, because the cut is now stable.

2.1.1 Reset/Restart Functions

After performing a set of cutting trials or analyzing several cuts there are two methods for starting over.

Both methods require using the shift key to activate the secondary functions.

RESET (Click Shift and then the 1 "key", not simultaneously) returns the Harmonizer to the original start screen and allows the user to re-enter all the parameters again, including,
• spindle speed
• maximum speed
• number of cutting edges
• recording length
• threshold strategy

**RESTART** (Click Shift and then click the 4 "key") keeps the last suggested or entered spindle speed. All other parameters. Maximum speed, recording length and threshold are NOT changed. The unit is brought back immediately to the Current Spindle Speed screen to allow the user to enter a new spindle speed if desired. This assumes the user will **USE THE SAME**:

• maximum speed
• number of cutting edges
• recording length
• threshold strategy

![Virtual Pocket Harmonizer](image)

### 2.2 Threshold Options

The threshold options are accessible just after a recording and during setup by pressing the SHIFT key and then the 5 "key". There are three possible methods.

The **Cutting** method is set by entering zero (0) on the keypad. This is recommended for cases where the recording contains only the cut and no other noises. The threshold adaptively adjusts during the cut to best identify chatter. This method eliminates the step of doing a preliminary idle run or guessing at an acceptable fixed value. No other activity is needed when selecting the Cutting threshold method.
The **IDLE RUN** method is set by entering the number one (1) on the keypad. This method sets the threshold with a preliminary recording that is certain to not contain chatter noise. It is the most common method as it is the most sensitive and reliable approach in accounting for the background noise. After entering 1, the Harmonizer will queue the user to record background noise when ready, as shown in the screen below. **BACKGROUND RECORDINGS ARE ADVISED TO BE TAKEN WHILE THE SPINDLE IS OPERATING AT SOME HIGH SPEED AND NOT CUTTING.** The user should press enter when ready and may repeat this procedure as many times as needed by using the "Back" button in the lower left of the keypad.

Once the recording is complete the screen will show the calculated threshold. If acceptable, press "Enter" to store the threshold value. I not press "Back" to repeat the measurement. This is a fixed value and will not be changed unless the user revisits the threshold settings or RESETS the Harmonizer.
Pressing enter will return the user to the next screen and likely the Ready to Record state, depending on where in the steps the user originally entered the threshold settings screen.

The final method is the **FIXED** method and is selected by entering the number two (2). Here the user simply enters the desired threshold value and press "Enter". This is only for the most experienced users who may wish to specifically set the sensitivity of the Harmonizer. Again, it will not change until the threshold settings are again entered or the Harmonizer is reset.

**2.3 Options**

The options for the Harmonizer are set using the Shift key and then pressing the two (2) key. These options are fixed and do not change until the user changes them. The default settings are acceptable in most cases but the user may wish to change them. Each option is selected using the key pad with a number or key assigned to the specific selection or question being asked.

The first option is to set the spindle speed readout as RPM (0 key) or Surface Speed in SFM (1 key).

The next option is to "Auto Tune Spindle Speed" (0 for No and 1 for Yes). During cutting the Harmonizer can often determine the instantaneous spindle speed as long as the initial RPM input is reasonably close (within the Spindle Filter Width %, see later). This is beneficial for adjusting the Harmonic Filters of the Harmonizer as accurately as possible. It is generally recommended to use this setting, e.g. Auto Tune 1=YES.
Next is "Regulation Strategy" (0 for simple and 1 for advanced). This is a legacy setting and will likely be removed in the near future. Always use ADVANCED.

"Threshold Estimation Factor" allows the user to more aggressively set the thresholding strategy. It is effective for the "cutting" and "idle run" methods of thresholding. A value of 100 is generally recommended. Reducing it will make it more likely that the user will get false positive readings of chatter. Increasing it will increase the possibility that valid chatter conditions are overlooked. Depending on the success of the Harmonizer after several uses, the user may want to lower or raise this value depending on whether chatter is not being detected or if too many false positives are indicated, respectively.

The next two options set the maximum and minimum chatter frequency. The default ranges are generally valid. The user may wish to adjust these to avoid some known prevalent frequencies in the shop that are not chatter. However, the user must also be sure that chatter will not occur outside the set range.
"Min. Spindle Speed (rpm)" sets the lower limit of the suggested spindle speed. The Harmonizer will not suggest spindle speeds below this range. The user may wish to increase this to insure that lower spindle speeds are not suggested. If the Harmonizer cannot suggest a speed above the minimum spindle speed it will suggest reducing the depth of cut.

The "Spindle Filter Width (%)" adjusts the harmonic filter width. This is dependent on how much the spindle speed control changes when the cut increases in load or simply fluctuates under normal control. 5% is a recommended value for most spindles. Others may require slightly higher values of up to 10% if they are much older machines or alternate powered spindles such as air turbine driven spindles. This setting also limits the range that the Harmonizer can detect the actual speed from the input speed.

"Highest Stable Lobe" sets the number of the stable pockets that the Harmonizer will search. The higher the number the more speeds are searched. Higher numbers search in lower speed ranges. By setting the higher number more opportunities exist but the probability of a "stable" spindle speed being found is not dramatically increased because the higher lobe numbers (11 and higher) have smaller stable speed windows/ranges and make stabilization less likely for any given attempt. The setting should only be increased in situations where low cutting edges are used, like turning and single point boring where the lower lobe numbers (higher speeds) are generally not reachable within the upper spindle speed (e.g. max spindle speed).
"Signal Processing Window" is used to improve the signal quality and reduce noise and false positives. The only sacrifice is a slight loss of sensitivity to chatter. It is generally recommended that the Hann window (Enter 1) be utilized.

"Lobe Size (Maximum/Minimum)" adjusts the target range for the spindle speed selection algorithm. Setting each value to 1 forces the unit to make only one selection (e.g. no opportunity for subsequent attempts and the "too deep" message can result after just one attempt). Increasing the range "loosens" the algorithm and allows more iterations for difficult to regulate situations. The default values of 1.1 for maximum and 0.8 for minimum have been found to be optimal in most cases.

"FFT Length" and "FFT Stepover Amount (seconds)" controls the accuracy and responsiveness of the algorithm. Higher FFT values provide more precise spindle speed recommendations. The step-over amount affects the speed and sensitivity of the application. Smaller values will also improve the sensitivity of the system to short chatter bursts. Large FFT's and small step-overs improve performance, but both slow system operation and analysis time.
2.4 Other Functions including File Save

There are a few additional functions of the Pocket Harmonizer.

**PlayBack Function**

The most recent file recorded can be played back to verify what was recorded by clicking on SHIFT and then the number three (3) Key. This will play the sound through the PDA or PC speaker.

**Closing the Virtual Pocket Harmonizer**

Closing of the application is done by simply clicking on SHIFT twice.

**Saving Files**

Any file can be saved by pressing the Shift key and then the 6 key.

Once this is done a File Save Window will appear and the file can be named and saved. The file can be imported into the standard Harmonizer and analyzed further.
Part III
3 Example

Here is one example from a provided set of .wmv files. The cutting parameters are as follows.

- **Tool:** 4-Flute, 0.75 inch (19.05 mm) carbide end mill.
- **Holder:** Collet holder with maximum speed limit of 10 krpm
- **Material:** 7075-T6 aluminum
- **Machine:** High Speed Horizontal
- **Initial RPM:** 10,000 rpm
- **Top Speed:** 10,000 rpm
- **Feed:** 0.005”/tooth, 160 ipm (4064 mm/min)

The top machine speed was limited at 10 krpm as the holder was not balanced for a higher spindle speed. This was also the case for the first cutting trials which consisted of two slots.

Cutting Trial 1: Full Slot, 10,000 rpm, at 2 mm (0.080”) deep -- stable.

Cutting Trial 2: Same slot, 10,000 rpm, 4 mm (0.160”) deep -- chattered

The speed was changed per the recommendation below and the cut was increased again to the following depths.

Cutting Trial 3: New slot, 8,535 rpm programmed, 5 mm (0.200”) deep -- stable, chatter eliminated.

Cutting Trial 4: New slot, same speed, 8 mm (0.315”) -- stable

Cutting Trial 5: New slot, same speed, 10 mm (0.390”) -- stable

Cutting Trial 6: New slot, same speed, 12 mm (0.475”) -- marginally stable

CONCLUSION:
- **Initial Parameters:** 2 mm deep, 10,000 rpm
- **Final Parameters:** 10 mm deep, 8,535 rpm

This corresponds to over 300% in stable metal removal rate or consumed power.

Using the Example Cutting Videos
"Carbide End Mill Slotting Video 3 Harmonizer Chatter.wmv"
"Carbide End Mill Slotting Video 3 Harmonizer Stable.wmv"

We will enter the parameters as above.

First start the Pocket Harmonizer or VPH and press enter. Then on the Current Spindle Speed enter the current spindles speed of 10,000 rpm and press enter.
Next enter the maximum allowable speed. In this case it is 10,000 rpm as the holder is not rated above this speed and press enter.

Enter the number of effective cuttings edges and press Enter. The example is a 4 flute end mill and 4 edges should be entered, click on 4 and press enter.

Enter the desired recording length and press Enter. For this example a value of 2 seconds will be used. Click on 2 and press enter.

Enter 0 for the "Cutting" threshold method, this will skip over a background measurement. Press Enter.
The cut is now ready to be recorded. Place the microphone near the computer speaker and start the video. Just after the cutter enters the cut, click on enter. A sampling message will be displayed and then possibly an analyzing message. The end screen should report something similar as follows.

```
Pocket Harmonizer

9992RPM CHATTERED AT 2 FREQs!
New Spindle Speed: 8535rpm
Press ENTER...
```

In some cases the New Spindle Speed will be somewhat different because of the quality and tone of the speaker playback for the supplied video. Also, care should be taken when using the "Cutting" threshold to make sure that the recording does not contain a non-cutting signal, the user can press Play to listen to the recorded sound to make sure they captured the cutting noise.

After pressing Enter the next cut is ready to be started. The "stable" video is at the suggested speed mentioned above. The screen looks like this or will have a value within a couple hundred RPM. Start the stable video and record any of the cuts provided at 5 mm, 8mm, 10mm or 12mm. Again make sure that the recording contains only the cut and nothing else, by playing the recorded trial (click shift, and then the 3 "key").

```
Pocket Harmonizer

Run #2 Ready to record.
NEXT CUT AT 8535RPM
Press ENTER (or BACK)...```

Recording any of the cuts on the second video should result in the following screen.

```
Pocket Harmonizer

NO CHATTER FOUND AT 8498RPM
Press RESET or RESTART;
OR ENTER to try a deeper cut.
```

At this point the program can be run again at the given speed with deeper or higher feed rate cuts.
Note that since the "auto-tune" function is ON the spindle speed reported has been adjusted to best reflect what was detected by the video. It confirms that the speed the video is near input. For Cutting Trial 1 above the Harmonizer reported the first cut to be at 9992 rpm instead of the input 10,000 rpm and then for Cut Trial #2 it reported the actual speed from the video sound was 8,498 rpm then the suggested 8,535 rpm.

If the user wishes to try a completely different cutter than press SHIFT and the one (1) key for RESET. This will reset the entire algorithm. If the user wishes to just start with a new spindle speed but the same tool then press SHIFT and the four (4) key for RESTART and only the spindle speed will be changeable and then take the user right back to the recording step.

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**Pocket HARMONIZER**

Run #2 Ready to record.
NEXT CUT AT 8498 RPM
Press ENTER (or BACK)...

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Part IV
4 FAQ's

What is the effect of nearby machines?

Audio has a very logarithmic decay behavior. If there are other noisy machines then attempt to move as close as possible to the machine to be analyzed. If an external microphone is being used then point it so the other machines are behind the microphone.

I seem to always be getting 5 or more chatter frequencies regardless of what I am recording.

Check that the default audio setting is for the microphone that is being used. This is found in the Windows Multimedia Settings under the Audio tab. Also check that the microphone is active and is on.

After recording, check the sound recording by playing it back (click shift and then the 3 "key").

I have tried 5 different RPM's, and it still chatters?

It is most often a case where the cut is too aggressive and the depth of cut (DOC) is too large. Try reducing the DOC until the cut is stable, then gradually increase DOC until chatter occurs, then attempt regulation. The Harmonizer is design however to alert the user to this exact situation and advises a lower depth of cut.

How do I determine MAX Spindle Speed?

The highest that is recommended by the machine tool specification, tool holder limits, or tool speed based on Material Surface Speed limits.
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