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Vamp Torquer System

Stevan Nikolic, M.Sc.E.E.
Leading R&D Associate in Innovative Center of Faculty of Mechanical Engineering, Belgrade University.
Corresponding Author: Stevan Nikolic

Abstract: *The paper presents a downstream of VAMP (Virtual Angular Momentum Precession) system implementation in so-called VAMP torquer system. Basically the system physics are the same as described in the paper under title "Gyro VAMP Propulsion System"[1] only different gyro modules are used (rotators instead of gyros). The main features of the said system are: self-exiting, ease output torque regulation, no energy consumption in off-state indicating numerous advantages for particular applications. Practical application shall be explain in so called torque converter where input rotation should be coupled with driving object enabling smooth and steady input-output linkage. Coupling between input and output shaft shall be performed through platform where rotator modules are spaced and phase shifted to fit the purpose. A simple example is given as an illustration. The Control system requires appropriate computer hardware & software designed for particular application.*

Keywords: *Angular Momentum, Gyro dynamics, Virtual Angular Momentum Precession, torque propulsion*

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I. INTRODUCTION

A basic configuration of the so-called rotator module is shown in the Fig 1. As shown in the Fig.1 the rotator has three principal axis i.e. x, y & z and defined as specific configuration of the rigid body [3,4]. Although rotation about axis y is considered as no sense the focus on that particular case shall be paid. Namely, the main aim of this approach is to have rotating angular momentum (AM) generated as an active element enabling further consideration of the system performance based on VAMP technology [1,2].

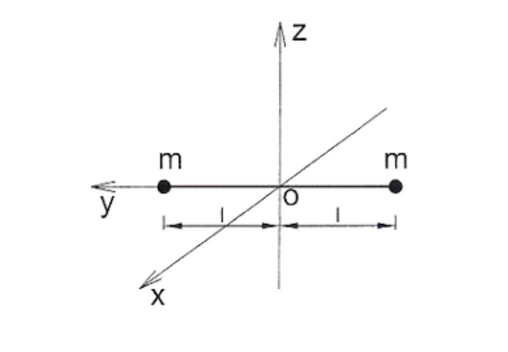

Fig. 1 - Rotator

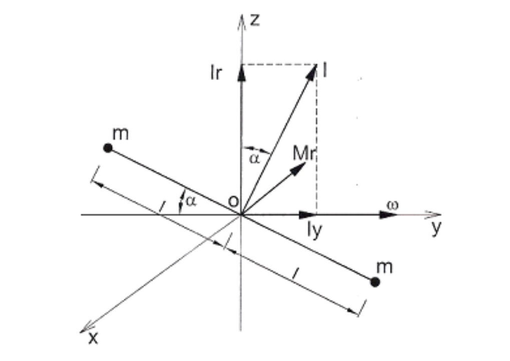

Fig. 2 - Exited rotator

II. BASIC CONSIDERATION

The Fig. 2 shows what would be the case if so called an excitation takes place i.e. shifting the rotator axis for an angle α. It gives the following:

$$I = 2ml^2 \omega \sin\alpha \qquad (1)$$

The AM ***I*** has two components e.g. along the y axis and rotating one in the plane orthogonal over the axis y:

$I_y = 2ml^2\omega \sin^2\alpha$ (2a)	$I_r = 2ml^2\omega \sin\alpha\cos\alpha$ (2b)

followed by a torque M_r displaced by $\pi/2$ in the same rotating plane: $M_r = 2ml^2\omega^2 \sin\alpha\cos\alpha$ (2c).
For small excitation angle $\underline{\alpha}$ the above formula (2b) and (2c) can be written as:

$I_r = 2ml^2\omega\cdot\alpha$ (3a)	$M_r = 2ml^2\omega^2\cdot\alpha$ (3b).

It is interesting to mention that in terms of analogy or similarity between mechanical vs electro-mechanical systems (such as torque is analogous to current, angular speed to voltage etc) a displacing angle is analogous to magnetic flux (something like excitation) [5].
Once produced rotating AM followed by torque than the next step is implementation of VAMP technology to configure the system. By using n identical rotator modules spaced by $2\pi/n$ in the platform plane and phase shifted by $-2(k-1)\pi/n$ $(k=1,2,..,.n)$, than the system becomes as shown in the Fig. 3. For the sake of simplicity n=3 and only rotator 1 is shown. It is assumed that all rotators are identical, rotating with the same angular speed $\underline{\omega}$ and all rotating axis are intersecting in fixed point O. It is obvious that the resultant vectors of the system would be [1,2]:

- Rotating AM in the platform plane P of the intensity equal to $n/2 * I_r$ and
- Rotating torque following the resultant AM in the same plane (displaced by $\pi/2$) of the intensity equal to $n/2 * M_r$.

The platform plane is denoted as P having two degree of freedom enabled by two gimbals G_1 and G_2.

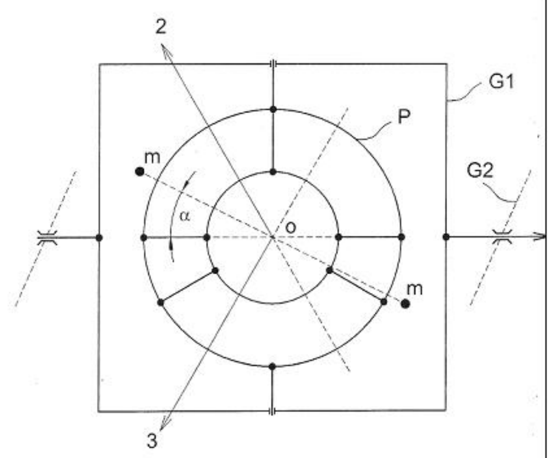

Fig. 3 - Polyphase VAMP configuration

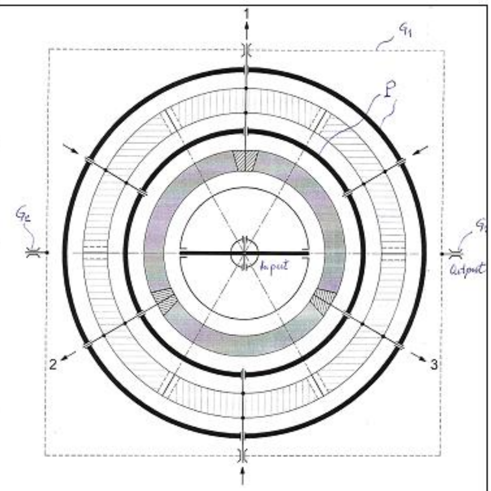

Fig. 4 - Three phase arrangement

The resultant AM arbitrarily positioned in the plane P can be treated as a composite gyro having similar properties as the dual DC motor model [1]. That means if any torque applied to the platform P the system will react as per well-known gyro properties. The said torque can be arbitrarily positioned in the space having two components i.e. in the plane P and perpendicular over it. Both components will generate adequate reaction of the AM.

If each individual rotator rotates with angular speed $\underline{\omega}$ in directions of axis denoted as 1, 2 & 3 than resultant AM and torque will rotate in the plane P by the same angular speed following the sequence of 1, 2 & 3 (indicating rotator phase shifting sequence). To bring the resultant AM in stable position (steady state) than the gimbal G_2 should rotate in opposite direction to sequence 1, 2 & 3 with the same angular speed $\underline{\omega}$. It is clear that only steady AM will exist while all torques in the system will be compensated. By other words the structure of the platform plane will be stressed by generated torques mutually compensated (in the plane P and along the axis perpendicular to P).

Owing to the AM conservation law the system will keep steady state itself. That means the system will react to any disturbance of the steady state regardless either to decelerate or accelerate the gimbals G_2 acting as system output (system input are rotating axis 1, 2 & 3 of rotators).

Let us assume that a torque M_{out} is applied along the output axis z (perpendicular to plane P). If the M_{out} decelerates the output G_2 than resultant AM will slip in direction 1, 2 & 3 what would generate reacting torque displace by π/2 causing platform P to precess. The angular velocity of precession Ω will depend on the following relation:

$\Omega \times \frac{n}{2} I_r = M_{out}$ (4a)	$\Omega \times \frac{3}{2} I_r = M_{out}$ (4b)

Since the platform P is rotating by angular speed ω than precession Ω will produce a deflection angle Ψ of the P with amplitude Ω/ω. Precession Ω will also generate an opposite torque to input axis drive 1, 2 & 3 causing deceleration of input angular speed demanding more input power for the system. If input angular speed is kept constant than load torque is transmitted to the input by the system conversion i.e. input power equal to output power (losses neglected). The more load torque the more slippage of AM will be exerted. The previously said indicates that the system performance is propulsion similar to induction AC motor.

III. PRACTICAL APPLICATION

The following example will be an illustration of the previously discussed. The Fig. 4 shows a so-called VAMP torquer system (platform) applied between primary mover and driving unit as a coupling device.
Input shaft (perpendicular to the drawing plane) is arranged with cross linkage with driving gear over input pinions 1, 2 & 3. The three phase rotator arrangement is obtained with six toothed wheel placed in the frame P (platform). Platform P is placed in two gimbals G_1 & G_2 where gimbal G_2 is co-linear with input shaft acting as output. If there is no load over the output than by rotating the input shaft the resultant AM will be placed arbitrarily in the plane P (after reaching a steady state).
For the purpose of practical calculation the following values are assumed:

m=0.1 kg l=0.1 m; α=π/6 rad;	ω=100π rad/s (input shaft driving angular speed); n=3:1 (input gear vs pinions ratio); ω_0=ω*n/(n+1)=0.75 ω (rotator angular speed, no load); max ω_0=n*ω=3*ω (in case of G2 is stuck);

By using formula in relations (2) & (3) the following is obtained in steady state:

$$I_r = \frac{\sqrt{3}}{2} \cdot 0.1 \cdot 0.01 \cdot 0.75 \cdot 100\pi = \sqrt{3} \cdot \frac{1}{2} \cdot 0.75 \cdot \pi / 10 \text{ kgm}^2/\text{s} \qquad (5a)$$

Thus, composite AM is:

$$I_{rr} = \frac{3}{2} \cdot I_r \approx 0.3 \text{ kgm}^2/\text{s} \qquad (5b)$$

In steady state stressing torques over platform P are balanced and amount cca

$$M_{rr} = I_{rr} \cdot 0.75 \cdot 100\pi \approx 72 \text{ Nm} \qquad (5c)$$

Furthermore, in steady state the input shaft is rotating with angular speed of 100π, input angular speed of rotators is 75π, output angular speed of gimbal G_2 is prox the same (no load torque across output shaft). In reality there will be certain slippage due to resistance and friction in the system. The slippage of G_2 will be in direction of 1-2-3 with fraction of rotator angular speed (prox 0.5-1 %).
If load torque of 1 Nm is applied than the system response will be precession of the platform P with

$\Omega = M_{out}/I_{rr} = 1:0.3 = 3.33$ rad/s (6a)

producing an amplitude of platform deflection of

Ψ=Ω/(0.75*100π)=3.33/(0.75*100π)=0.014 rad (6b).

The precession Ω is rotating in the plane P with angular speed $\omega - \omega^1$, where ω is synchronous RPM and ω^1 RPM close to ω i.e. Ω is slipping in sequence 1-2-3 (similar to induction motor current frequency in rotor).
It is possible to calculate max output torque. Namely, if defection angle Ψ is limited to π/12 than Ω will be cca 60 rad/s yielding M~ 0.3*60=18 Nm. Basic practical configuration of VAMP Torquer system is shown in Fig. 5. The Figure 4 shows arrangement of items 4 & 5 in the Fig. 5.

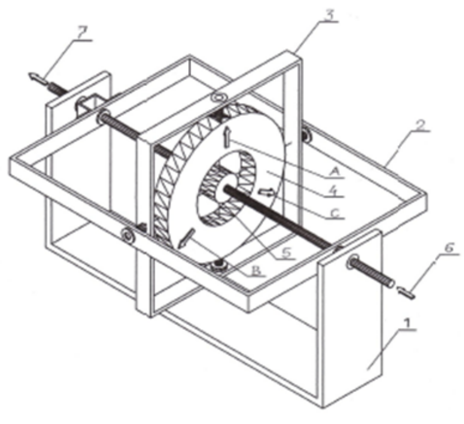

FIG. 5, Basic Configuration of VAMP Torquer

Items in the Fig. 5 are explained below:

1. Supporting frame
2. Outer gimbal
3. Inner gimbal
4. Integrating platform
5. Inner cross coupling
6. Input shaft
7. Output shaft

IV. DISCUSSION & CONCLUSION

The main intention of this paper is to introduce one specific approach of a mechanical power propulsion system based on gyro properties of rigid bodies. By using the patented VAMP system the authors tried to explain main properties of the so called VAMP torquer suitable for power transmission in various applications. The real-time control system anticipates application of an appropriate computer both hardware & software capable to handle the VAMP torquer excitation control and output performance as well. The said is supposed to be onward attempts in order to enable potential users of the system in their particular application.

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