COEFFICIENT PLANE MODELS FOR CONTROL SYSTEM ANALYSIS AND DESIGN pdf

1: Control Tutorials for MATLAB and Simulink - Aircraft Pitch Variables

*Coefficient Plane Models for Control System Analysis and Design (Mechanical engineering research studies) [D. R. Towill] on www.enganchecubano.com *FREE* shipping on qualifying offers.*

Pioneer years[edit] The Wright Brothers began experimenting with the foreplane configuration around Their first kite included a front surface for pitch control and they adopted this configuration for their first Flyer. They were suspicious of the aft tail because Otto Lilienthal had been killed in a glider with one. The Wrights realised that a foreplane would tend to destabilise an aeroplane but expected it to be a better control surface, in addition to being visible to the pilot in flight. The Fabre Hydravion of was the first floatplane to fly and had a foreplane. Some, including the Wrights, experimented with both fore and aft planes on the same aircraft, now known as the three surface configuration. After , few canard types would be produced for many decades. Evans commented that "the Canard type model has practically received its death-blow so far as scientific models are concerned. The C 1 was a failure. Two examples were built and one of them continued flying until These were attempts at using the canard configuration to give advantages in areas such as performance, armament disposition or pilot view, but no production aircraft were completed. The Shinden was ordered into production "off the drawing board" but hostilities ceased before any other than prototypes had flown. It was reportedly a favorite among MiG OKB test pilots for its docile, slow-speed handling characteristics and flew for some years, being used as a testbed during development of the swept wing of the conventional layout MiG jet fighter. XB Valkyrie experimental bomber With the arrival of the jet age and supersonic flight, American designers, notably North American Aviation , began to experiment with supersonic canard delta designs, with some such as the North American XB Valkyrie and the Soviet equivalent Sukhoi T-4 flying in prototype form. But the stability and control problems encountered prevented widespread adoption. The success of this aircraft spurred many designers, and canard surfaces sprouted on a number of types derived from the popular Dassault Mirage delta-winged jet fighter. The close-coupled canard delta remains a popular configuration for combat aircraft. The Viggen also inspired the American Burt Rutan to create a two-seater homebuilt canard delta design, accordingly named VariViggen and flown in Rutan then abandoned the delta wing as unsuited to such light aircraft. These designs were not only successful and built in large numbers but were radically different from anything seen before. Canards visible on a JAS 39 Gripen Canards on a Su Static canard designs can have complex interactions in airflow between the canard and the main wing, leading to issues with stability and behaviour in the stall. The development of fly-by-wire and artificial stability towards the end of the century opened the way for computerized controls to begin turning these complex effects from stability concerns into maneuverability advantages. The Dassault Rafale multirole fighter first flew in , followed by the Saab Gripen first to enter service in , the Eurofighter Typhoon in and the Chinese Chengdu J in Basic design principles[edit] Su , with canards A canard foreplane may be used for various reasons such as lift, in stability, trim, flight control, or to modify airflow over the main wing. Design analysis has been divided into two main classes, for the lifting-canard and the control-canard. Lift[edit] Rutan Long-EZ , with high-aspect-ratio lifting canard and suspended luggage pods In the lifting-canard configuration, the weight of the aircraft is shared between the wing and the canard. It has been described as an extreme conventional configuration but with a small highly loaded wing and an enormous lifting tail which enables the centre of mass to be very far aft relative to the front surface. As the canard lift adds to the overall lift capability of the aircraft, this may appear to favor the canard layout. In particular, at takeoff the wing is most heavily loaded and where a conventional tail exerts a downforce worsening the load, a canard exerts an upward force relieving the load. This allows a smaller main wing. However, the foreplane also creates a downwash which can affect the wing lift distribution unfavorably, so the differences in overall lift and induced drag are not obvious and they depend on the details of the design. This causes the rear of the craft to drop, deepening the stall and sometimes preventing recovery. Hence, the wing must be larger than otherwise necessary, reducing or even reversing the reduction in size enabled by the canard lift. Highly loaded canards do not have sufficient extra lift available to balance this moment, so lifting-canard aircraft cannot readily be designed with powerful trailing-edge flaps. In a control-canard design, most of the weight of the aircraft is carried by the wing and the canard is used primarily for pitch control during maneuvering. A pure control-canard operates only as a control surface and is nominally at zero angle of attack and carrying no load in normal flight. Modern combat aircraft of canard configuration typically have a control-canard driven by a computerized flight control system. The electronic flight control system uses the pitch control function of the canard foreplane to create artificial static and dynamic stability. An all-moving canard capable of a significant nose-down deflection can be used to counteract the pitch-up due to the tip stall. As a result, the aspect ratio and sweep of the wing can be optimized without having to guard against pitch-up.

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2: Development and Analysis of the Control Effect of a Reid Damper with Self-Centering Characteristics

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On this design it is possible that the most critical condition for elevator control will be at take-off. Unless careful attention is given to the location of the landing gear, the elevens alone may not be powerful enough to meet the Army requirements for getting the nose wheel off the ground at 80 percent of take-off speed. Use of the trim flaps in conjunction with the elevons will help provide enough longitudinal control to meet this requirement. The values of the effective-dihedral parameter Cp and the directional-stability parameter Ch obtained for the different test conditions from these figures are plotted in figure 12 in the form of a stability diagram. The values of Cn a and C1p for corresponding conditions for the model tested at high Reynolds numbers are also presented in figure The values of C for the flap-retracted condition at angles of attack of 0 and 60 are relatively low about 0. Increasing the angle of attack to with flaps retracted caused an increase in Cn to 0. The lower values of Cn shown in figure 12 for the model tested at high Reynolds numbers are attributed to the lower drag of this model. For an all-wing tailless design with low dihedral, the drag of the wing contributes a major part of the static directional stability. The value of Ct increased with increasing lift coefficient as expected for the swept- back wing. AL 1i that this model had 20 geometric dihedral whereas the free-flight-tunnel model had 0o geometric dihedral. The directional stability was not dangerously low, however, inasn: Deflection of the flans or addition of the vertical tails caused noticeable ir. Previous free-flillgt-tunnel investigations have shown that, for an airplane with low directional stability, low effective dihedral is necessary to avoid a: It is probable that the lateral stability character- istics of a full-scale airplane of the design tested would not be so good as those of the free-flight model because the values of Cnp of a full-scale airplane will probably be lower than those for the free-flight model. At the higher lift coefficients, which could not be reached in the free-flight-tunnel tests because of longitudinal instability, the requirements of the airplane would be more severe for directional stability and the airplane would probably be considered unsatisfactory in this respect. In order to secure satisfactory flying characteristics with a tailless all-wing airplane of this type, it appears desirable to maintain a low value of effective dihedral and to supplement the directional stability of the wing by means of vertical tails or an automatic stabilizing device. A better quantitative indication of the weakness of the aileron control was obtained in the force tests, the results of which are presented in figures 13 and l and which are summarized and compared in figure 15 with results of tests at high Reynolds numbers. The high Reynolds number data of figure 15 indicate that the flying-qualities requirement for a: The free- flight-tunnel force tests indicate even weaker aileron control but this result is partly attributed to the low Reynolds number of the tests, to the wing section used, and to the initial reflex of the trailing edge of the win7. The free-flight-tunnel test results do indicate, however, that linking the rudder surfaces to move as ailerons with the elevens provides a substantial improve- ment in aileron control. In order to obtain satisfactory aileron control with eleven surfaces located well inboard of the tip as on this design, larter-chord surfaces than those on the free- flight-tunnel model should be used or the rudder surfaces should be linked with the elevens in order to provide greater effective eleven area. Inasmuch as the yawing moments caused by aileron deflection were small fig.

3: Lightweight Airplane Design - MATLAB & Simulink

Flight Control System Design and Analysis of a Light Sport Aircraft INCAS BULLETIN, Volume 10, Issue 2/ The preliminary design of the concept airplane was followed by a series of wind tunnel.

Correspondence should be addressed to Ling-yun Peng ; nc. This is an open access article distributed under the Creative Commons Attribution License , which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. Abstract To improve the recoverability of structures following an earthquake, a Reid friction damper with self-centering characteristics is proposed and its hysteretic behavior is studied by theoretical analysis and experimental research. The main parameters of the damper are the equivalent stiffness and energy dissipation coefficient. Based on a story steel frame structure, 10 energy dissipation design schemes using the proposed Reid damper are proposed. The additional equivalent damping ratios of the 10 schemes are equal, whereas the energy dissipation coefficients of the dampers are different. The vibration control effects of the energy dissipation structures are analytically investigated under four earthquake loads. The experimental results of the friction damper are in good agreement with the theoretical results, and the hysteretic behavior of the damper follows that of a typical Reid model. The seismic response and structural damage can be reduced using any of the 10 design schemes; however, the effects are different. When the energy dissipation coefficient is in the range of 0. Therefore, the optimum range of the energy dissipation coefficient of a Reid damper intended for energy dissipation structures should be 0. Introduction Currently, the performance-based seismic design has been widely recognized, and scholars from various countries have conducted numerous studies on the same [1]. Scholars in the United States and Japan have proposed the resilient city as a general direction for cooperation in earthquake engineering [2]. Under the premise that a structure meets the performance target, a postearthquake structure can be quickly repaired and restored to its normal function. This has become one of the important research directions for the sustainable development of earthquake resistant projects. The difficulty in restoring earthquake-hit structures and the associated economic cost is directly related to the residual deformation of the structures. Therefore, restricting their residual deformation has become a key point for structural recovery [3]. Metal-yielding energy dissipaters, such as buckling-restrained braces BRBs , can be used to significantly improve the seismic performance of an entire structure; however, the downside is the higher residual deformation following a strong earthquake [4]. In recent years, the development of energy dissipating devices with good energy dissipation and self-centering characteristics has become a hot topic [5 â€" 10]. A self-centering damper has two parts: The energy dissipation part is similar to that of a conventional damper, performing functions such as metal-yielding energy dissipation [5 , 6], friction energy dissipation [7 , 8 , 11 â€" 13], and viscous energy dissipation [9]. The restoring force part mainly comprises shape memory alloys SMAs [5 , 11], dish springs [7 , 9], synthetic fiber material [12 , 13], and prestressed steel strand [14]. The SMA is used to provide resilience for the dampers, owing to its shape memory property. Another important property of SMAs is pseudoelasticity superelasticity , which implies that the large strain produced during loading will be recovered and the energy will be dissipated simultaneously. Based on the excellent properties of SMA, many SMA dampers with self-centering characteristics have been designed [10 , 15 â€" 17]. For self-centering dampers, the idealized bilinear elastic model is generally used to simulate the restoring force, whereas the bilinear elastoplastic model is used to simulate the dissipated energy. Hence, the hysteretic models of self-centering dampers are flag-shaped [18] or improved flag-shaped [6 , 19 â€" 21], which have attracted significant attention. Another model that can describe the self-centering dampers is the Reid model [22 â€" 24]. This model is used to describe the damping force, which is proportional to the displacement amplitude and in phase with the velocity [25]. One of its important characteristics is that it can consider the varying amplitude damping force with the increase in the structural deformation and can better meet the demand of shock absorption under earthquakes of varying intensity. Currently, the damper that can realize the Reid model mainly comprises a variable friction device and a restoring force device. The restoring force device uses the same parts as those in other self-centering dampers. The main methods of achieving variable friction include piezoelectricity [26], variable contact surface friction coefficient [27], and variable friction contact surface [28]. The force-displacement hysteretic curve of the EDR is consistent with the Reid model. The results show that Reid dampers are effective to control the vibration response of the structure, but the control effect for the multidegree of the freedom structure and the structure in the nonlinear stage is not involved. In this paper, the hysteresis curves and energy dissipation characteristics of a Reid model are first analyzed. A Reid friction damper is then proposed and studied by theoretical analysis and experimental research. Based on a story steel frame structure, 10 energy dissipation design schemes using the Reid dampers are determined. Compared to an uncontrolled structure, the vibration control effects on the displacement, acceleration, energy dissipation, structural damage, and residual deformation of the energy dissipation structures are analytically investigated under four earthquake loads. Finally, based on the research results, the design of the Reid damper for energy dissipation structures is proposed. Reid Hysteresis Model Figure 1 a shows the force-displacement relationship of the Reid hysteretic model. The two diagonal triangles, which are symmetric about the origin, in the first and third quadrants constitute the hysteresis loop. It is assumed that the transition between the loading and unloading states is instantaneous. For the Reid hysteresis model, the relationship between the damping force and the displacement can be expressed as follows: As shown in Figures 1 b and 1 c , the Reid model can be decomposed into a linear hysteretic damping model, whose force is proportional to the displacement amplitude and in phase with the velocity, and a linear spring model. Accordingly, the relationship between the damping force and displacement can be rewritten as follows: Furthermore, from Equations 1 and 2 , it follows that The Reid hysteretic loop shows that the damper will automatically return to its initial position after unloading and will not generate residual deformation. With regard to the energy dissipation capacity, the energy dissipated when repeatedly loading a cycle for a displacement can be obtained as follows: Theoretical Analysis of Reid Damper According to the classical friction theory, the sliding friction magnitude is related to only the magnitude of the pressure and friction coefficient of the contact surface. The greater the pressure and friction coefficient, the greater the sliding friction. The formula for calculating the frictional force of the constant friction damper is as follows: The frictional force of the constant friction damper is independent of the displacement but is in phase with the velocity. To realize a linear hysteretic damping model, the friction magnitude should vary linearly with respect to the displacement. In current piezoelectric friction dampers, the positive force between the frictional contact surfaces can be changed by applying a voltage. However, they are semiactive devices, and the construction is more complex. Figure 2 shows the schematic of the passive variable friction damper, which can realize the Reid model. In Figure 2 , denotes the friction coefficient between the sliding block and the friction plate, denotes the friction coefficient between the sliding block and the extrusion block, and denotes the angle between the two frictional contact surfaces. During the loading, the interaction force between the extrusion block and the sliding block will increase, consequently, increasing the friction between the sliding block and the friction plate. Schematic of the passive variable friction damper. At the same time, the compression force acting on the spring increases. During the unloading, the interaction force between the extrusion block and the sliding block and the friction between the sliding block and the friction plate decrease. The transition between the loading and unloading stages of the damper is assumed to be instantaneous. As shown in Figure 3 a , the sliding and extrusion blocks are isolated. During the loading, the damping force is equal to the sum of the spring compression reaction force and the frictional force. During the unloading, the damping force is equal to the difference between the spring compression reaction and the frictional force. Force balance of the passive variable friction damper: The damping force is obtained as follows: For the loading stage, as shown in Figure 3 b , the force balance relationship can be obtained by considering the extruded block as an isolated body: With the sliding block considered as an isolated body, the frictional force and positive pressure can be obtained by balancing the forces as follows: The relationships between the positive pressure and the frictional force are as follows: Combined with Equations 6 â€” 8 , the damping force can be obtained as follows: Equation 9 can be rewritten as follows: The damping force for the unloading stage can be obtained using the same method:

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4: Canard (aeronautics) - Wikipedia

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Additional products you will need to explore this model further are: Ideally, you perform iterations before building any hardware. The challenge is to perform the iterations quickly. Typically, different groups work on different steps of the process. Effective collaboration among these groups and the right set of tools are essential to addressing this challenge. Defining Vehicle Geometry The geometry of this lightweight aircraft is from reference 1. The original design objective for this geometry was a four-seat general aviation aircraft that was safe, simple to fly, and easily maintainable with specific mission and performance constraints. For more details on these constraints, see reference 1. Potential performance requirements for this aircraft include: Level cruise speed Acceptable rate of climb Acceptable stall speed. Lightweight four-seater monoplane [1]. Once you choose the geometric configuration, you can obtain the aerodynamic characteristics by means of: Analytical prediction Wind tunnel testing of the scaled model or a full-sized prototype Flight tests. While wind tunnel tests and flight tests provide high-fidelity results, they are expensive and time- consuming, because they must be performed on the actual hardware. Analytical prediction is a quicker and less expensive way to estimate aerodynamic characteristics in the early stages of design. In this example, we will use Digital Datcom, a popular software program, for analytical prediction. This software is publicly available. To start, create a Digital Datcom input file that defines the geometric configuration of our aircraft and the flight conditions that we will need to obtain the aerodynamic coefficients. Normally, this is a manual process. There is no need for manual input. Each Digital Datcom output is imported into the MATLAB technical computing environment as a cell array of structures, with each structure corresponding to a different Digital Datcom output file. In our model, we need to check whether the vehicle is inherently stable. To do this, we can use Figure 2 to check whether the pitching moment described by the corresponding coefficient, Cm, provides a restoring moment for the aircraft. A restoring moment returns the aircraft angle of attack to zero. In configuration 1 Figure 2 , Cm is negative for some angles of attack less than zero. This means that this configuration will not provide a restoring moment for those negative angles of attack and will not provide the flight characteristics that are desirable. Configuration 2 fixes this problem by moving the center of gravity rearward. Shifting the center of gravity produces a Cm that provides a restoring moment for all negative angles of attack. Visual analysis of Digital Datcom pitching moment coefficients. Creating Flight Vehicle Simulation Once we determine aerodynamic stability and control derivatives, we can build an open-loop plant model to evaluate the aircraft longitudinal dynamics. A Web view is an interactive HTML replica of the model that lets you navigate model hierarchy and check the properties of subsystems, blocks, and signals. A typical plant model includes the following components: This model highlights subsystems containing Aerospace Blockset blocks in orange. It highlights Aerospace Blockset blocks in red. This model will help us determine whether the flight vehicle is longitudinally stable and controllable. We design our subsystem to have the same interface as a six degrees-of-freedom DOF version. When we are satisfied with three DOF performance, stability, and controllability, we can implement the six DOF version, iterating on the other control surface geometries until we achieve the desired behavior from the aircraft. To calculate the aerodynamic forces and moments acting on our vehicle, we use a Digital Datcom Forces and Moments block from the Aerospace Blockset library Figure 5. This block uses a structure that Aerospace Toolbox creates when it imports aerodynamic coefficients from Digital Datcom. For some Digital Datcom cases, dynamic derivative have values for only the first angle of attack. The missing data points can be filled with the values for the first angle of attack, since these derivatives are independent of angle of attack. To see example code of how to fill in missing data in Digital Datcom data points, you can examine the asbPrepDatcom function. We also use Aerospace Blockset blocks to create actuator, sensor, and environment models Figures 6, 7, and 8, respectively. In addition to creating the following parts of the model, we use standard Aerospace Blockset blocks to ensure that we convert from body axes to wind axes and back correctly. Implementation of actuator models using Aerospace Blockset blocks. Implementation of flight sensor model using Aerospace Blockset blocks. Environmental effect of wind, atmosphere, and gravity using Aerospace Blockset blocks. Designing Flight Control Laws Once we have created the Simulink plant model, we design a longitudinal controller that commands elevator position to control altitude. The traditional two-loop feedback control structure chosen for this design Figure 9 has an outer loop for controlling altitude compensator C1 in yellow and an inner loop for controlling pitch angle compensator C2 in blue. Figure 10 shows the corresponding controller configuration in our Simulink model. Structure of the longitudinal controller. Longitudinal controller in Simulink model. Using the Simulink Control Design interface, we set up the control problem by specifying: Two controller blocks Closed-loop input or altitude command Closed-loop output signals or sensed altitude Steady-state or trim condition. Using this information, Simulink Control Design software automatically computes linear approximations of the model and identifies feedback loops to be used in the design. To design the controllers for the inner and outer loops, we use root locus and bode plots for the open loops and a step response plot for the closed-loop response Figure Design plots before controller tuning. We then interactively tune the compensators for the inner and outer loops using these plots. Because the plots update in real time as we tune the compensators, we can see the coupling effects that these changes have on other loops and on the closed-loop response. To make the multi-loop design more systematic, we use a sequential loop closure technique. This technique lets us incrementally take into account the dynamics of the other loops during the design process. With Simulink Control Design, we configure the inner loop to have an additional loop opening at the output of the outer loop controller C1 in Figure This approach decouples the inner loop from the outer loop and simplifies the inner-loop controller design. After designing the inner loop, we design the outer loop controller. Figure 13 shows the resulting tuned compensator design at the final trimmed operating point. Block diagram of inner loop, isolated by configuring an additional loop opening. Design plots at trim condition after controller tuning. You can tune the controller in Simulink Control Design software in several ways. You can use a graphical approach, and interactively move controller gain, poles, and zeros until you get a satisfactory response Figure After you specify frequency domain requirements, such as gain margin and phase margin and time domain requirements, Simulink Design Optimization software automatically tunes controller parameters to satisfy those requirements. Once we have developed an acceptable controller design, the control blocks in the Simulink model are automatically updated. We can now run our nonlinear simulation with flight control logic and check that the controller performance is acceptable. Figure 15 shows the results from a closed-loop simulation of our nonlinear Simulink model for a requested altitude increase from 2, meters to 2, meters starting from a trimmed operating point. Although a pilot requests a step change in altitude, the actual controller altitude request rate is limited to provide a comfortable and safe ride for the passengers. The final check is to run nonlinear simulation with our controller design and check that altitude purple tracks altitude request yellow in the stable and acceptable fashion. We can now use these simulation results to determine whether our aircraft design meets its performance requirements. As we can see, the aircraft climbed from 2, to 2, meters in less than 20 seconds, providing a climb rate higher than 2. Therefore, this particular geometric configuration and controller design meets our performance requirements. In addition to traditional time plots, we can visualize simulation results using the Aerospace Blockset interface to FlightGear Figure Visualizing simulation results using the Aerospace Blockset interface to FlightGear. Completing the Design Process Building a hardware-in-the-loop system to test real-time performance Building the actual vehicle hardware and software Conducting the flight test Analyzing and visualizing the flight test data. Because these steps are not the focus of this example, we will not describe them here. Summary In this example we showed how to: Use Digital Datcom and Aerospace Toolbox software to rapidly develop the initial design of your flight vehicle and evaluate different geometric configurations. Use Simulink and Aerospace Blockset software to rapidly create a flight simulation of your vehicle. Use Simulink Control Design software to design flight control laws. This approach enables you to determine the optimal geometrical configuration of your vehicle and estimate its performance and handling qualities well before any hardware is built, reducing design costs and eliminating errors. In addition, using a single tool chain helps facilitate communication among different groups and accelerates design time. Based on your location, we recommend that you select: You can also select a web site from the following list: Other MathWorks country sites are not optimized for visits from your location.

5: Control Tutorials for MATLAB and Simulink - Cruise Control: System Analysis

It is proposed that mathematical models, of limited complexity, can provide the necessary insight to guide the design and appraisal of live system models built with a continuous computer package. The paper concludes by developing the idea that a generic application in the study of scheduling strategies for live manufacturing systems.

6: Flight dynamics (fixed-wing aircraft) - Wikipedia

"Coefficient Plane Models for Control System Analysis and Design", Research Studies Press, John Wiley and Sons, Chichester () 9 Towill D.R. "Exponential Smoothing of Learning Curve Data".

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