Mr. Milkovic's two-stage oscillator as a parametric oscillator

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Purpose

In this document I will show that Mr. Milkovic's two stage oscillator may be viewed as a damped parametric oscillator, and that pumping of energy from the driving, swinging pendulum is not a precedent in the world of physics, but rather, an expected effect due to a well-known phenomenon called parametric excitation, parametric resonance or parametric pumping. Consequently, a ready-set of modeling tools should be applicable to properly model the device.

A brief introduction to parametric resonance

Let it be sufficient to say that since 1883, when Lord Rayleigh published his paper "On maintained vibrations", Philosophical Magazine, vol. 15, pages 229-235, a body of research has been produced on the topic of parametric resonance. Ironically, most of it has been dealing with how to prevent instability in mechanical systems and electric circuits. The latest research around parametric resonance is visible in many scientific disciplines, from biology to quantum physics, pointing to the fact that parametric resonance is an often encountered and yet to be fully understood and utilized natural phenomenon.

Now let's review some well known definitions related to parametric resonance and oscillators. The statements in items 1 through 4 are taken verbatim from Wikipedia's pages on harmonic and parametric oscillators.

1. "A parametric oscillator is a simple harmonic oscillator whose parameters (its resonance frequency w and damping ß) vary in time. Another intuitive way of understanding a parametric oscillator is as follows: a parametric oscillator is a device that oscillates when one of its "parameters" (a physical entity, like capacitance) is changed."

2. “Remarkably, if the parameters vary at roughly twice the natural frequency of the oscillator, the oscillator phase-locks to the parametric variation and absorbs energy at a rate proportional to the energy it already has. Without a compensating energy-loss mechanism, the oscillation amplitude grows exponentially. (This phenomenon is called parametric excitation, parametric resonance or parametric pumping.) However, if the initial amplitude is zero, it will remain so; this distinguishes it from the non-parametric resonance of driven simple harmonic oscillators, in which the amplitude grows linearly in time regardless of the initial state.”

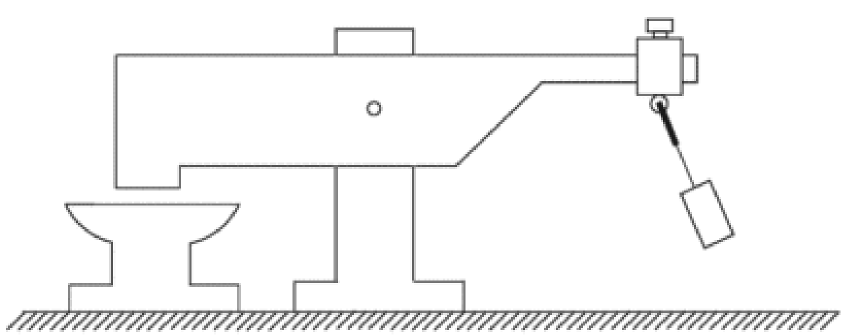
3. Capacitance in a parallel RLC electric circuit is equivalent to mass in a translational mechanical system, or to moment of inertia in a rotational system.

NOTE: A familiar experience of parametric oscillation is playing on a swing. By alternately raising and lowering their center of mass (and thereby changing their moment of inertia, and thus the resonance frequency) at key points in the swing, children can quickly reach large amplitudes provided that they have some amplitude to start with (e.g., get a push). Doing so at rest, however, goes nowhere.

4. "The problem of the simple harmonic oscillator occurs frequently in physics because a mass at equilibrium under the influence of any conservative force, in the limit of small motions, will behave as a simple harmonic oscillator. A conservative force is one that has a potential energy function.”

NOTE: For example, G force acting on a pendulum is considered a conservative force.

Mr. Milkovic’s Two-Stage Oscillator



This seemingly simple device shown in the picture below consists of a lever with a free-swinging pendulum on one side and a counter-weight on the other side of the lever. For detailed claims by Mr. Milkovic and his associates regarding the device, including the COP of 12 claim, please go to http://www.veljkomilkovic.com/indexEng.htm.

I will not attempt to prove any of those claims, but I will discuss a mechanism employed in the inner workings of the device that should:

- point to the legitimacy of those claims.
- point to design parameters required for a successful construction of the device.

Mr. Milkovic's invention should be viewed as a five -component system: the lever, the lever's fulcrum, the pendulum, the pendulum's fulcrum, and finally the counter-weight (not shown in the picture above as a separate component).

A key to understanding the device is in the overlooked motion of the pendulum's fulcrum. Since the pendulum's fulcrum is attached to the lever, its motion describes an arc, in other words, has both vertical and horizontal components to its movement. Thus, the pendulum in Mr. Milkovic's invention can be viewed as a hybrid, vertically-driven and horizontally-driven pendulum.

Vertically-driven pendulums and horizontally-driven pendulums are classes of pendulums in their own right, exhibiting two important effects of non-linear dynamics, namely, instability and bifurcation. Vertically driven pendulums are also typical examples of parametric resonance/excitation/pumping, which has already been rehashed in the literature. See Mr. Franz-Josef Elmer's on-line lab at http://monet.physik.unibas.ch/~elmer/pendulum for simulations on driven/forced pendulums.

In general, uncontrolled instability in parametric resonance leads to pumping of energy into the system from "seemingly nowhere", and ultimately chaos – breakdown of both mechanical and electrical devices. While engineers have been trying to get rid of these anomalies, from architecture to RLC circuits, Mr. Milkovic found a way to elegantly employ the phenomenon. What is happening in Mr. Milkovic's device is neither ordinary resonance nor harmonic oscillations due to the pendulum fulcrum's displacement along the arc. Rather, it is this controlled, bounded instability of the vertically and horizontally driven pendulum that's the root cause of the unusual features of the device.

Small vertical and horizontal displacements of the pendulum's fulcrum turn this non-linear oscillator into a driven pendulum, that is, into a parametric oscillator. Floquet, Hill, and Mathieu are the names to be looked up for those who want to model parametric oscillators. It is worth mentioning that their differential equations are first cousins to Schrodinger's equations, perhaps leading one to wonder if an unifying principle is involved.

So, how do all of these things come together in Mr. Milkovic's invention?

Based on what we know about parametric resonance, if the moment of inertia (let's simplify it a bit and call it weight) of the (driving) pendulum is being changed at the frequency twice that of the whole lever system, the lever system should phase-lock to the parametric variation and, according to the principle of parametric resonance, absorb energy proportional to the energy it already has. A lever system comprised of a pendulum on one side and a counter-weight on the other side may be viewed as a parametric oscillator, as long as we can show that the pendulum varies its physical property twice per one oscillation of the lever.

The weight of the driving pendulum in this device is indeed being varied at twice the frequency of the lever. When the counter-weight is in its top position, the pendulum has maximum speed and maximum weight. When the counter-weight is in the bottom position, the pendulum is in a top position, and has zero weight. That's half of the cycle. For the whole cycle of the counter-weight (and the lever), starting in the top position, going down, and back up again to its (relative) starting position, the pendulum weight varied in two extremes -> from max weight to zero weight (1), and then back from 0 weight to max weight (2). Thus for one cycle of the lever, the driving pendulum's weight changed twice, as required per 2 above. By symmetry, both the vertical and horizontal displacements of the pendulum by the lever are also in the parametric 2:1 ratio: for two full oscillations of the lever, there are two half-oscillations or one full oscillation of the pendulum around its pivot.

Thus, the two stage oscillator fulfills the requirements for parametric excitation/resonance, in other words – parametric pumping. And with parametric pumping, all bets are off–exponentially. See 2. above.

Since there is a compensating energy loss mechanism in Mr. Milkovic's device, the oscillation amplitude of the pendulum and consequently the oscillation amplitude of the overall lever system does not grow exponentially, but stays bounded and phase locked with the pendulum's change in weight as it travels through the G field. While the lever and the counter-weight are seeking its (potential) equilibrium in the G field, and can not find it at rest due to the pendulum's motion and constantly changing weight, they, together, keep looking for balance in an oscillating motion. At the same time, the resonantly moving, vertically driven pendulum mass in the G field is pumping energy into the lever system. It is important to realize that it is the lever system (with the moving pendulum and the counter-weight) that's responsible for moving of the pendulum's pivot. When the counter-weight is moving down, the pendulum's pivot is being forced up by the surplus weight on the counter-weight side (left side) via the lever. The fact that the pendulum is also getting "lighter" in this phase also contributes to the surplus of weight on the left side of the lever. When the counter-weight is moving up, the surplus weight from the rotationally moving pendulum is responsible for the pendulum's pivot moving downward. Again, it is not the pendulum's individual motion that's causing its pivot to move downward. Rather it is the imbalance of weights in the lever that's causing it. Thus, one can say that the pendulum is being "driven" by an outside mechanism/force.

So where is this claimed extra energy coming from? Look at 2. above: PARAMETRIC PUMPING. One could argue that the initial energy required to lift and start the pendulum is being reapplied to the system via pendulum's constantly changing moment of inertia exhibited during its half-rotation around its fulcrum.

The reason for having to slightly push the pendulum when the system is doing actual work is damping caused by a load, the overall system's air resistance, as well as the fulcrums' friction, which, all put together, tend to push the system out of parametric resonance. By keeping the pendulum moving, the instability of the system is maintained, and therefore its ability to continuously provide the mechanical advantage of a lever.

I propose that Mr. Milkovic's invention belongs in a new category of devices called "Double-(fulcrum)-Bounded Parametric Oscillators."