Identifying different types of gyrocopter vibrations.

I find that when I talk to people about frequency analysis and vibrations at different frequencies, their eyes glaze over and I can see that I've lost them. I know this feeling, it’s like when somebody explains to me how simple it is to update my computer, my eyes glaze over and they might as well be talking Chinese.

I will try to explain.

In my experience with European gyros, mostly tandems, there are four vibrations that are usually dominant.

1. **1/rev or synchronous** at about 6 hz or 360 rpm. This vibration is mainly due to unbalance or tracking or both. These vibrations can be reduced by balancing and tracking either statically or dynamically.
   The simplest way to simulate a 1/rev vibration is to take a bottle of ketchup and shake it as fast as you can (make sure the top is screwed on). That is 5 to 6 hz. Most guys will find this motion quite natural; they don't even need a bottle of ketchup. So if the stick and/or cockpit are shaking at a frequency that you can simulate by shaking a bottle of ketchup its 1/rev and your excitation is due to imbalance, tracking or alignment.

2. **2/rev vibration** at about 12 hz or 720 rpm. These vibrations are usually due to five potential causes.

   a) Rotating drag, or the difference in drag between when the rotor is at 3-9 o’clock and 12–6 o’clock. This is inherent in all 2 bladed Bensen type rotors. Proposed solutions (or rather methods to reduce) include slider roll pivots and “limber” masts.

   b) In-plane resonance. The in-plane (or xylophone) natural frequency of the rotor is about 6 hz which is the same as the rotor rpm and this creates a 2/rev (yes surprisingly) vibration. In my opinion this probably isn’t applicable to all of our gyros because while we experience high (in my opinion) 2/rev vibrations I don’t think they are high enough to be true resonance. The published examples I know of are Chuck Beaty’s gyro and the video of the early Bell helicopters. In both cases the pilots reported that the machines were unflyable. While most eurogyros have high 2/rev vibrations I wouldn’t say they were unflyable. I would guess that we are near the natural frequency but probably not on it. Solutions are stiffer in plane rotors, slider roll pivots and “limber” masts.

   c) Inertia around the spanwise blade to blade C of G axis. Due to the fact that the blade tip plane is not perpendicular to the rotor bearing axis there is a 2/rev moment at the teeter bolt acting in the bearing shaft. With an optimum undersling the 2/rev vibration caused by this moment is minimised but there is always some. Incorrect undersling (either too large or too small) increases the moment of inertia around the spanwise axis and increases the resulting 2/rev vibration. The best solution is to optimise undersling.

   d) High friction in teeter bearings. This is seldom a problem on Eurogyros because they usually use needle or roller teeter bearings (except AutoGyro). This could be a problem if these bearings were badly corroded and started to seize up. This problem seems to be more common with smaller gyros with teeter bushings rather than bearings.

   e) Tail heavy rotor blades. A blade that is heavily under balanced chordwise will have a cyclic twisting motion as it rotates causing a 2/rev vibration.

3. **Prop unbalance**. This is usually about 33 hz or 2000 rpm. A prop with mismatched blade pitch will also tend to create a 1/rev vibration at prop rotational frequency.

4. **Chassis component resonance.** It is not unusual to find certain structures that have a natural frequency at, or very close to, the rotor or propeller frequencies or one of their harmonics to be excited by the rotor or prop and transmit through the fuselage a vibration at that frequency. This is usually felt as cockpit shake rather than stick shake.

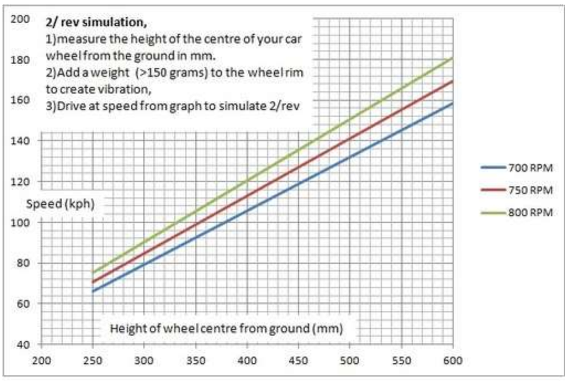
Typically the 2/rev is dominant, the 1/rev is more uncomfortable and the prop needs to really bad (it sometimes happens) before it is worse than the other two. Component resonance can be very uncomfortable for the pilot and even destructive.

With the exception of perhaps undersling there's almost nothing the average owner can do to change any of these causes.
Another simple and cheap way to find the major excitation frequency is with a portable telephone. Jukka Trevamaki suggested it with an i phone and I've used a free app (https://play.google.com/store/apps/d...ovalyzer&hl=en) on my Android phone in the past and have recently discovered a better one called "Vibration Isolator Pro" that allows you to capture the spectrum to look at it later . If you strap it to the stick you can quickly see the peak frequencies at which the stick vibrates.

A simple method to simulate 2/rev is to measure the height of the centre of your car wheel from the ground.

Get some tyre balance weights, you'll need a lot. I had to put 130 grams (4.5 ounces) on mine to get a decent vibration. Stick them on the inside of the rim so that centrifugal force will help keep them in place.

Find a smooth bit of straight road and drive at the speed from the graph that corresponds to 2 times your rotor rpm.



The vibration you feel will be your 2/rev vibration. Get used to what it feels like and then go fly after shaking a bottle of ketchup.

Another method that was suggested to me is to take a wet towel and put it in your spin dryer. Set the speed for as near to 700 rpm as possible, start the dryer and sit on it. This will give you a good simulation of 2/rev cabin/cockpit shake.

This should help you decide if you need to find someone with a balancer or not.

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