1. What is Engine RPM?

Engine RPM is an app that measures the RPM of an engine using the sound produced by that engine. In particular, the pitch of the sound is what determines the calculated RPM.

The sound produced by an engine is complex and includes many harmonics. In addition, there is usually some extraneous noise mixed in with the engine sound, making the task of identifying the pitch more difficult. For these reasons, the Engine RPM program has a variety of settings and modes of operation designed to make the measurement process more reliable. At the very least, you must select an engine configuration (number of cylinders and 2-cycle or 4-cycle) that defines the relationship between pitch and RPM.

The main RPM display page looks like this. At the top in large numerals is the RPM. The RPM measurement is made continuously. The total measurement range is 130 RPM to 90,000 RPM. The page shown here is of the program in fixed hint band mode, which is described in more detail later. In this mode you specify a nominal RPM “hint” and a tolerance in percent. This directs the software to limit its search to the RPM range you specify. If the search range is not restricted, you may get a false reading in difficult cases.

The Log button displays a log of recent RPM measurements taken every two seconds. In that Log display you can also send the entire log out in an e-mail for later analysis or storage.

The display of RPM is shown in white if it is a reliable measurement. It is shown in blue if it is a questionable measurement, and shown in yellow when you are in the process of adjusting the tracking RPM, as described later.

The two blue bands shown here are adjustment controls that allow you to set the nominal RPM and the tolerance by swiping your finger left or right through those bands. The current setting of those two values is shown just above the blue bands.

Below the blue bands is shown the currently selected engine configuration. Below that is a graph that shows the autocorrelation function for the sound picked up by the microphone. You don’t have to understand what autocorrelation means to use the app. All you need to know is that the evenly-spaced peaks in this graph represent the periodic sound made by the engine. If the graph has clear peaks, like the one shown in this example, the sound is good enough to use. And if you see several yellow lines
that coincide perfectly with the first few peaks, the RPM reading is reliable. Otherwise the RPM reading will be “-----”. If evenly-spaced peaks are visible, but the yellow lines do not line up with them, the RPM range is probably set wrong. You should adjust the RPM range, as described later, until the yellow lines do line up with the peaks in the graph.

Above the left side of the graph is “Sample = 372 msec”. This tells how long the sample period is for each RPM measurement. On the Settings screen you can select different sample periods from 93 msec. to 2972 msec. (2.972 seconds). In general, the longer sample periods produce a more precise reading. However the engine sound may not be stable enough to use long sample periods, and so a shorter sample period may produce more reliable readings. If the RPM is changing while you are measuring it, use a shorter sample period. Also the very longest sample period is nearly three seconds, so the RPM reading will only be updated once every three seconds. Experiment to find out what works best for a particular situation.

Engine RPM also has an automatic mode in which no adjustments are necessary and the hint adjustment are removed from view. In automatic mode the RPM range is set to a fixed range of 750 RPM to 5000 RPM. This mode is convenient if it works. But having such a wide RPM range means it is more likely for the software to lock on to the wrong harmonic of the sound and report an RPM that is a multiple of the correct RPM. Keep this in mind if you use automatic mode.

If the RPM you want to measure is outside this range you cannot use automatic mode; use the fixed hint band instead. The fixed hint band can be adjusted to a range of ± 60% around some center RPM.

Whether the graph at the bottom of the screen shows autocorrelation or the frequency spectrum, you can adjust the upper range of the graph by sliding your finger left or right through the graph itself. The upper range of the graph is displayed on the right side above the graph. It is in milliseconds for the autocorrelation function and Hz for the frequency spectrum. The best setting for this display is when at least 6 – 15 peaks are visible in the graph. The actual setting of the range of this graph has no effect on the RPM calculation. It is only for your convenience when trying to interpret the graph. Otherwise don’t worry about the range setting of the graph.

For very low RPM measurements, there is a mode that generates a sound that you can manually match to the sound of the engine. This mode is described later in more detail.

At the bottom of the screen there is the Settings button, which looks like two gears. Tap on this button to switch to the Settings page, which is also described later.

2. How the program determines RPM

The data shown in the autocorrelation graph at the bottom of the screen is what the software uses to calculate the RPM. Peaks in this graph represent periods of repeating patterns in the sound waveform. The more repeating patterns the software finds, the clearer the peaks will be. If there are no peaks, the sound does not have an identifiable pitch, and RPM cannot be calculated. Since the peaks identify the period of the repeating pattern in the sound, the software can calculate the pitch of the sound from that information.
Regardless of how the fundamental pitch of the sound is determined, calculating the RPM requires one more step. That step is the conversion of the pitch in cycles per second to RPM based on engine configuration (the number of cylinders and whether a 2-cycle or 4-cycle). For example, suppose you select the 4-cycle 4-cylinder engine configuration, and that engine is running at 2400 RPM. We assume that the sound from the engine comes primarily from the exhaust strokes. Since each revolution of the engine crankshaft produces two exhaust strokes, the total number of exhaust strokes over any period of time is going to be twice the number of crankshaft revolutions. If the crankshaft speed is 2400 RPM, the sound will contain 4800 exhaust strokes per minute, which is 80 cycles of sound per second. Therefore the Engine RPM software will measure a primary pitch of 80 Hz. To convert 80 Hz to RPM the software multiplies by 60 (to convert from cycles per second to cycles per minute) then divides by the number of engine events per crankshaft cycle, which is 2 in this case. Therefore the Engine RPM app calculates:

\[ 80 \times 60 \div 2 = 2400 \text{ RPM} \]

and so it displays 2400.

3. Automatic mode

When it works, this is the easiest mode to use because there is nothing to adjust (although it is not the most reliable). All you have to do is select the engine configuration and the rest is automatic. However this mode does have some limitations. Automatic mode can only measure RPM in the range of 700 RPM to 5000 RPM. If you are expecting RPM lower or higher than this range then you should consider using fixed hint band mode as described in the next section. Another consideration when using automatic mode is that in some cases it might lock onto a harmonic of the engine sound. Therefore automatic mode should be used only when the engine sound is especially clear and the peaks in the autocorrelation graph are also clear. If the RPM reading does not seem reasonable or if the peaks in the autocorrelation graph are not clear and distinct, do not use automatic mode.

4. Fixed hint band mode

This is the most reliable mode of operation. In this mode you specify a nominal RPM and a tolerance in percent. For example, suppose you set the nominal hint RPM to 2100 and the tolerance to ±10%. That would establish an RPM range from 1890 RPM to 2310 RPM. As long as the actual RPM is in that range, the program has a chance of finding and displaying it. The tolerance can be set as high as 60%, however such a wide tolerance range should only be used for very clear engine sounds with very distinct peaks in the autocorrelation graph. If the situation is less than ideal, a wide tolerance range makes it more likely that the software will lock onto some harmonic of the engine sound rather than the fundamental pitch.

The fixed hint band mode is enabled by a switch on the Settings page. When that switch is turned off, the program operates in tracking mode.
5. Tracking mode

Tracking mode, as shown here, is enabled by turning off fixed hint band mode. In this mode, the program establishes a search range around the previous RPM reading. After the current reading is displayed, the search range will center around that reading, so the next reading will be restricted to be inside the revised search range. The effect of constantly recalculating the RPM search range based on the previous reading is to establish tracking behavior. The program can track gradual changes in the actual RPM, even if the actual RPM ultimately varies over the entire 130-90,000 RPM range.

In order to be effective, this mode must have a way of manually initializing the RPM close to the actual RPM. This is necessary when first getting started in this mode or when the actual RPM manages to move outside the tracking range. In tracking mode, the displayed RPM can be forced to any value by swiping through the blue band below the RPM display. When you do this, the displayed RPM turns yellow to warn you that it is not a calculated reading but is just a forced value that you are controlling. When you stop adjusting it, the displayed RPM turns white and once again represents the calculated RPM based on the search through the frequency spectrum.

When using tracking mode, you must force the displayed RPM to be within the tracking range of the actual RPM, based on your knowledge of the engine and what the approximate RPM should be. If you are not sure what the approximate RPM should be, then you can use the autocorrelation or spectrum display to help to decide how the displayed RPM should be adjusted. If you see that the peaks in the graph are not spaced the same as the yellow or red vertical lines, adjust the tracking RPM until they are spaced the same. You can tell when the program manages to lock onto the correct RPM when you see the yellow or red lines match up with the peaks in the graph.

In tracking mode, the width of the tracking range is determined by a setting that you adjust on the Settings page. That setting is indicated by “Track RPM X % per second.” You can set X to any value from 1% to 20%. For example, suppose you set it to 5% per second. Since the RPM readings are recalculated every 3/4 of a second, a change of 5% per second means a change of about 3.75% for each reading. So if the current reading is 2100 RPM, then the tracking range for the next reading will be from 2021 RPM to 2178 RPM. This range applies only to the very next reading. The one after that will have a tracking range that is centered around the next reading. A narrow tracking range can be used, provided you are ready to force the displayed RPM into the correct range if it should ever wander out of lock.
6. **Manual RPM Match mode**

Detecting the pitch of the sound of an engine is the most difficult when the RPM is very low. Sometimes our ears can hear a repeating pattern in the sound when software cannot find this pattern by analyzing the waveform. This is the case in the antique “hit-and-miss” very low speed engines. In this case you can use **Manual RPM Match mode**. In this mode the software generates a “ticking” sound at a known rate. You can adjust this rate by swiping through the blue adjustment bar. When the ticking sound matches the sound from engine, the resulting RPM can be read from the screen.

When this option is selected, the engine configuration works differently from the listening modes. With this option, the generated ticks are assumed to be one tick every other rev (for 4-stroke engines) or one tick every rev (for 2-stroke engines). The number of cylinders is ignored. If the engine configuration is an explicit "Events per rev", then that number will be taken as the number of generated ticks per revolution. (For example, 0.50 events per revolution would mean a 4-stroke engine.)

This mode works all the way down to 55 RPM. To use this method, listen to the engine for a while to get a sense of the rhythm of the sound. Then listen to the ticking sound generated by the software. Adjust the ticking rate until it sounds like the same rhythm as the engine. Finally, listen to both the engine and the software ticking sound together. Determine if the software ticks are falling behind or getting ahead of the engine sound. Make small adjustments accordingly in the software ticking until the engine and the generated sounds track together for as long as possible. When you have adjusted things as closely as possible, just read the RPM off the screen.

6. **The Settings page**

Tap on the Settings button shown here to see the Settings screen. On the settings screen you can select the engine type, the Sampling Period, tracking rate (in Tracking mode), and a variety of other options.

The picture on the left shows what the Settings screen looks like with all the options showing. In various modes, some of these options are irrelevant and so are hidden.

The question marks (?) are buttons that show detailed help for that particular line. The right-carets (▶) are buttons that lead to adjustments of the engine configuration or the tracking rate (in Tracking mode). We will consider these settings in the order they appear on the screen:

**Engine Configuration** must be selected to conform to the proper engine type (number of cylinders and two-stroke or four-stroke). Tap on the right-caret at the top to change the configuration. A new window will open showing the possible engine configurations.

When the **Automatic mode** switch is turned on, the display of several other options is hidden. See section 4 above to details on automatic mode. This mode can be convenient when it works, but it only works in limited situations.
When the fixed hint band switch is turned on, the software searches for the RPM over the range you specify, as described in section 4 above. This is generally the most reliable mode of operation, if the hint range is set properly.

When the envelope detection switch is turned on, the software processes the microphone signal by first detecting the points where the signal rises above the average volume level. These would be the peak bursts of sound that correspond to explosive events in the engine. So instead of trying to find a repeating pattern in each little wiggle in the sound waveform, the software looks for a repeating pattern in the overall rising and falling of the amplitude of the sound waveform – the so-called signal envelope. This option is not for most high or medium RPM measurements, but it can be of some use in measuring very low RPMs, in conjunction with a longer sample period. When measuring very low RPM, if the standard processing does not work, try envelope detection.

The Sample length slider is a control that you can use to select between five different sampling periods, ranging from 93 msec. to 2972 msec. As described earlier, the longer sample periods may be useful for low RPM and the shorter sample periods may be more useful for RPMs that are changing (not very stable). Also long sample periods result in less frequent RPM updates.

The Manual match RPM switch enables the mode where the software generates a ticking sound, as described in section 6 above. When this switch is turned on, all the other options except for engine configuration are hidden. This mode is for RPMs that are slow enough to count individual rotations.

7. Problems with RPM Measurement

There are some situations where the RPM is measured with great difficulty or not at all with the Engine RPM app. Here are some things to look out for.

- If sound is being produced by something besides the engine itself, this sound can interfere with the pitch detection and RPM calculation. These interfering sounds could be coming from the alternator, water pump, air conditioner, or any other attachment to the engine. For example, consider a riding lawnmower with belt drive to the blades. It is possible that the cutting blades can be making more noise than the engine. And since the blades are driven by belts, their RPM is not the same as the RPM of the engine. So the sounds made by the blades are at completely different frequencies from the engine sounds. Under these conditions the Engine RPM app will not be able to produce a reliable measurement, and the displayed measurement probably will be some random number. If possible, disengage the blades from the engine so only the engine is making a sound. Note that direct-drive lawnmower blades do not have this problem since they go around at exactly the same rate as the engine and so the sound they produce is at exactly the same pitch as the engine sounds.

- If engine sound is muffled then the sound may have no discernible pitch. For normal passenger cars with a muffler, you may not be able to get an RPM reading at all, except perhaps at higher RPMs, and then only if your muffler is leaking.
• If the actual RPM is outside the RPM search range of the software, the calculated RPM will not be correct. But you can use the autocorrelation graph to diagnose the problem and determine a more appropriate range. For instance, consider the autocorrelation graph shown here. The yellow lines that mark the detected peaks actually are marking every other peak. This means the software is finding a pitch that is half the true pitch, and so the displayed RPM is probably half of what it should be. Most likely the RPM search range has been set too low and the true RPM is double the RPM shown. In the example shown here, the real RPM is 5882, but that number is not within the search range of 3230 ±17%. So the software was able to find a match for only half of the correct RPM (2941). The remedy is to make a quick swipe through the adjustment band in order to raise the RPM search range to include the true RPM. Of course, this assumes you have set the engine configuration correctly. The example here specifies a 4-cycle 4-cylinder engine. But if the engine really is a 2-cycle 4-cylinder engine, then 3220 would actually be the correct RPM. In that case the solution is to correct the engine configuration selection.

• If the RPM changes rapidly, the pitch of the sound also will be changing. If that pitch is not constant over the sample period, the software will be unable to detect the pitch. This would be the case for a chainsaw or motorcycle, where rapid changes in RPM are common. When possible, keep the RPM of the engine constant while making a measurement, or select a shorter Sample Length in the Settings.

• If the autocorrelation graph does not look something like the ones shown in this manual with distinct peaks in the graph, the software will not be able to find the RPM. In general this means the sound is not very periodic. The software draws yellow lines to mark the peaks that it finds. If a peak is too low compared to other peaks, it is not counted. So the number of yellow lines is a measure of how good the peaks are. If you do not see lots of peaks with yellow lines on them, try improving the sound perhaps by moving the microphone to a better location until the display improves.

• If all else fails, try Manual match RPM mode. It always works if you can match the generated sound to the engine sound.

• It is possible to measure the RPM of an engine that is far away from where you are. For example, you can measure the RPM of a distant airplane engine since it usually is so loud. However, if the engine is moving toward you or away from you, remember that the Doppler Effect will distort the pitch of the sound. If you are trying to measure the RPM of an airplane engine that is flying overhead, the RPM reading will be inaccurate, unless the airplane is moving perpendicular to you (neither toward you nor away from you).
8. RPM Logging

As the Engine RPM app displays RPM, it also logs the displayed RPM every two seconds. You can see that log by tapping on the Log button in the upper left of the screen. The Log looks like this:

You can scroll through all the recent readings. They are time-stamped from the oldest logged reading. If a reading was displayed in blue on the main screen, that reading will be displayed here in the log with a question mark (?) after it, to indicate that it was a questionable reading.

If you tap the action button in the upper right, you can chose to do one of the following:

1. Reset RPM Log (start over with no logged readings)
2. Send Log by e-mail
3. Reverse log order

That last option allows to you view the log entries from newest to oldest, or from oldest to newest. The e-mail option constructs a message using your built-in e-mailer on your device. You specify the destination address, and you can even add comments to the message before you send it.