ISSN: 2248-9622 www.ijera.com
Vol. 1, Issue 3, pp.542-545

INTRODUCTION TO THE DEVELOPMENT AND DESIGN OF A MECHATRONIC SYSTEM

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Abstract

Mechatronics is a way of combining the classical engineering disciplines for mechanical, electrical engineering and computer science. The objective is to build smart products and "intelligent" machines.

This paper presents about the architecture of mechatronic system and its key elements. This main objective of this paper is the development and design of mechatronic systems. The major objective of mechatronics is the design and implementation of mechatronic systems as a new type of system in which mechanical, electro, and electronic subsystems are naturally designed into a whole system.

Keywords : Mechanical, Electronics, Development, Design, Mechatronic system.

1.0 Introduction

Mechatronics is a system-level approach to designing electromechanical systems that merges mechanical, electrical, control and embedded software design. Explore these mechatronics resources and learn how to lower your development costs, reduce risk, and produce higher-quality products.

IT is the fusion of the technologies of electronics and mechanics. Examples include numerically controlled machine tools, industrial Robots, digital clocks, and electronic calculators.

Mechatronics (or Mechanical and Electronics Engineering) is the synergistic combination of mechanical engineering, electronic engineering, controls engineering and computer engineering to create useful products. The purpose of this interdisciplinary engineering field is the study of automata from an engineering perspective and serves the purposes of controlling advanced hybrid systems. The word itself is a combination of 'Mechanics' and 'Electronics'.

1.1 Description

Engineering cybernetics deals with the question of control engineering of mechatronic systems. It is used to control or regulate such a system. Modern production equipment consists of mechatronic modules that are integrated according to a control architecture. There are many systems in the existing world that require a synergy of these expertise areas including systems in automotive aerospace, medical, material processing, manufacturing and the consumer products application sector. Some examples of mechatronics system include air craft light control and navigation systems, automobile fuel injection and anti-break systems, automated manufacturing equipments (e.g...Robots).The field of robotics can be considered to be a subfield of mechatronics.The typical of a robotic system includes the actuator, communicator, control element, end-effector, manipulator, power supply as well as sensors. An excellent example of a mechatronic system is the photocopy machine. Analog circuits are used to control the lamp, heater and power. Digital system controls the digital displays and the indicator lights. Buttons and switches are used for the user interface. All of these complex interactions are transparent to the eventual user of the system; typically a mechatronics design goal for any mechatronic system.

2.0 Key elements of a Mechatronic system

2.1 Microprocessors and integrated circuits: It is a general-purpose programmable logic device. It is a digital device which receives information in digital form. According to stored programs this information is processed. A microprocessor is a semiconductor device having electronic logic circuits manufactured by using LSI (Large Scale Integration) or VLSI (Very Large Scale Integration) technique. It is a chip capable of performing arithmetic and logic functions according to a defined program. A controller and computer designed using microprocessor is called a micro-computer and micro-controller respectively. It consists of memory and I/O devices besides microprocessor. Microcomputer is able to carry out complicated control operations due to its memory. Microprocessors are present in various mech. applications such as Automobiles, Washing machines, Process instrumentation etc.

2.2 Interfacing Devices: Mechatronic systems essentially consist of energy and information domains. Data processing is done in digital devices while physical detection in sensors and power output in actuator requires analog capability. Hence appropriate devices for Digital to analog and vice-versa are necessary.

2.3 Sensors: It is a sensing device that converts physical phenomena and chemical composition into electric, pneumatic or hydraulic output signals. Some of modern sensors developed for mechatronics applications are Disposable blood pressure sensors, Pressure sensors for automotive manifold air pressure, Accelerometers for airbag systems etc

2.4 Actuators: The actuator performs task of converting control signal into action on the control element. The actuator often supplies large force or torque to manipulate some control element such as valve, switch etc. Conventional actuators use electric motors and fluid power as their energy source. Modern actuators for mechatronic applications use novel technology such as ultrasonic motors, micromotors, piezoelectric and magnetostrictive forces and shape memory alloys to derive necessary energy. Some of the common types of devices are listed in figure below:

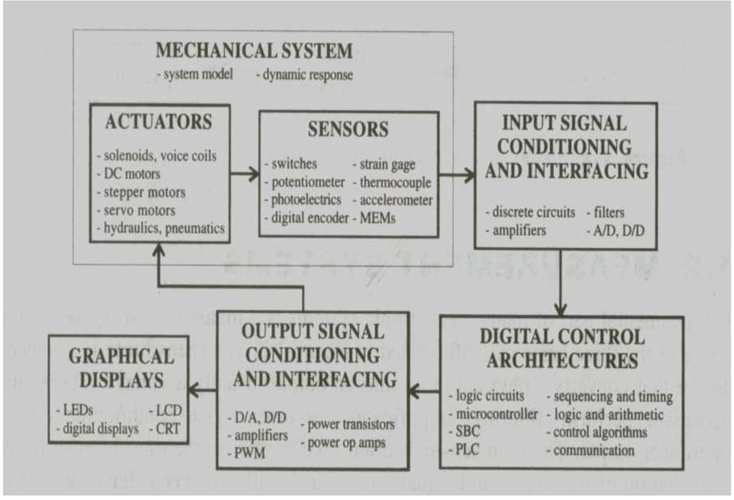

Fig:1 Key elements of a Mechatronic system

3.0 Designing for Mechatronics

Engineers are grappling with how to more effectively design products that have mechanical, electronics and software components. But this not your father's systems engineering approach When an average vehicle boasts more than 1 million lines of software code and dozens of ECUs (engine control unit) and common household appliances like dishwashers and refrigerators come standard with mini on-board computers, it doesn't take a rocket scientist to see something about the traditional engineering process has to give.

The complexity of today's products has added another dimension to product development as companies from car manufacturers to appliance makers struggle to integrate mechanical, electrical and software components into their products and, at the same time, uphold their business goals of improving time-to-market and meeting ever-higher quality standards. Unlike traditional design processes where electrical engineers worked on their components relatively unconnected to the design efforts of mechanical engineers or the software development team, this new kind of product development — mechatronics as it's sometimes called — demands a wholesale shift to a more concurrent, systems engineering approach where all the disciplines collaborate early on in the process. The reason for this cross-discipline collaboration is simple: With companies facing fierce competitive pressures, they can no longer afford to bump up against possible design flaws or incompatibilities between systems at the end of the design cycle when making changes is expensive and an impediment to shipping products in a timely manner.

3.1 Diagram of a Mechatronic System

Diagram of a Mechatronic System provides insight into the design process for a mechatronic system

1) Select elements in each of the areas
2) Model/Analyze/characterize behavior of the elements
3) Account for interactions between modules

3.2 Design of Mechatronic Systems

Stages in Design Process

- The need
- Analysis of problem
- Preparation of Specification
- Generation of possible solutions
- Selection of a suitable solution
- Production of a detailed design
- Production of working drawings

3.1 Goals and specific objectives

The life cycle for mechatronic design requires:

- Delivery parameters such as time, cost and medium;
- Reliability issues such as failure rates, materials and tolerance;
- Maintainability, whish necessitates modular design;
- Upgradeability
- Disposability processes including recycling and hazardous materials.

The key to success for any mechatronics system is to strike a balance between:

- Modeling, analysis, control design, computer simulation of dynamic system
- Experimental Validation of models, analysis and understanding key issue of hardware implementation

4.0 More Features

4.1 More User-Friendly

Mechatronics solutions also appeal to consumers because they are more user-friendly. The improvements in automotive technology over the past decades are evidence of this fact. Power windows, power door locks, keyless entry, and numerous other conveniences testify to the fact that consumers prefer mechatronic solutions.

4.2 Precision Control

Flow rate, speed, position, and any number of other variables can be controlled preciselywith a microcontroller. In many applications, purely mechanical solutions are not as efficient, nor as precise as mechatronic solutions. Cruise control in an automobile is a great example of how a mechatronic solution allows for precise control. A microcontroller based solution will factor in many different variables (i.e. velocity, acceleration, cumulative changes in velocity) in order to give the car a smooth acceleration to the desired speed as well as maintaining a constant velocity over varying load conditions.

4.3 More Efficient

The efficiency of a system can be improved by adding intelligence to the design. Certain portions of the system can be shut-off when not in use or a microcontroller can make better use of the energy available by offering the precision control described previously. Techniques such as Pulse Width Modulation (PWM) can be used instead of resistive elements to vary the voltage and current to a load, thereby increasing the efficiency of the system.

4.4 Lower Cost

In some cases, a mechatronic solution costs less than the alternative mechanical solution. A complex mechanical solution may be simplified using a microcontroller-based approach. Design time, product size, and reliability can all be improved with a mechatronic solution. All these factors impact the cost over the lifetime of a product.

4.5 Flexible Design

Design flexibility is a huge advantage to designing with a microcontroller. The specifications of a product can change during the course of its design. When a PIC MCU is used, the timing of a signal, the sequence of events, or any number of software controlled parameters can be changed quickly without the need for a product redesign.

This flexibility also allows the same hardware to be used in different products. The software is simply changed to meet the needs of each product.

4.6 Increased Reliability

Mechanical designs are prone to wear and tear over time. In many situations a mechatronic solution is more reliable. A good example of this is the odometer in your car. Mechanical odometers use a direct drive system that consists of a flexible cable running from the transmission to the odometer gage. The solution is unreliable because the cable is prone to failure. The modern mechatronic solution consists of an optical encoder and digital display, which increases system reliability.

4.7 Smaller Size

Adding a microcontroller to a system may result in space savings. Motor drive circuits, for instance, traditionally had to have over-sized drive stages to handle in-rush current. In-rush current can be limited and the size of the drive stage can be reduced by
implementing soft-startup using a microcontroller.

4.8 Safer

Adding intelligence to a system makes it safer. Whether you add an automatic shutdown to a coffee pot or sense when a system is overheating, numerous safety checks can be easily added to a system when a microcontroller is controlling the system.

5.0 Application Areas of Mechatronics

- Automation, and in the area of robotics
- Servo-mechanics
- Sensing and control systems
- Automotive engineering, in the design of subsystems such as anti-lock braking systems
- Computer engineering, in the design of mechanisms such as computer drives

6.0 Conclusion

Mechatronics plays a vital role in different applications of mechanical engineering, In many applications, purely mechanical solutions are not as efficient, nor as precise as mechatronic solutions. It is concerned with generating motions in machinery in a controlled way. Today's engineering systems requires multi-disciplinary design teams. In addition, the computer tends now to be an integral component of these complex systems. With the explosively increasing cost/size-effectiveness of computers, mechatronic systems are becoming common in any engineering discipline dealing with the modulation of physical power.

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