# FREQUENTLY CONTROLLED VIBRATORY ELECTRIC DRIVE'S STATIC STABILITY CONDITION

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**Abstract –**
For electromagnetic vibration exciters (EMVE) using in test desks of radio technical and telecommunication devices, working on resonance mode with frequency changer (FC), simulator, where EMVE and FC are concerned as a few interrelated resonance circuits is suggested. In addition, Variable speed drives (VSDs), and Variable Speed Drive with Optional Starter cases were studied and analyzed. In addition, steering wheel position and yaw velocity information were used to assess lateral stability and Sine-coded PWM Waveform instruments were tested.

**Key words**: electromagnetic vibration exciters (EMVE), frequency changer (FC), Variable Speed Drive with Optional Starter cases, FWIA electric vehicles, Sine-coded PWM Waveform instruments, Mechanical characteristics of motor and mechanism.

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## Introduction

The Action Strategy for the further development of the Republic of Uzbekistan for 2017-2021 sets tasks, including " the introduction of knowledge and communication technologies within the economy, social sphere, management, expanding the coverage of networks of mobile operators". First, RSS allows lateral dynamics system of the vehicle to be inherently unstable to reinforce overall structure design flexibility. Three FWIA electric vehicles (a racecar, a railcar, and a military vehicle) are shown to demonstrate the advantage of RSS. By applying the RSS, the configuration flexibilities of the battery pack location of those vehicles are improved by 95.4%, 167% and 20%, respectively. Second, the closed-looped handling stability may well be improved by yaw moment control through the pole assignment technique. The target pole's positions of closed-looped lateral dynamics system are selected in keeping with va

rious performance requirements. Four cases of target pole locations are given as examples to indicate the principle of choosing the target pole locations for various type vehicles. A pole assignment controller is meant with the consideration of the parametric uncertainties caused by tire nonlinear behavior. Finally, an FWIA electric vehicle, which is constructed by the authors, is employed as testbed to indicate the good thing about the RSS. The experiments in step steer and sine steer conditions prove the efficiency and robustness of the controller, in addition because the convenience of adjusting target pole locations per various performance requirements.

## Variable Speed Drives

Variable speed drives (VSDs), also called adjustable speed drives (ASDs), are devices that may vary the speed of a normally fixed speed motor. In HVAC systems, they're used primarily to regulate fans in variable air volume systems rather than other devices like inlet vanes and discharge dampers. Variable speed drives are more energy efficient than these other devices (their main advantage), but they also reduce noise generation at part-load, allow fans to control at much lower loads without causing the fan to work in surge (an unstable condition which will lead to violent pulsations and possibly cause damage to the fan), and reduce decline mechanical components like belts and bearings. Variable speed drives are wont to control pumps on variable flow pumping systems and to manage refrigeration compressors in centrifugal chillers.

Many types of variable speed drives are used over the years, starting with dc drives used primarily in industrial applications, and mechanical drives that varied sheave diameter. one amongst the foremost important developments in recent years has been the advancement of variable frequency drive (VFD) technology. These drives use solid-state electronic circuitry to regulate the frequency and voltage of the ability to the motor, which successively varies the speed.

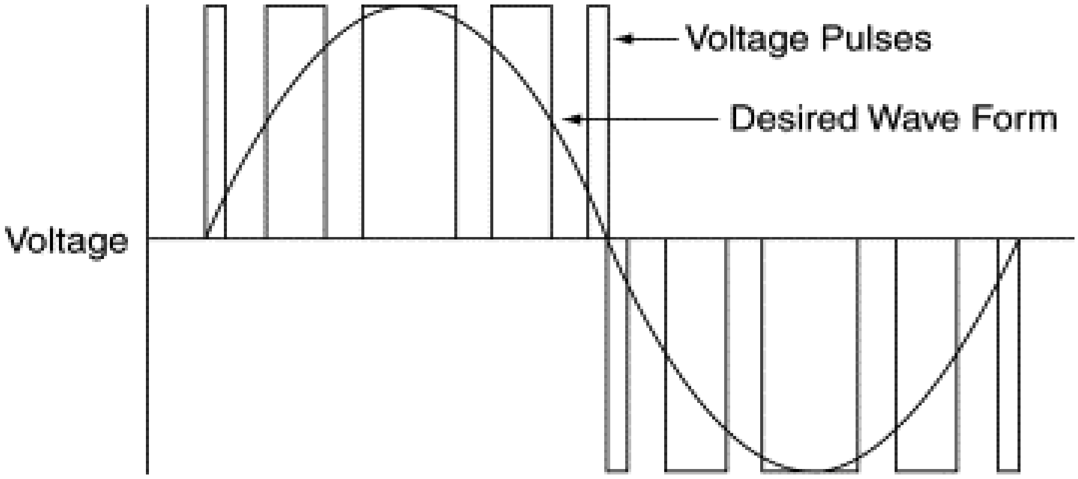

Figure 1. Sine-coded PWM Waveform

Do you remember earlier within the chapter once we noted that after we measure the voltage and current in a very pure sinewave ac circuit we are measuring the rms value? In most situations, being clear about rms doesn't matter because the waveform is near a sinewave. As you'll see in Figure 1 the waveform isn't a sinewave. a typical meter may read substantially high or low during this nonsinewave situation. With the output of a VFD it really matters that you just use a meter designed to offer you "true rms" readings. Meters are sold as "true rms" meters and are more costly than those which require actuality sinewave input.

Variable speed drives (VSDs) take the place of a starter. they need both starting capability and overload protection in-built. In fact, the microprocessor controls in most drives provide additional protection against other faults (such as under-voltage, over-voltage, ground-fault, loss of phase, etc.). Variable speed drives also provide for soft-start of the motor (if so programmed), reducing in-rush current and reducing go down belts and sheaves (Figure 2).

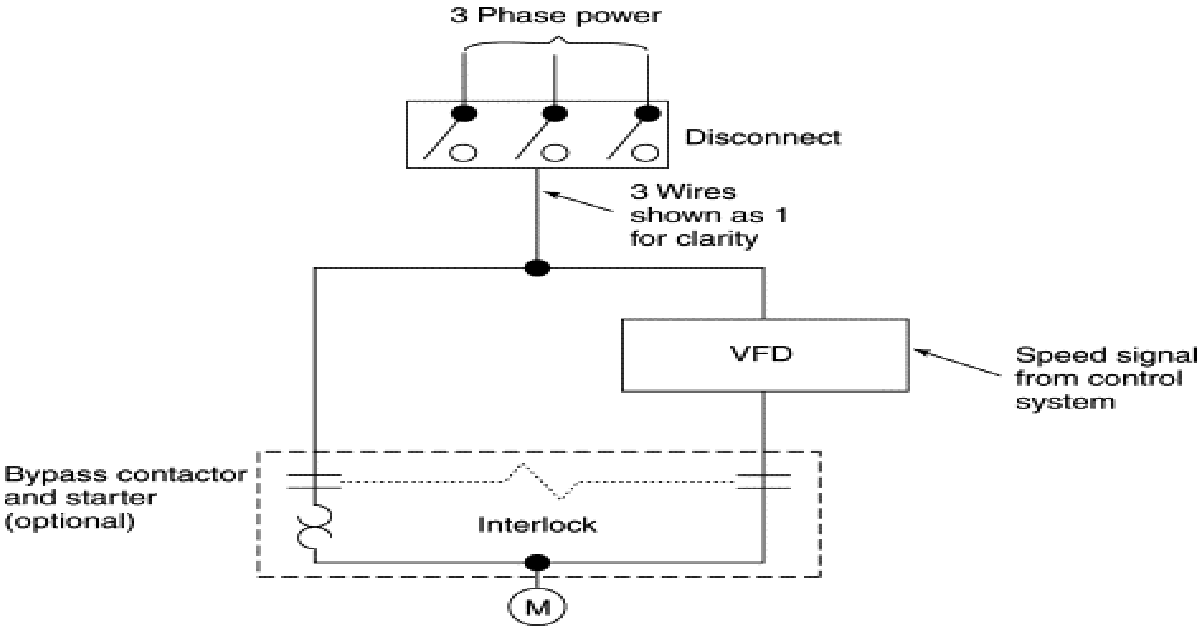

**Figure 2. Variable Speed Drive with Optional Starter**

### Main components of a VSD unit

Basics of variable speed drive operation A VSD unit receives alternating voltage from the facility supply at a continuing (usually 60 Hz) frequency, internally rectifies this to an on the spot voltage, then synthesizes an alternating voltage of any frequency at its output; output current fluctuates in keeping with the load on the unit. Connecting the device between the ability system and also the pumping unit's causal agent, motor speed, and, consequently, pumping speed are often changed at will within a reasonably broad range. VSD units have the subsequent three basic components (see Fig. 3):

1.the rectifier section converts the 60 Hz AC voltage into a DC voltage,

2. the DC control section provides a smooth DC waveform to the following section, and

3.the inverter section creates an AC voltage at a particular frequency, simulating a wave.

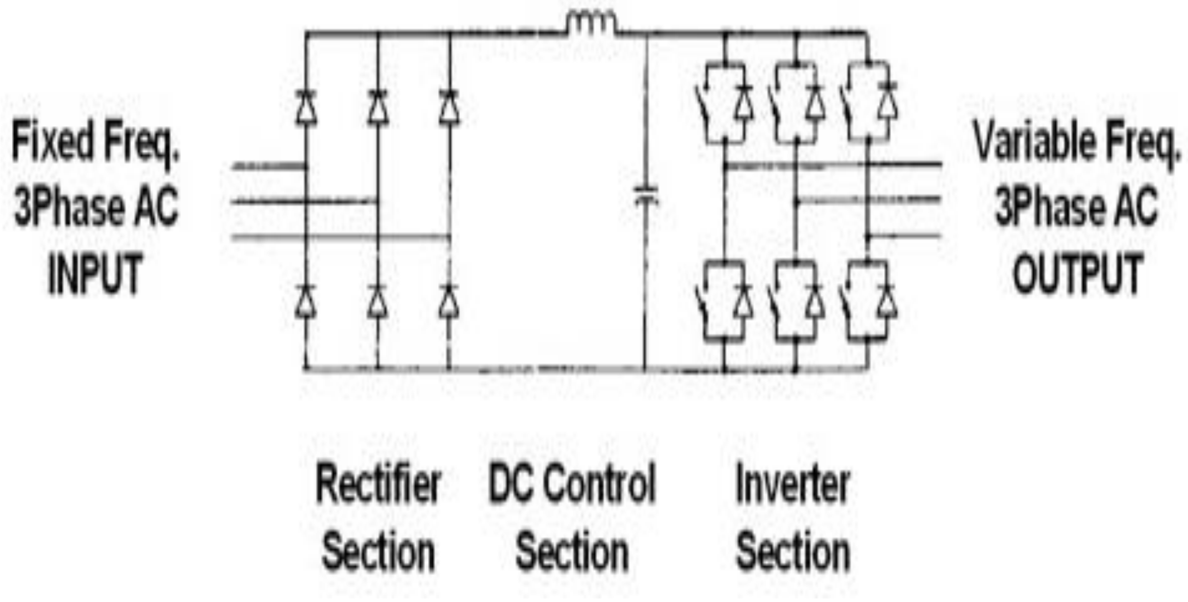

**Figure 3. Main components of a VSD unit.**

**Static drive versus fluid coupling**

Variable-speed drives are essential for several industrial applications requiring variable operating parameters during the course of operation. Such variations may be within the flow of fluid and pressure of air or gas etc. the traditional method of throttle control through a vane or a damper causes a substantial waste of energy. to get a variable speed and yet save on energy, one can use either a static drive as discussed earlier or a variable speed fluid coupling (Fug. 4)

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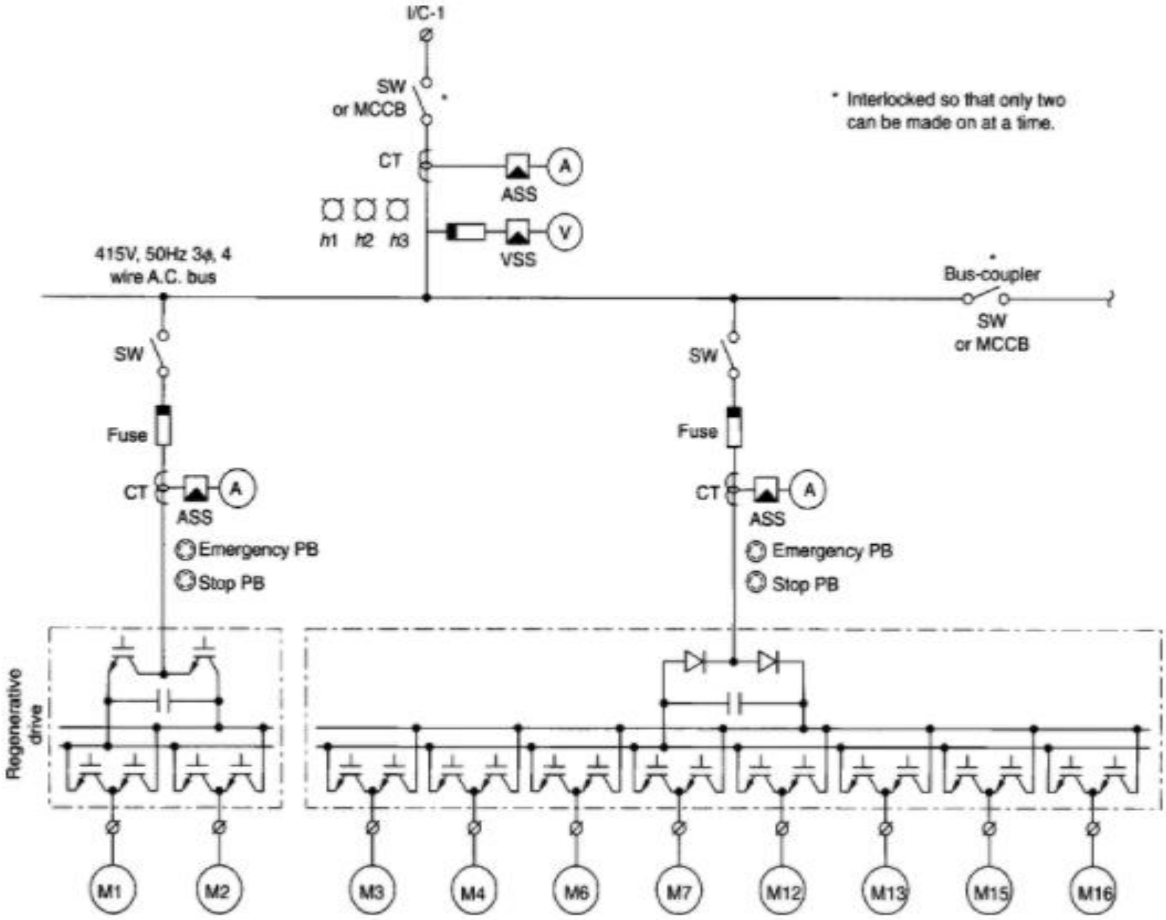

**Figure 4. Static drive versus fluid coupling**

In theory of electric drives, it's assumed to consider the drive's typical load in which static resisting moment of actuating mechanism Mc is a monotonic function engine speed ω. So, working zone of drive's static mechanical characteristic M(ω) intersects actuating mechanism's mechanical characteristic just in one point. For that reason, if it's demanded to fulfill condition of static stability

$$\frac{dM}{d\omega} < \frac{dMc}{d\omega} , \qquad (1)$$

it's also demanded for drive to fulfill this condition, in which working zone M(ω) (i.e. drive's linearized mechanical characteristic) acting as a dropping characteristic. Thus, in static mode "long-period stability" succeed, and it's not demanded special requirements for mechanical characteristic's rigidity [1].

In prevalent inertial vibratory electric drive (VED) with restoring force and open-loop system of tuning control to resonant mode Mc(ω) is nonmonotonic function with extremal behavior (curves 1 and 2 in fig. 1) [2]:

Mc (ω) = M C.B.H. (ω/ ωH)2 + (2)

k – constant; and ω0 parameters of vibrating system; ω – working body vibration frequency that equals rotary rotations per minute; M C.B.H. – ventilation component of resisting moment when nominal frequent is ωH ; curves 1 and 2 on figure are constructed for vibrational test machine BM-175 by (2) for different load values are the same.

In case of frequency transit by increasing ω above resonance zone Mc (ω) is static unstable and this mode named Sommerfeld effect [1, 2]. So, when VED with induction motor (IM) which tuned to above resonance mode with natural resonant frequency ω01 operates, static mode that defined as interception point B of resistance static moment (curve 1 on figure) and static electromagnetic moment of IM (curve 3) is mistaken assuming as long-period stability since fulfilment of condition (1). While load is increasing, natural resonant frequency also increasing from ω01 to ω02 and then Mc (ω) defined as curve 2. If to support in above resonant mode by IM parametric control method it's possible to support only soft working zone M (ω) of motor (curve 4), then it crosses Mc (ω) in three points and system will not be stable. Because of such major difference Mc (ω) from typical loads it's necessary to search and define new conditions, which complete condition (1) of VED static stability.

## Steering wheel position and yaw velocity information used to assess lateral stability

The aim of this work is defining additional conditions of frequency-controlled resonant VED static stability. For that it's necessary to define first cause of controlled VED's unstable work in general, and on the above resonant zone in particular.

Static mode will be stable in point A (fig. 5), if while oscillation caused infinitesimal deviation of frequency dω from static ωA, the system tend to initial state. Therefore, if in the neighborhood of a static equilibrium point A infinitesimal increment ωA ω originates, it's necessary to have dynamic moment's infinitesimal increment dMj, with sign opposite to dω. Then dynamic moments equilibrium equation is

$$M(\omega, t) – M_c(\omega, t) = J\,\frac{d\omega}{dt}\,.$$

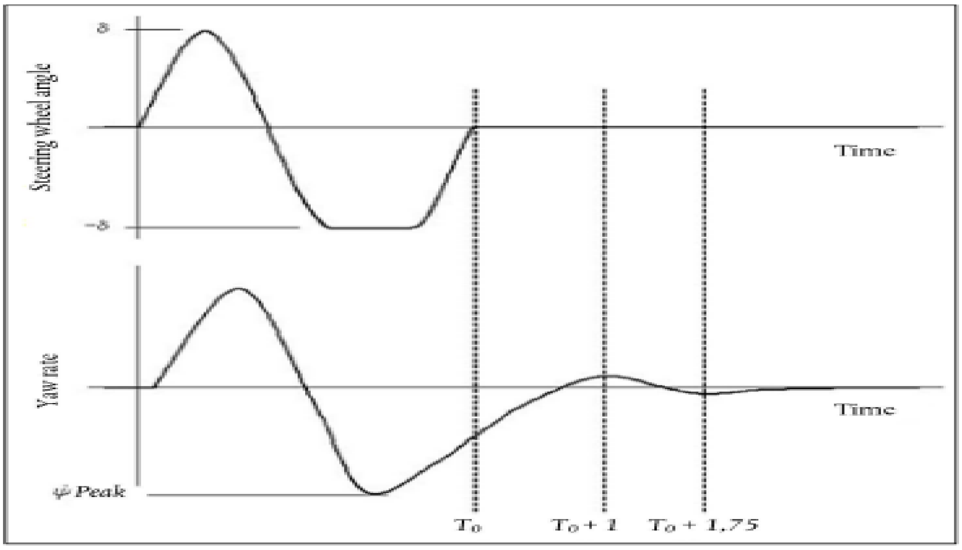

**Figure 5. Steering wheel position and yaw velocity information used to assess lateral stability Mechanical characteristics of motor and mechanism**

Where a vehicle has been physically tested in accordance with paragraph 8, the compliance of versions or variants of that same vehicle type may be demonstrated by a computer simulation, which respects the test conditions of paragraph 8 and the test procedure of paragraph 9.9. The use of the simulator is defined in Annex 4 to this Regulation. The yaw rate measured 1 second after completion of the Sine with Dwell steering input (time T0 + 1 in Figure 1) shall not exceed 35 per cent of the first peak value of yaw rate recorded after the steering wheel angle changes sign (between first and second peaks) ( in Figure 6) during the same test run.

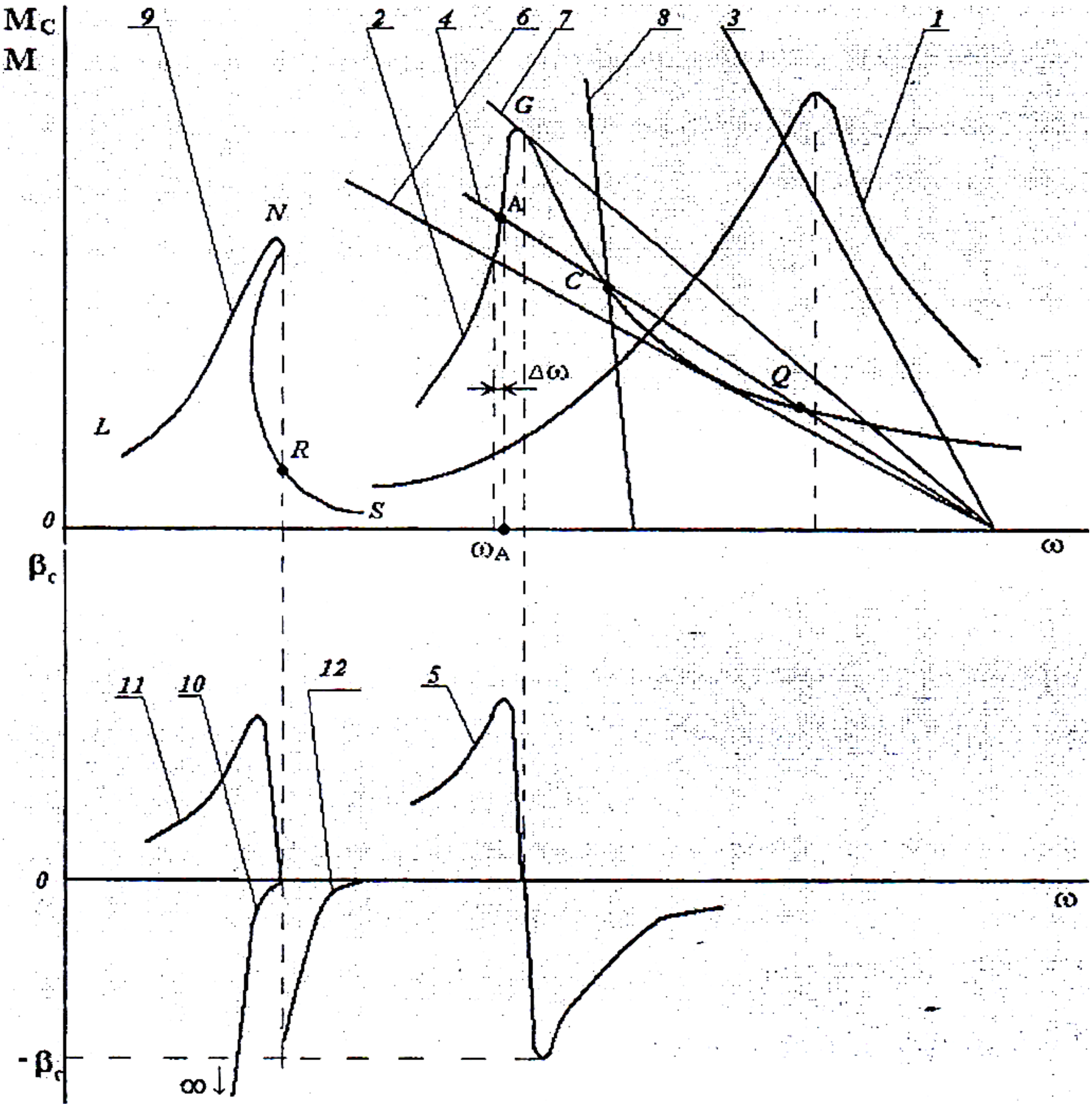

**Figure 6. Mechanical characteristics of motor and mechanism**

By the stability condition when dynamic moment increases:

$$d\left[M(\omega,t) - M_c(\omega,t)\right] = -Sign(d\omega)\cdot\left|dM_\partial\right|$$

или

$$\left.\frac{\partial M}{\partial\omega}\right|_{(\omega_A+d\omega)} d\omega + \left.\frac{\partial M}{\partial t}\right|_{(\omega_A+d\omega)} dt - \left.\frac{\partial M_C}{\partial\omega}\right|_{(\omega_A+d\omega)} d\omega + \left.\frac{\partial M_C}{\partial t}\right|_{(\omega_A+d\omega)} dt =$$

$$= -Sign(d\omega)\cdot\left|dM_\partial\right|. \qquad (3)$$

Often in electric drives dynamic modes instead of motor dynamic moments M (ω, t) and manufacturing mechanism Mc (ω, t), static characteristics are accepted [1]. Considering such simplification, regarding that dynamic and mechanic characteristics are identical to static, expression (3) can be written as:

$$\left\{ \frac{dM}{d\omega}\bigg|_{(\omega_A + d\omega)} - \frac{dM_C}{d\omega}\bigg|_{(\omega_A + d\omega)} \right.$$

Target condition of stability through mechanic characteristics hardness is:

$$\beta\,\big|_{\omega_A + d\omega} - \beta_C\,\big|_{(\omega_A + d\omega)} < 0 .$$

From dependence ⍰ c = f(ω) that constructed through differentiation (2) (curve 5), implies that in VED with linear restoring forces above resonant zone has negative So for motors with soft M (ω), that located between lines 6 and 7, zones GCQ are static instability zone.

In contrast to electric drives with typical load in VED working zone M (ω) can cross Mc (ω) in several points. Points A, G and Q that fulfill condition (1) are static short-period stable, point C – unstable. When M (ω) is more hard (line 8), point C that fulfill conditions (1) and (4), previously has been in instable zones of GCQ, becomes static long-period stable.

We can see that in working area M (ω) (curve 8) crosses M c(ω) just in one point and this can be used as additional static stability condition. Therefore, for static long-period stability at whole scale ω it's necessary to use condition (4) with additional motor hardness requirements ⍰

$$-\infty \le \beta < \beta_{c.\min} ,$$

c. min defines from function (2):

$$\beta_{c.\min} = \frac{0{,}44\,k}{(\omega^2 + 440\,\rho^2}$$

So, in VED with linear restoring forces Sommerfeld effect appears only when conditions (5) and (6) doesn't fulfill to motor mechanic characteristics hardness.

In VED with nonlinear restoring forces expression (2) becomes more complicate [4] and Mc (ω) gets the curve 9, as in a figure. As hardness ⍰ c is not a continuous function (curves 10, 11 and 12), fulfilling the conditions (5) and (6) at whole scale ω is impossible. Therefore, zones Mc (ω) LN and RS for degressive M(ω) of motor are short-period stable, and zone NR is instable. So Sommerfeld effect takes place in zone Mc (ω) NR.

So, in VED with linear restoring forces, in contrast to electric drives with typical loads, to achieve static long-period stability it's necessary to fulfill requirements (5) and (6) to condition (1), supplying the Mc (ω) crosses working zone M (ω) just in one point. In this case Sommerfeld effect is absent.

## References

1. Klyuchev V.I. Electric drive theory. -M.: Energoatomizdat, 1985. -560 p.
2. Kononenko V.O. Mechanic systems nonlinear oscillations. -Kyiv.: Naukova dumka, 1980. -384 p.
3. Driesen J. Electric vehicle charging integration. In: IECON 2013–39th Annualconference of the IEEE industrial electronics society. Vienna, Austria; 2013.
4. Craig B. Smith and Kelly E. Parmenter Energy Management Principles. Book • Second Edition 2016 https://www.sciencedirect.com/book/9780128025062/energy-management-principles
5. Ehsani M, Gao Y, Gay SE, Emadi A. Modern electric, hybrid electric, and fuel cellvehicles: fundamentals, theory, and design. Taylor & Francis; 2005.
6. Murata S. Innovation by in-wheel motor drive unit. Veh Syst Dyn2012;50(6):807–30.
7. Geng C, Mostefai L, Denai M, Hori Y. Direct yaw-moment control of an in-wheel-motored electric vehicle based on body slip angle fuzzy observer. IEEETrans Indust Electron 2009;56(5):1411–9.
8. Shibahata Y, Shimada K, Tomari T. Improvement of vehicle maneuverability

bydirect yaw moment control. Veh Syst Dyn 1993;22(5–6):465–81.

9. Kim D, Kim C, Kim S, Choi J, Han C. Development of adaptive direct yaw-moment control method for electric vehicle based on identification of yaw-rate model. In: IEEE intelligent vehicles symposium; 2011.

10. Sawase K, Ushiroda Y, Miura T. Left-right torque vectoring technology as thecore of super all wheel control (S-AWC). Mitsub Mot Tech Rev 2006;18:16–23.

11. Graf M, Lienkamp M. Torque vectoring control design based on objectivedriving dynamic parameters. In: FISITA 2012 world automotive congress, 27–30 November 2012. Beijing, China.

12. Dinora Baratova, Khayrullo Khasanov, Ikromjon Musakhonzoda, Shokhruh Abdumuratov and Khusniddin Uktamov. The impact of the coronavirus pandemic on the insurance market of Uzbekistan and ways to develop funded life insurance. E3S Web of Conferences **296**, 06028 (2021). https://www.e3sconferences.org/articles/e3sconf/abs/2021/72/e3sconf_esmgt2021_06028/e3sconf_esmgt2021_06028.html

13. Alikul Nomozovich Rakhmonov, Jamshid Sharafetdinovich Tukhtabaev, Alisher Xudayberdievich Eshbaev, Khusniddin Fakhriddinovich Uktamov, Barno Ramizitdinovna Tillaeva, Dilafruz Baymamatovna Taylakova, Bekzod Abduraxmanovich Shukurov, Magomed Abduaxat og'li Saidov. Economic And Legal System Of Elections And Characteristics Of Electoral Legislation In Germany. International Journal of Aquatic Science ISSN: 2008-8019 Vol 12, Issue 02, 2021. http://www.journal-aquaticscience.com/article_134719.html

14. Uktamov Kh. F. and act. Improving the Use of Islamic Banking Services in Financing Investment Projects in Uktamov Kh. F. Uzbekistan. REVISTA GEINTEC-GESTAO INOVACAO E TECNOLOGIAS (Management, Innovation and Technologies) Journal. Vol. 11 No. 2 (2021). http://www.revistageintec.net/index.php/revista/article/view/1869

15. Umarov, A.Z., Razikov, O. T., Shukurov, A. K., Zainiddinov, F. A. U., Akbarova, Z. T., & Uktamov, K.F. (2021). MINERALOLOGICAL PROPERTIES OF MINERAL RESOURCES DEVELOPMENT AND KYZYLALMASAY RADIATION (EASTERN UZBEKISTAN). Review of International Geographical Education Online, 11(10), 1105-1115.