

An Analytical Approach to Solving Motor Vibration Problems

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Abstract: Vibration problems in induction motors can be extremely frustrating and may lead to greatly reduced reliability. It is imperative, in all operations and manufacturing processes that down time is avoided or minimized, if a problem does occur the source of the problem is quickly identified and corrected. With proper knowledge and diagnostic procedures, it is normally possible to quickly pinpoint the cause of the vibration. All too often erroneous conclusions are reached as a consequence of not understanding the root cause of the vibration. This may result in trying to fix an incorrectly diagnosed problem, spending a significant amount of time and money in the process. By utilizing the proper data collection and analysis techniques, the true source of the vibration can be discovered. This includes, but is not limited to:

Electrical imbalance
Mechanical unbalance – motor, coupling, or driven equipment
Mechanical effects – looseness, rubbing, bearings, etc.
External effects – base, driven equipment, misalignment, etc.
Resonance, critical speeds, reed critical etc.

Once the electrical and mechanical interactions in a motor are understood, and the influence external components have on the apparent motor vibration, identification of the offending component is usually straightforward. This paper provides an analytical approach for expeditiously understanding and solving these types of problems.

Index Terms: Induction Motors, Troubleshooting Vibrations, Cause of Vibration.

I. INTRODUCTION

Much has been written about vibration over the years. This includes many papers and books on vibration in general and a number of papers on vibration in induction motors in particular. This is an ongoing subject, continually extended by advances in analytical and diagnostic tools and methods. For this reason, and because this is an important and complex subject, it is worthwhile periodically to both present any new knowledge and experience as well as to review prior knowledge and concepts.

Vibration problems can occur at anytime in the installation or operation of a motor. When they occur it is normally critical that one reacts quickly to solve the problem. If not solved quickly, one could either expect long term damage to the motor or immediate failure, which would result in immediate loss of production. The loss of production is oftentimes the

most critical concern. To solve a vibration problem one must differentiate between cause and effect. For this to happen, one must first understand the root cause of the vibration. In other words: where does the force come from? Is the vibratory force the cause of the high levels of vibration or is there a resonance that amplifies the vibratory response. Perhaps the support structure is just not stiff enough to minimize the displacement. In this paper the various sources of electrical and mechanical forces will be explained. Additionally, how the motor reacts or transmits this force and how this force can be amplified or minimized will be explained as well. When a vibration problem occurs it is important that one use a good systematic, analytical approach in resolving the problem. This includes performing the proper diagnostic tests. The process starts by listing all the possible causes for the particular identified frequency of vibration and any variations under different operating conditions. Then eliminate the incorrect causes one by one until all that remains is the true source of the problem, and now this can be efficiently eliminated.

II. SOURCES OF VIBRATION

There are many electrical and mechanical forces present in induction motors that can cause vibrations. Additionally, interaction of these various forces make identification of the root cause elusive. In subsequent sections, the major mechanisms are discussed. For a more comprehensive list of electrically and mechanically induced vibrations Table I should be referenced.

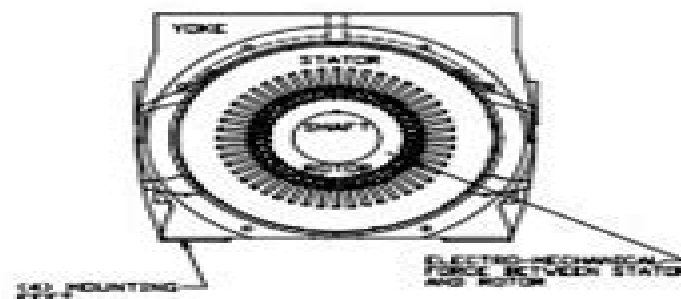


FIG. 1. Stator and Rotor

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Vibration Monitoring of Induction Motors William T. Thomson, 2020-12-03 Master the art of vibration monitoring of induction motors with this unique guide to on line condition assessment and fault diagnosis building on the author's fifty years of investigative expertise It includes Robust techniques for diagnosing of a wide range of common faults including shaft misalignment and or soft foot rolling element bearing faults sleeve bearing faults magnetic and vibrational issues resonance in vertical motor drives and vibration and acoustic noise from inverters Detailed technical coverage of thirty real world industrial case studies from initial vibration spectrum analysis through to fault diagnosis and final strip down An introduction to real world vibration spectrum analysis for fault diagnosis and practical guidelines to reduce bearing failure through effective grease management This definitive book is essential reading for industrial end users engineers and technicians working in motor design manufacturing and condition monitoring It will also be of interest to researchers and graduate students working on condition monitoring

Vibration Control and Actuation of Large-Scale Systems Hamid Reza Karimi, 2020-05-20 Vibration Control and Actuation of Large Scale Systems gives a systematically and self contained description of the many facets of envisaging designing implementing or experimentally exploring advanced vibration control systems The book is devoted to the development of mathematical methodologies for vibration analysis and control problems of large scale systems including structural dynamics vehicle dynamics and wind turbines for example The research problems addressed in each chapter are well motivated with numerical and simulation results given in each chapter that reflect best engineering practice Provides a series of the latest results in vibration control structural control actuation component failures and more Gives numerical and simulation results to reflect best engineering practice Presents recent advances of theory technological aspects and applications of advanced control methodologies in vibration control

Noise, Vibration and Harshness of Electric and Hybrid Vehicles Lijun Zhang, Dejian Meng, Gang Chen, 2020-12-29 The noise vibration and harshness NVH also known as noise and vibration N V is a critical feature for customers to assess the performance and quality of vehicles NVH characteristics are higher among factors that customers use to judge the vehicle's quality This book sets out to introduce the basic concepts principles and applications of the NVH development and refinement of Battery Electric Vehicles BEV Hybrid Electric Vehicles HEV and Fuel Cell Electric Vehicles Each type comes with its own set of challenges

Mechanical Design and Manufacturing of Electric Motors Wei Tong, 2022-05-19 This Second Edition of Mechanical Design and Manufacturing of Electric Motors provides in depth knowledge of design methods and developments of electric motors in the context of rapid increases in energy consumption and emphasis on environmental protection alongside new technology in 3D printing robots nanotechnology and digital techniques and the challenges these pose to the motor industry From motor classification and design of motor components to model setup and material and bearing selections this comprehensive text covers the fundamentals of practical design and design related issues modeling and

simulation engineering analysis manufacturing processes testing procedures and performance characteristics of electric motors today This Second Edition adds three brand new chapters on motor breaks motor sensors and power transmission and gearing systems Using a practical approach with a focus on innovative design and applications the book contains a thorough discussion of major components and subsystems such as rotors shafts stators and frames alongside various cooling techniques including natural and forced air direct and indirect liquid phase change and other newly emerged innovative cooling methods It also analyzes the calculation of motor power losses motor vibration and acoustic noise issues and presents engineering analysis methods and case study results While suitable for motor engineers designers manufacturers and end users the book will also be of interest to maintenance personnel undergraduate and graduate students and academic researchers

Energy Efficiency in Motor Systems Paolo Bertoldi, 2021-09-24 This book contains selected peer reviewed papers presented at the 11th International Conference on Energy Efficiency in Motor Systems EEMODS 19 held in Tokyo Japan from 17-19 September 2019 As with previous conferences in this series EEMODS 19 provided a scientific forum to discuss and debate the latest developments and impacts of electrical motor systems on energy and the environment energy efficiency policies and programmes adopted and planned standards including ISO 50 001 and the technical and commercial advances made in the dissemination and penetration of energy efficient motor systems Topics covered include technologies research and innovation in the areas of electric motors from life cycle costing to 3D printing to artificial intelligence machine learning based monitoring systems emerging motor technologies power electronics and drives pump systems including life cycle costing energy efficiency improvements maintenance and operation for industrial water supply and treatment building and irrigation compressed air systems fans exhaust systems refrigeration systems maintenance and operation mechanical power transmission motors in household appliances and HVAC residential and commercial motors and drives for transport applications including policies programmes regulation and international standards industrial management policies and standards motor system audit and verification policies programmes and financing analysis of motor system energy use and greenhouse gas emissions for motor systems e vehicles and related charging infrastructure harmonization of global motor efficiency test standards evaluation of utility programmes for improving energy efficiency in motor systems and policy implementation market surveillance and enforcement mechanisms including case studies The conference is international by nature and aims to attract high quality and innovative contributions from all corners of the globe while the papers facilitate the development of new technologies policies and strategies to increase energy efficiency

Optimal Auxiliary Functions Method for Nonlinear Dynamical Systems Vasile Marinca, Nicolae Herisanu, Bogdan Marinca, 2021-07-14 This book presents the optimal auxiliary functions method and applies it to various engineering problems and in particular in boundary layer problems The cornerstone of the presented procedure is the concept of optimal auxiliary functions which are needed to obtain accurate results in an efficient way Unlike other known analytic approaches this procedure provides us with a simple

but rigorous way to control and adjust the convergence of the solutions of nonlinear dynamical systems The optimal auxiliary functions are depending on some convergence control parameters whose optimal values are rigorously determined from mathematical point of view The capital strength of our procedure is its fast convergence since after only one iteration we obtain very accurate analytical solutions which are very easy to be verified Moreover no simplifying hypothesis or assumptions are made The book contains a large amount of practical models from various fields of engineering such as classical and fluid mechanics thermodynamics nonlinear oscillations electrical machines and many more The book is a continuation of our previous books *Nonlinear Dynamical Systems in Engineering Some Approximate Approaches* Springer 2011 and *The Optimal Homotopy Asymptotic Method Engineering Applications* Springer 2015

Automotive Software Engineering Thomas Zurawka, Joerg Schaeuffele, Roger Carey, 2016-09-18 Since the early seventies the development of the automobile has been characterized by a steady increase in the deployment of onboard electronics systems and software This trend continues unabated and is driven by rising end user demands and increasingly stringent environmental requirements Today almost every function onboard the modern vehicle is electronically controlled or monitored The software based implementation of vehicle functions provides for unparalleled freedoms of concept and design However automobile development calls for the accommodation of contrasting prerequisites such as higher demands on safety and reliability vs lower cost ceilings longer product life cycles vs shorter development times along with growing proliferation of model variants Automotive Software Engineering has established its position at the center of these seemingly conflicting opposites This book provides background basics as well as numerous suggestions rare insights and cases in point concerning those processes methods and tools that contribute to the surefooted mastery of the use of electronic systems and software in the contemporary automobile

Nonlinear Dynamical Systems in Engineering Vasile Marinca, Nicolae Herisanu, 2012-01-05 This book presents and extends different known methods to solve different types of strong nonlinearities encountered by engineering systems A better knowledge of the classical methods presented in the first part lead to a better choice of the so called base functions These are absolutely necessary to obtain the auxiliary functions involved in the optimal approaches which are presented in the second part Every chapter introduces a distinct approximate method applicable to nonlinear dynamical systems Each approximate analytical approach is accompanied by representative examples related to nonlinear dynamical systems from various fields of engineering

Rotating Machinery, Vibro-Acoustics & Laser Vibrometry, Volume 7 Dario Di Maio, 2025-08-07 Rotating Machinery Vibro Acoustics Vibro Acoustics Experimental Techniques Scanning Laser Doppler Vibrometry Methods

Mechatronics 2017 Tomáš Březina, Ryszard Jabłoński, 2017-08-16 This book presents nearly 90 carefully selected contributions at the 12th International Conference Mechatronics which took place in Brno Czech Republic on 6-8 September 2017 Reflecting the most progressive and constantly changing areas of mechatronics these proceedings includes papers concerning modeling and simulation automatic control robotics sensors and actuators electrical

machines and energy harvesting It not only offers inspiration but also deepens readers interdisciplinary and integrated understanding of modern engineering The book is intended for experts in the integration of electronic mechanical control and computer sciences Designing Sound Andy Farnell,2010-08-20 A practitioner s guide to the basic principles of creating sound effects using easily accessed free software Designing Sound teaches students and professional sound designers to understand and create sound effects starting from nothing Its thesis is that any sound can be generated from first principles guided by analysis and synthesis The text takes a practitioner s perspective exploring the basic principles of making ordinary everyday sounds using an easily accessed free software Readers use the Pure Data Pd language to construct sound objects which are more flexible and useful than recordings Sound is considered as a process rather than as data an approach sometimes known as procedural audio Procedural sound is a living sound effect that can run as computer code and be changed in real time according to unpredictable events Applications include video games film animation and media in which sound is part of an interactive process The book takes a practical systematic approach to the subject teaching by example and providing background information that offers a firm theoretical context for its pragmatic stance Many of the examples follow a pattern beginning with a discussion of the nature and physics of a sound proceeding through the development of models and the implementation of examples to the final step of producing a Pure Data program for the desired sound Different synthesis methods are discussed analyzed and refined throughout After mastering the techniques presented in Designing Sound students will be able to build their own sound objects for use in interactive applications and other projects Proceedings of the FISITA 2012 World Automotive Congress SAE-China,FISITA,2012-11-14 Proceedings of the FISITA 2012 World Automotive Congress are selected from nearly 2 000 papers submitted to the 34th FISITA World Automotive Congress which is held by Society of Automotive Engineers of China SAE China and the International Federation of Automotive Engineering Societies FISITA This proceedings focus on solutions for sustainable mobility in all areas of passenger car truck and bus transportation Volume 7 Vehicle Design and Testing I focuses on Vehicle Performance Development Vehicle Integration Platformized and Universal Design Development of CAD CAE CAM and CF Methods in Automotive Practice Advanced Chassis Body Structure and Design Automotive Ergonomic Interior and Exterior Trim Design Vehicle Style and Aerodynamic Design New Materials and Structures Above all researchers professional engineers and graduates in fields of automotive engineering mechanical engineering and electronic engineering will benefit from this book SAE China is a national academic organization composed of enterprises and professionals who focus on research design and education in the fields of automotive and related industries FISITA is the umbrella organization for the national automotive societies in 37 countries around the world It was founded in Paris in 1948 with the purpose of bringing engineers from around the world together in a spirit of cooperation to share ideas and advance the technological development of the automobile Intelligent Transportation Systems (ITS) Beatriz L. Boada,2021-04-22 This book presents collective works

published in the recent Special Issue SI entitled Intelligent Transportation Systems ITS These works address problems of mobility environmental pollution and road safety as well as their related applications The presented problems are complex and involve a large number of research areas and many advanced technologies such as communication sensing and control which are used for managing a large amount of information The applications vary and include fleet management driving behavior traffic control trajectory planning connected vehicles and energy consumption efficiency Recent advances in communication technologies are becoming fundamental for the development of new advances in fleet management traffic control and connected vehicles This works collected in this Special Issue propose solution methodologies to address such challenges analyze the proposed methodologies and evaluate their performance This book brings together a collection of multidisciplinary works applied to ITS applications in a coherent manner Integrated Vehicle Health Management Timothy Wilmering, 2017-07-24 Integrated Vehicle Health Management IVHM is the unified capability of a system of systems SoS to assess the current or future state of the member system health and integrate it within a framework of available resources and operational demand As systems complexities have increased so have system support costs driven by more frequent and often enigmatic subsystem failures IVHM strategies can be used to mitigate these issues by taking a Systems of Systems view Combined with advanced decision support methods this approach can be used to more effectively predict isolate schedule and repair failed subsystems reducing platform support costs and minimizing platform down time Integrated Vehicle Health Management System of Systems Integration brings together ten seminal SAE technical papers addressing the challenges and solutions to maintaining highly complex vehicles The strategy requires that the IVHM system must provide actionable decision support to operators and maintainers informing platform operational capabilities and maintenance procedures The goal is to prevent a given component from degrading to the point of failure or predictable impending failure Specifications should also reflect a common means for communicating this information to other health ready IVHM system components

Dynamical Systems in Applications Jan Awrejcewicz, 2018-09-01 The book is intended for all those who are interested in application problems related to dynamical systems It provides an overview of recent findings on dynamical systems in the broadest sense Divided into 46 contributed chapters it addresses a diverse range of problems The issues discussed include Finite Element Analysis of optomechatronic choppers with rotational shafts computational based constrained dynamics generation for a model of a crane with compliant support model of a kinetic energy recuperation system for city buses energy accumulation in mechanical resonance hysteretic properties of shell dampers modeling a water hammer with quasi steady and unsteady friction in viscoelastic conduits application of time frequency methods for the assessment of gas metal arc welding conditions non linear modeling of the human body s dynamic load experimental evaluation of mathematical and artificial neural network modeling for energy storage systems interaction of bridge cables and wake in vortex induced vibrations and the Sommerfeld effect in a single DOF spring mass damper system with non ideal excitation **The Shock**

and Vibration Digest ,1993 **Proceedings of ... International Conference on Power Electronics and Drive Systems** ,2005 **Vibration Problems ICOVP 2011** Jiří Náprstek, Jaromír Horáček, Miloslav Okrouhlík, Bohdana Marvalová, Ferdinand Verhulst, Jerzy T. Sawicki, 2011-08-26 This volume presents the Proceedings of the 10th International Conference on Vibration Problems 2011 Prague Czech Republic ICOVP 2011 brings together again scientists from different backgrounds who are actively working on vibration related problems of engineering both in theoretical and applied fields thus facilitating a lively exchange of ideas methods and results between the many different research areas The aim is that reciprocal intellectual fertilization will take place and ensure a broad interdisciplinary research field The topics indeed cover a wide variety of vibration related subjects from wave problems in solid mechanics to vibration problems related to biomechanics The first ICOVP conference was held in 1990 at A C College Jalpaiguri India under the co chairmanship of Professor M M Banerjee and Professor P Biswas Since then it has been held every 2 years at various venues across the World

4th International R&D Conference, Water and Energy for 21st Century, 28-31 January 2003, Aurangabad, Maharashtra: Energy ,2003 Chiefly with reference to India *Applied Mechanics* Henry Görtler, 2013-10-05

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web the brown recluse spider *loxosceles reclusa* belongs to the genus *loxosceles* they are also known as fiddle back or violin spiders recluse spiders are a venomous genus of spider known for their venomous necrotic death of cells and living tissue bite

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web 2 days ago certainly identifying the spider is helpful as the brown recluse has a unique appearance with a yellow to brown color and a fiddle or violin shaped mark on its back he says they typically grow to between 1 and 1 1 2 inches long 2 5 to 3 5 centimeters friedman adds that these spiders like dark warm dry spaces like attics or under

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web oct 9 2019 the brown recluse spider is a type of recluse spider with a range that is limited to the midwestern and south central united states the species has necrotic venom and its bite like other brown spiders requires immediate medical attention

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web brown recluse spiders belong to the *sicariidae* family the *sicariidae* family contains approximately 160 different spider species the most renowned members of which are the brown recluse spider and the six eyed sand spider brown recluse spiders reach adulthood in the span of one year and they typically live for two to four years in the wild

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spiders within the genus *Loxosceles* there are actually 11 spiders native to the U.S. and four of them are known to be of risk to humans expect the following characteristics from Sicariid spiders

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web for laypersons the most distinguishing feature of a brown recluse is a dark violin shaped mark on its back with the neck of the violin pointing toward the rear abdomen of the spider this feature is consistent in adult brown recluses but sometimes less obvious in younger spiders

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web may 1 2023 what are brown recluse spiders the brown recluse *Loxosceles reclusa* is a small house spider about the size of a quarter it isn't aggressive so people who live in a house full of brown recluses may never be bitten they will bite when provoked however

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web nov 17 2022 the brown recluse spider *Loxosceles reclusa* is one of the most poisonous spiders in the United States their venom is necrotic meaning that it destroys blood vessels causing tissue near the site of the bite to die getting bitten by one is uncommon and the bite alone rarely kills people

brown recluse spider about the brown recluse insects it s - Feb 26 2022

web feb 3 2010 the brown recluse is a nocturnal spider and will roam at nighttime searching for prey while resting in the daylight hours in his web the web is a loose very irregular sticky set of threads that are colored an off white color brown recluse it is built in a corner which is largely undisturbed by outsiders brown recluses often hide in human

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web nov 3 2022 the brown recluse is part of the *Loxosceles* genus of spiders members of this group have violin shaped markings on the top of their cephalothorax fused head and thorax where the legs are

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web the brown recluse is one of three spiders in North America with toxic venom the others being the black widow and the Chilean recluse brown recluse spiders are usually between 6 and 20 millimetres 0.24 and 0.79 in but may grow larger while typically light to medium brown they range in color from whitish to dark brown or blackish gray

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web aug 29 2018 the brown recluse spider is also known as the violin or fiddle back spider it lives in midwestern and southeastern parts of the U.S. this spider is brown and has a darker violin shaped

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web aug 17 2023 brown recluse *Loxosceles reclusa* venomous light tan or yellow spider most common in the western and

southern united states it has a body length of about 7 mm 0 25 inch and a leg span of about 2 5 cm 1 inch on the front half of its body the cephalothorax it has a dark violin shaped brown recluse venomous bite symptoms

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web the recluse spiders *Loxosceles* also known as brown spiders fiddle backs violin spiders and reapers is a genus of spiders that was first described by r t lowe in 1832 they are venomous spiders known for their bite which sometimes produces a characteristic set of symptoms known as loxoscelism

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web apr 24 2023 brown recluses are small spiders with light brown bodies and legs 6 eyes and fine hair on their legs true to their name brown recluses favor sheltered out of the way places and typically aren't out in plain sight brown recluse spiders are native to the southeastern and midwest united states

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web a brown recluse has a dark brown violin shape on the cephalothorax the portion of the body to which the legs attach the neck of the violin points backward toward the abdomen however what you should look at instead is the eye pattern of 6 eyes in pairs with a space separating the pairs most spiders have 8 eyes in two rows of four

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web overview what is a brown recluse spider the brown recluse spider is an eight legged arachnid that is tan to dark brown in color with a violin marking on its back that can range anywhere from 1 4 inch to 1 2 inch long younger spiders or those that have just molted won't have the violin marking

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web the brown recluse or violin spider has an upside down violin thus the nicknames fiddleback spider and violin spider this brown recluse was trapped in an office light fixture and freed in the woods by a friendly receptionist brown recluse or violin spider hiding under a cushion ultra closeup of a female brown recluse spider

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