Advances in Transdisciplinary Engineering series

Volume 79

Advances in Machinery, Materials Science and Engineering Application XI

Proceedings of the 11th International Conference (MMSE 2025), Paris, France, 25–27 July 2025

EDITED BY
Jun Ma
Rachid Masrour
Antonio Gloria
Kaige Wang
Sanjay M R

IOS Press

ADVANCES IN MACHINERY, MATERIALS SCIENCE AND ENGINEERING APPLICATION XI

Advances in Transdisciplinary Engineering

Transdisciplinary engineering is the exchange of knowledge about product, process, organization, or social environment in the context of innovation. The ATDE book series aims to explore the evolution of engineering, and promote transdisciplinary practices, in which the exchange of different types of knowledge from a diverse range of disciplines is fundamental. The series focuses on international collaboration and providing high-level contributions to the internationally available literature on the theme of the conference.

Volume 79

Recently published in this series

Vol. 78. Y.-W. Chen and R. Li (Eds.), Imaging, Signal Processing and Communications – Proceedings of the 9th International Conference (ICISPC 2025), Osaka, Japan, 11-13 July 2025

Vol. 77. Z. Wang (Ed.), Computer and Electrical Engineering – Proceedings of the 18th International Conference on Computer and Electrical Engineering (ICCEE 2025), Singapore, 20-22 June 2025

Vol. 76. F. Trigos, C.-J. Chou and J. Stjepandić (Eds.), Transdisciplinarity for a Better World – Proceedings of the 32nd International Society of Transdisciplinary Engineering (ISTE) Global Conference, Monterrey, Nuevo Leon, Mexico, 7-11 July 2025

Vol. 75. L. Trajković, S.S. Agaian, D. Avola and J. He (Eds.), Image Processing, Electronics and Computers – Proceedings of the 6th Asia-Pacific Conference (IPEC 2025), Dalian, China, 16-18 May 2025

Vol. 74. L. Trajković, G. Zhang, X. Yu, C.-Y. Su, M. Paprzycki and S.S. Agaian (Eds.), Machine Intelligence and Digital Applications – Proceedings of the 2nd International Conference (MIDA 2025), Ningbo, China, 18-20 April 2025

Vol. 73. F. Lumban Gaol, Y. Xu and Y. Dessouky (Eds.), Management Science and Industrial Engineering – Proceedings of the 7th International Conference (MSIE 2025), Bali Island, Indonesia, 24-26 April 2025

ISSN 2352-751X (print)
ISSN 2352-7528 (online)

Advances in Machinery, Materials Science and Engineering Application XI

Proceedings of the 11th International Conference (MMSE 2025),
Paris, France, 25–27 July 2025

Edited by

Jun Ma
University of South Australia, Australia

Rachid Masrour
Faculty of Sciences Dhar El Mahraz, Sidi Mohamed Ben Abdellah University, Fez, Morocco

Antonio Gloria
University of Naples Federico II, Italy

Kaige Wang
Institute of Photonics and Photonic Technology, Northwestern University, China

and

Sanjay M R
King Mongkut's University of Technology North Bangkok, Thailand

Sage | IOS Press

ISBN 978-1-64368-628-8 (online)
doi: 10.3233/ATDE79

IOS Press

A Sage company
Nieuwe Hemweg 6B
1013 BG Amsterdam

Sage
1 Oliver's Yard
55 City Road
London EC1Y 1SP

Sage
2455 Teller Road
Thousand Oaks
California 91320

Sage
Unit No 323-333, Third Floor, F-Block
International Trade Tower
Nehru Place, New Delhi – 110 019

Sage
8 Marina View Suite 43-053
Asia Square Tower 1
Singapore 018960

Foreword

The 11th International Conference on Advances in Machinery, Material Science and Engineering Application (MMSE 2025) is the premier international conference in the fields of mechanical engineering, material science and engineering application. This volume includes all papers accepted for presentation at the MMSE 2025 Conference, which was held in Paris, France, from 25 to 27 July. MMSE 2025 is organized by ISAE-SUPMECA, France and Wuhan University, China, co-sponsored by Wuhan University of Science and Technology, China; Huazhong University of Sciences and Technology, China; Wuhan University of Technology, China; China University of Geosciences (Wuhan), China; Wuhan Textile University, China; National University of Singapore, Singapore; Portland State University, USA; Washington University-St. Louis, USA; University of Reims Champagne-Ardenne, France; George Mason University, USA; Laboratoire Quartz, France, and the Institute of Materials, Minerals and Mining (IOM3), UK, among others.

The conference aims to bring together faculty members, leading scientists, academicians, research and graduate scholars, industry professionals, and decision-makers to discuss the latest developments, applications, advanced technologies, and processes in mechanical engineering and advanced materials, with particular focus on the interdisciplinary applications.

The two-day conference in Paris consisted of keynote speeches, scientific presentations, poster presentations and technical discussions. The proceedings of the conference contains 117 high-quality papers selected from 292 submissions, including international contributions from Asia and Europe, representing an acceptance rate of approximately 40%.

The accepted papers highlight the latest developments and research trends from a wide range of disciplines within the scope of the conference, and cover a broad range of topics, including mechanical design; advanced manufacturing technology; applied mechanics; fatigue and creep of materials; corrosion; coatings; electrical power; electronic techniques; energy storage; automation and control system design; robots; shock and vibration; simulation and modeling; machine vision; object detection; failure analysis; chemical engineering; marine engineering; structural engineering; electro-optical technology; autonomous driving technology; and emerging industrial applications and interdisciplinary technology. All contributions were subjected to a rigorous peer review process to ensure academic rigor innovation, and a contribution to the advancement of knowledge.

We would like to express our sincere gratitude to the conference chairs: Prof. Emin Bayraktar, ISAE-SUPMECA/Paris, France; Prof. Seeram Ramakrishna, National University of Singapore, Singapore and Prof. Ephraim Suhir, Life Fellow of IEEE, ASME, SPIE, IMAPS, Fellow of APS, IoP (UK) and SPE and Associate Fellow of AIAA, Portland State University, USA, for their dedication in making this MMSE 2025 a success.

We would also like to express our sincere gratitude to our keynote speakers: Prof. Yaohua Zhu, Hong Kong Polytechnic University, China, Prof. Yunfeng Liu, Zhejiang University of Technology, China, Prof. Weiguo Li, College of Aerospace Engineering, Chongqing University, China, Prof. Raul Duarte Salgueiral Gomes Campilho, ISEP – School of Engineering, Portugal, Prof. Michael Todinov, Oxford Brookes University, UK, who joined us to present and share their latest findings. Thanks are also due to the MMSE reviewers, authors, and others who contributed to the success of the conference. We appreciate the support and assistance provided by all committee members throughout the event. MMSE 2025 is also indebted to IOS Press for their assistance and support in the publication of this volume.

Finally, on behalf of this MMSE 2025 Committee, and indeed the whole MMSE team, we would like to express our sincere appreciation to all authors and participants for their contributions. We believe that this MMSE 2025 proceedings will serve as an important archival reference for researchers and practitioners in the field. The next 12th International Conference on Advances in Machinery, Material Science and Engineering Application (MMSE 2026) will be held in Wuhan, China, hosted by Huazhong University of Sciences and Technology, China from 26 to 27 July 2026, and we look forward to seeing you in Wuhan next year.

Emin Bayraktar
ISAE-SUPMECA/Paris
27 July 2025

About the Conference

Conference Name
2025 11th International Conference on Advances in Machinery, Materials Science and Engineering Application (MMSE2025)
Conference Location: Paris, France
Date: 25–27 July 2025

Peer Review Statement
Number of submissions: 292
Number of accepted papers: 117
Acceptance rate: 40%

Conference Organization

Conference Chairs
Emin Bayraktar, ISAE-SUPMECA/Paris
Seeram Ramakrishna, National University of Singapore, Singapore
Ephraim Suhir, Life Fellow of IEEE, ASME, SPIE, IMAPS, Fellow of APS, IoP (UK) and SPE and Associate Fellow of AIAA, Portland State University, USA

Co-Chairs
Roberto Zivieri, University of Messina, Italy
Ghenadii Korotcenkov, Department of Physics and Engineering, Moldova State University, Rep. of Moldova
Hongwei Wu, University of Hertfordshire, UK
Rezia Maria Molfino, University of Genova, President of SIRI (Italian Association of Robotics and Automation), Italy

Program Chairs
Shengyi Yang, Beijing Key Lab of Nanophonics and Ultrafine Optoelectronic Systems, Beijing Institute of Technology, China
Qiang Xu, University of Hudersfield, UK
Vladislav Deev, Russian Academy of Natural Sciences, Vladimir State University, Russia
Jun Xu, Xi’an Jiaotong University, China

Editors
Jun Ma, University of South Australia, Australia
Rachid Masrour, Faculty of Sciences Dhar El Mahraz, Sidi Mohamed Ben Abdellah University, Fez, Morocco
Antonio Gloria, University of Naples, Federico II, Italy
Kaige Wang, Institute of Photonics and Photonic Technology, Northwestern University, China
Sanjay M R, King Mongkut’s University of Technology North Bangkok, Thailand

International Committee Members

Xiaolong Wang, State Key Laboratory of Solid Lubrication, Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences, China
Mohd Faizul Mohd Sabri, Universiti Malaya, Malaysia
Brahim Ben Fathallah, University of Tunis El Manar, Tunis
Zafar Khan Ghouri, Teesside University, UK
Martín Enrique Durán García, Departamento de Tecnología Industrial, Universidad Simón Bolívar, Venezuela
Radchenko Andrey, Institute of Strength Physics and Materials Science of the Siberian Branch of the Russian Academy of Sciences, Tomsk State University, Russia
Fateh Mebarek-Oudina, Faculty of Sciences, University of 20 Août 1955-Skikda, Algeria
Sampan Rittidech, Faculty of Engineering, Mahasarakham University, Thailand
Sergei Alexandrov, Ishlinsky Institute for Problems in Mechanics, Russian Academy of Sciences, Russia
Han-Ki Kim, Sungkyunkwan University, Korea
Shaik Zainuddin, Department of Materials Science and Engineering, Tuskegee University, USA
Yunfeng Liu, Zhejiang University of Technology, China
Jiyong Hu, Donghua University, China
Guanglei Wu, Dalian University of Technology, China
Weiguo Li, College of Aerospace Engineering, Chongqing University, China
Li Zheng, Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, China
Y. Al-Douri, University of Malaya, Malaysia
Noé Cheung, University of Campinas – UNICAMP, Brazil
Saad A. EL-Syaed Hamad, Zagazig University, Egypt
Doğuş ÖZKAN, Turkish Naval Academy of National Defence University, Turkey
Yigit Karpat, Dept. of Industrial Engineering, Bilkent University, Turkey
Jintendra Nath Roy, Department of Physics, Kazi Nazrul University, India
Ali Kandil, Egypt-Japan University of Science and Technology (E-JUST), Egypt
Soula Mohamed, École Nationale des Ingénieurs de Tunis, Tunis
Anukorn Phuruangrat, Prince of Songkla University, Thailand
Abdelaziz M. Aboraia,Al-Azhar University, Egypt
Yarusova Sofya, Russian Academy of Sciences, Russia
Gang Jian, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, China
Evgeny S. Prusov, Vladimir State University, Russia
Ke Wang, Southern University of Science and Technology, China
Victor Yakovlevich Zyryanov, Kirensky Institute of Physics, Siberian Branch of Russian Academy of Sciences, Russia
Shimaa El-Hadad, Central Metallurgical R&D Institute Cairo, Egypt
Guanglei Wu, Dalian University of Technology, China
Yuansheng Wang, Fujian Institute of Research on the Structure of Matter, Chinese Academy of Sciences, China
Alokesh Pramanik, Department of Mechanical Engineering, Curtin University, Australia
Nataliya Kazantseva, Ural State University of Railway Transport, Russia
Ionelia Voiculescu, University Politehnica of Bucharest, Romania

Contents

Section 1

Mechanical Engineering and Manufacturing Technology

Advances in Machinery, Materials Science and Engineering Application XI
J. Ma et al. (Eds.)

doi:10.3233/ATDE251029

The Negative Derivative Feedback Controller Tuning for Vibration Suppression

Volodymyr PUZYROV [a,b], Nataliya LOSYEVA [a,b], Nina SAVCHENKO [c,1] and Daria TERMENZHY [d]
[a] *Universidad de Barcelona, Spain*
[b] *Nizhyn Mykola Gogol State University, Ukraine*
[c] *National Aerospace University, Ukraine*
[d] *State Tax University, Ukraine*

Abstract. This paper investigates the problem of suppressing vibrations induced by external harmonic excitation using a Negative Derivative Feedback Controller (NDFC). The relevance of this topic is driven by the growing demand for improved vibration control in lightweight and highly flexible engineering structures, which are increasingly used in aerospace, mechanical, and civil applications. Such structures are particularly sensitive to resonance phenomena due to their low inherent damping, leading to performance degradation and potential failure. A simplified single-degree-of-freedom (DoF) model of the main structure with an attached NDFC is considered. Two independent analytical procedures for tuning the controller are proposed, aimed at ensuring effective vibration mitigation. These procedures allow for a straightforward identification of optimal regions in the parameter space, particularly with respect to damping and cut-off frequency. The use of the NDFC provides an efficient means for passive vibration suppression. Numerical simulations confirm the effectiveness of the proposed methods and demonstrate good agreement with analytical predictions. The results contribute to the advancement of vibration control strategies, offering a practical and computationally accessible approach for enhancing the dynamic performance of flexible structures.

Keywords. Negative derivative feedback controller, stability, frequency-amplitude dependence, peak responses

1. Introduction

Industrial developments in recent decades have increased the requirements for vibration control, especially for lightweight and highly flexible structures [1,2]. The main problem with such systems is the rise of oscillations amplitude in the vicinity of resonant frequencies, mainly due to the low damping coefficient associated with the first structural modes. It may lead to a degradation of system performance and cause disruptions and breakdowns. One of the fruitful ideas to prevent such hazard was proposed by Fanson and Caughey [3] which suggests that the displacement is fed back with a positive sign

[1] Nina SAVCHENKO, Corresponding author, National Aerospace University, Ukraine; E-mail: n.savchenko@khai.edu.

through a second-order dynamic system. With the similar motivation in recent years the negative position feedback (NPF) [4] was suggested. This approach was tested experimentally [5] and shown its effectiveness. Jamshidi and Collete [6] proposed the design of NDF filter based on H_2 and H_∞ method for collocated systems. A positive position feedback (PPF) and negative derivative feedback (NDF) controllers are applied for reducing the vibrations of a cantilever beam [7]. Comparative analysis of PPF and NDF schemes as well as an experimental setup were presented in [8]. The theoretical methodology by using the averaging method for getting a perturbed solution was applied in [9].

In this paper, two independent procedures for tuning the NDF controller following the analytical scheme are discussed. The approach is quite simple and effective.

2. Formulation of the Problem

The system under study consists of a main structure modeled by a mass m with stiffness k and an attached NDF controller. An external force F_e is applied on the mass, and the NDF controller is producing an action force $F_a = k_c u$ which is dependent on the system displacement (figure 1). This system can be described by equations

$$m\frac{d^2\tilde{x}}{dt^2} + k\tilde{x} = A_e \cos\omega t + F_a,\ \frac{d^2u}{dt^2} + \xi_c\omega_c\frac{du}{dt} + {\omega_c}^2 u = -\omega_c\frac{d\tilde{x}}{dt}. \quad (1)$$

where $\tilde{x}$ is the mass displacement, u is the controller signal, ξ_c, ω_c and k_c are the damping ratio, cut-off frequency and gain of NDF controller respectively.

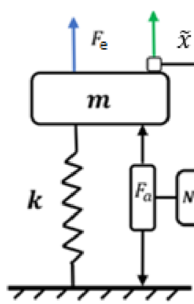


Figure 1. Schematic view of mechanical system.

Let us introduce the dimensionless variables and parameters according to formulas

$$\tilde{x} = \frac{A_e}{m}x,\ \alpha = {}^{\omega_c}/_{\omega_0},\ \beta = \frac{k_c}{k\xi_c}, \eta = {\xi_c}^2,\ \omega_0 = \sqrt{\frac{k}{m}},\ \tau = \omega_0 t,\ \Omega = \frac{\omega}{\omega_o}. \quad (2)$$

The amplitude of steady state harmonic responses is $F(\Omega^2) = {}^{P}/_{Q}$, where

$$P(q,\alpha,\eta) = q^2 + \alpha q(\eta - 2) + \alpha^2$$
$$Q(q,\alpha,\beta,\eta) = q^4 + q^3(\alpha\eta - 2\alpha - 2) + q^2[1 + \alpha^2 + 4\alpha - 2\alpha\eta(1+\beta)] - \alpha q[2(\alpha+1) - \eta(1+\beta)^2] + \alpha^2. \quad (3)$$

Note that, unlike the situation with the use of a dynamic absorber, for which the operating mode is always stable, in the case of NDF controller the instability is possible. The characteristic equation of the system (1) has the form

$$\lambda^4 + \eta\alpha\lambda^3 + (1+\alpha^2)\lambda^2 + \eta\alpha(1+\beta)\lambda + \alpha^2 = 0.$$

According to the criterion for asymptotic stability, it is necessary and sufficient to satisfy the conditions

$$1 + \beta > 0, \qquad \beta\,(\alpha^2 - 1 - \beta) > 0$$

which may be separated on two subcases:

$$\alpha^2 - 1 < \beta < 0,\ \alpha < 1 \quad \text{or} \quad 0 < \beta < \alpha^2 - 1, \alpha > 1. \tag{4}$$

3. Analysis of the Frequency-Amplitude Relation

Assuming, that system's mass and stiffness are given, we seek the parameters of controller which allow to reduce the maximal level of possible oscillation amplitude in some range of system's frequencies. With respect to dimensionless parameters this means that we have to suggest some optimal choice for vector (α, β, η). This goal may be achieved in different ways, and we suggest here two independent approaches.

The first one uses the classical idea of "peak equalizing" proposed by Den Hartog [10] and widely used in literature [11 – 13]. Geometrically this means that two peaks are of the same altitude, thus have the common tangent line (figure 2). Denote this altitude by H and consider the equality $\frac{P(q)}{Q(q)} = H$. The latter may be presented in the following form

$$\tilde{P}(q) \triangleq Q(q) - \frac{1}{H} P(q) = 0. \tag{5}$$

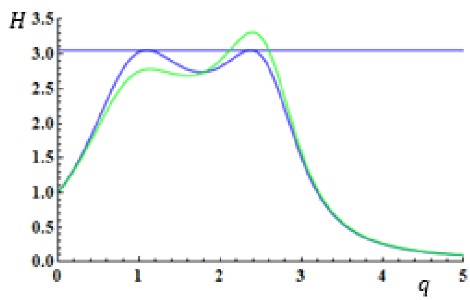


Figure 2. Peak equalizing: $\alpha = 3.17$; $\beta = 1.2$; $\eta = 0.48$ (green line), $\eta = 0.44$ (blue line).

Points of local maximums of polynomial $\tilde{P}(q)$ coincide with its zeros, which means that these zeros are of multiplicity two. Therefore, polynomial $\tilde{P}(q)$ may be presented in the form $\tilde{P}(q) = (q^2 - M\,q + \alpha\,N)^2$, where M, N are some constants unknown at the moment. Because two forms of polynomial $\tilde{P}$ are equal identically with respect to q, using formulas (3) and equating pairs of coefficient on each power of q, we come to the following relations

$$M = \alpha + 1 - \frac{1}{2}\alpha\eta,\ H = \frac{1}{1-N^2},\ \eta = \frac{2(1-N)(\alpha+N)}{\beta\,(2+\beta) - N\,(N-\alpha)},\ \check{P}\,(\alpha, \beta, \eta, N) = 0, \tag{6}$$

Where $\check{P}$ is polynomial of ninth order (which is bulky enough to be presented here).

It is obvious that if we want to achieve a decrease in the value of H, we should minimize the value of N by choosing the parameters α, β appropriately, while maintaining positivity of η and without violate the stability conditions. This problem can be considered as a formal search for the smallest value of an implicitly defined function $N(\alpha, \beta)$ with additional restrictions (which leads to rather cumbersome calculations).

However, it is much simpler to use the fact that $0 \le N < 1$ and directly check whether the equality $\check{P}=0$ has solutions for the value $N = 0$.

It leads to

$$\alpha^4 - 2\alpha^3\beta(\beta+2) + 2\alpha^2\beta(-2\beta^2+5\beta+2) + 2\alpha\beta^2(\beta^2+4) + \beta^2 - (\beta+2)^2 = 0. \quad (7)$$

The corresponding curve is shown in figure 3a. One can see that it is possible to minimize the value of H to 1 only for values of α greater than ≈ 5.44 and $\beta > \approx 2$.

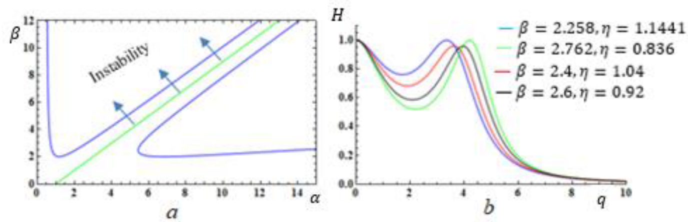


Figure 3. a: Curve (7), right branch corresponds to stable regime; b: dimensionless FA responses ($\alpha = 5.5$).

In figure 3b there are shown some curves for different pairs (α, β) satisfying (7).

Other approach is based on direct analysis of the expression P/Q. Let us determine conditions which guarantee that the magnitude of $F(q)$ will not exceed the value of 1. This can be done as follows. The condition $F < 1$ can be represented as

$$Q(q) - P(q) = q\,P_1(q) > 0, \quad (8)$$

where

$$P_1 = q^3 + A q^2 + B q + C, \; A = -2(\alpha+1) + \alpha\eta, \; B = \alpha[\alpha + 4 - 2\eta(\beta+1)], \; C = \alpha[\beta\eta(\beta+2) - 2\alpha]. \quad (9)$$

Our goal, therefore, is to find the conditions under which $P_1(q)$ has no positive roots. Let's analyze sequentially possible cases in the parameter space α, β, η.

It is obvious that if $C < 0$, then $P_1(q)$ has a positive root (Bolzano Theorem), therefore we will require the condition $C \ge 0$, that is

$$\eta \le \eta_C = \frac{2\alpha}{\beta(2+\beta)}.$$

The latter is possible only in the case of $\alpha > 1$, since otherwise, taking into account the stability condition, we have $\beta < 0, 2+\beta > 0$, hence $\eta_C < 0$ (but η should be positive).

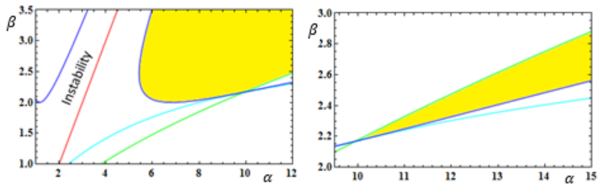
1.1) $C = 0, \; B < 0$ – there is at least one positive root ($lim_{q\to+0} P_1(q) = -0$);

1.2) $C = 0, \; B \ge 0, \; A < 0, \; B \le \frac{1}{4}A^2$ – there is at least one positive root because $P_1(\frac{1}{3}(-A + \sqrt{A^2 - 4B})) \le 0$.

1.3) $C = 0, \; B \ge 0, \; A < 0, \; B > \frac{1}{4}A^2$ – $P_1(q)$ does not have positive roots because $q(q^2 + Aq + B)$ is strictly positive with $q > 0$. In dimensionless physical parameters, this case corresponds to a region bounded by curves

$$\frac{\alpha^2}{\alpha+1} < \beta(2+\beta), \;\; \alpha(\beta^2 - 2\beta - 4) + 4\beta(\beta+2) \ge 0,$$
$$\alpha^4 - 2\alpha^3\beta(\beta+2) + 2\alpha^2\beta(2\beta^2+5\beta+2) - 2\alpha\beta^2(\beta+2)^2 + \beta^2(\beta+2)^2 < 0.$$

The corresponding region is shown in figure 4a.



a b

Figure 4. Domains where cases 1.3 (a) and 1.4 (b) stand.

1.4) $C = 0,\ A \geq 0,\ B \geq 0$. In this vase again there are no positive roots because $P_1(q)$ is increasing function to $q > 0$. Note that this case is valid only for sufficiently large values to the parameter α (figure 4b, $\alpha > 9.948$).

2.1) $A \geq 0,\ B < 0$. Then $D_1 = A^2 - 3B > 0$, and $P_1(q)$ has two critical points $q_{1,2} = \frac{1}{3}(-A \pm \sqrt{D_1})$. q_1 is negative (local maximum), and q_2 is positive (local minimum). The function $P_1(q)$ is decreasing on interval $(q_1,\ q_2)$ and increases when $q > q_2$. Thus it has absolute minimum at $q = q_2$ $(q > 0)$. Obviously, the requeriment $F < 1$ is fulfilled if anf only if $P(q_2) > 0$ or

$$2A^3 - 9AB + 27C > {D_1}^{3/2}. \tag{10}$$

In the case under consideration the condition

$$2A^3 - 9AB + 27C > 0 \tag{11}$$

is fulfilled, and without loss of generality, we can rewrite this inequality in rational form, namely

$$4A^3C - A^2B^2 - 18ABC + 4B^3 + 27C^2 > 0. \tag{12}$$

The expression on the left side is the discriminant of the polynomial $P_1(q)$ taken with the opposite sign.

Thus, in this case the necessary and sufficient condition for $F < 1$ is $D < 0$. According to formulas (9) we have the following expression

$$D = \alpha\eta\{4\alpha^3\eta^3 + 4\alpha^2\eta^2[(1-\beta)\alpha^2 + 2\alpha(\beta^2-4) - \beta^3 - \beta^2 + 10\beta + 4] + \alpha\eta[\alpha^4 + 8\alpha^3(2\beta-3) + 2\alpha^2(-31\beta^2 + 14\beta + 44] + 8\alpha(9\beta^3 + 4\beta^2 - 20\beta - 12) - 27\beta^4 - 36\beta^3 + 76\beta^2 + 80\beta + 16] - 4(\alpha-2)^3(\alpha-\beta)(\alpha-\beta-2)\} \tag{13}$$

2.2) $A < 0, B < 0$. This case is similar to the previous one with the difference that now the expression in left-hand side of (11) can be negative, that is, formally it is necessary to analyze the system of inequalities (12), (11). However actually, the fulfillment of condition (12) entails the fulfillment of (11). This may be shown without any additional transformation, only by logical reasoning. Indeed, if expression (13) is negative (which is necessary condition for (11)), then discriminant of P_1 is negative, therefore this cubic polynomial has only one real root. As $P_1(-\infty) = -\infty$ and $P_1(0) = C > 0$, this root is negative, in other words there are no positive roots which leads to $P_1(q_2) > 0$, thus (11) is valid (which is not possible if the left-hand side is not positive). So, we see that inequality (13) is also sufficient for requirement $F < 1$.

The domain bounded by surfaces $D = 0$, $C = 0$ and subject to stability conditions is shown in figure 5. As can be seen, with the growth of the parameter α, the possibility of varying the parameters β and η significantly expands.

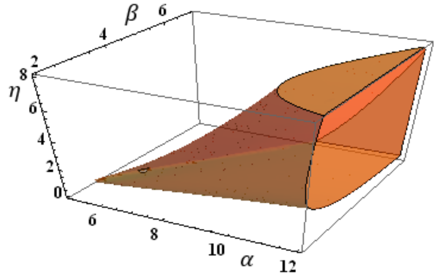


Figure 5. Domain in parameter space where condition $F < 1$ holds.

The figure 6 shows the "admissible" areas for different values of α. Also, figure 7 shows that for different sets the value of the maximum amplitude can be less than 0.5, although the value of the resonant frequency changes (and the area below the frequency-amplitude curve varies).

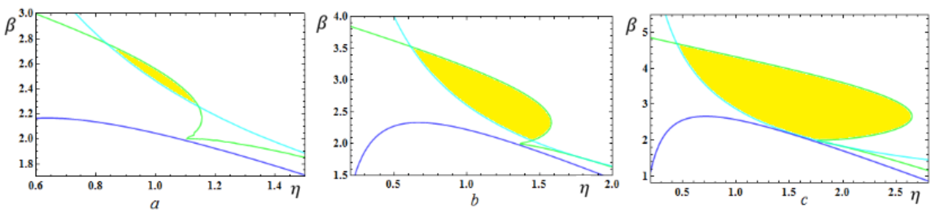


Figure 6. Fulfilment of conditions $C > 0, D < 0$ for different values of α. Respectively (a, b, c): $\alpha = (5.5, 6, 7)$.

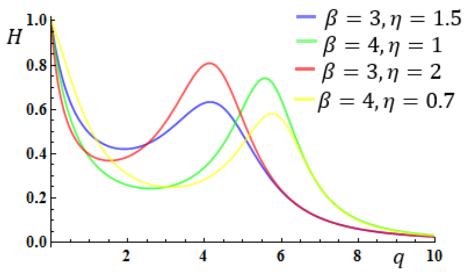


Figure 7. The influence of different parameters β, η on the FA curve shape ($\alpha = 7$).

4. Conclusion

The problem of NDFC tuning for the purpose of suppressing vibrations of a single-DoF system caused by an external periodic force is discussed. Two approaches based on analytical procedures are proposed, allowing to conveniently select effective regions in the space of mechanical parameters characterizing the controller. It is shown that cut-off frequency ω_c is a key tuning parameter. In particular, at values $\frac{\omega_c}{\omega_0} > 2.4$ it is possible to achieve a significant decrease in response peaks, improve the bandwidth, and an increase in the resonant frequency value.

The future work will be devoted to modifying presented results to nonlinear case.

Author Contributions

Conceptualization, Puzyrov V; Data curation, Puzyrov V and Losyeva N; Formal analysis, Puzyrov V and Termenzhy D; Methodology, Puzyrov V; Software, Puzyrov V and Savchenko N; Supervision, Puzyrov V and Losyeva N; Validation, Puzyrov V, Savchenko N and Termenzhy D; Visualization, Puzyrov V and Savchenko N; Writing – original draft, Puzyrov V; Writing – review & editing, Puzyrov V, Losyeva N and Savchenko N. All authors have read and agreed to the published version of the manuscript.

References

[1] Yan X, Shi L, Shan M, et al. Vibration-suppressed trajectory planning for flexible space manipulators during on-orbit operations. Nonlinear Dyn. 2025; 113: 20977–21000.
[2] Narisimha MT, Mehta K, Mutra RR, et al. Vibration mitigation in high-speed rotor-bearing systems with various control schemes. J. Vib. Eng. Technol. 2025; 13: 184.
[3] Fanson JL and Caughey TK. Positive position feedback control for large space structures. AIAA J. 1990;28: 717–24.
[4] Kim S. M., Wang S. and Brennan M. J. Comparison of negative and positive position feedback control of a flexible structure Smart Mater. Struct. 2011. 20, 015011.
[5] Cazzulani G, Resta F, Ripamonti F and Zanzi R. Negative derivative feedback for vibration control of flexible structures. Smart Mater. Struct. 2012; 21(7): 075024.
[6] Jamshidi R and Collette C. Designing negative derivative feedback controller based on maximum damping and H2 method. Smart Mater. Struct. 2022; 31: 075023.
[7] Abd El-Salam MN, Amer YA and Darwesh FO. Effect of negative velocity feedback control on the vibration of a nonlinear dynamical system. Int. J. Dynam. Control. 2023; 11: 2842–2855.
[8] Syed HH. Comparative study between positive position feedback and negative derivative feedback for vibration control of a flexible arm featuring piezoelectric actuator. Int. J. Adv. Robot. Syst. 2017; 14(4): 1–9.
[9] Moatimid GM, El-Sayed AT and Salman HF. Different controllers for suppressing oscillations of a hybrid oscillator via non-perturbative analysis. Sci. Rep. 2024; 14: 307.
[10] Den Hartog JP. Mechanical Vibrations. McGraw-Hill, New York, 1962.
[11] Habib G, Detroux T, Viguié R and Kerschen G. Nonlinear generalization of Den Hartog's equal-peak method. Mechanical Systems and Signal Processing. 2015; 52-53: 17–28.
[12] Li J, Gu X, Zhu S, et al. Parameter optimization for a novel inerter-based dynamic vibration absorber with negative stiffness. J. Nonlinear Math. Phys. 2022; 29: 280–295.
[13] Puzyrov V, Losyeva N and Savchenko N. On mitigation of oscillations of a mechanical system with two degrees of freedom in the vicinity of external resonances. Journal of Theoretical and Applied Mechanics. 2023; 61(3): 613-624.