**Review on Mechanical Issues and Driver Solutions of Industrial PMAC Servo Systems: Parameter Estimation and Auto-tuning Concepts**

**ABSTRACT**

**As a result of the advanced industrial technology, industrial servo drive systems need advanced skills for managing the system and motion. Industrial servo systems have challenging mechanical characteristic for sensitive control and accurate stability of driver systems. These mechanical issues occur with respect to drive train of servo systems such as mechanical assembly, motion elements, motion types and loads. In this context, on the driver and control side, there are several approach and solution methods for mentioned mechanical issues. In this paper, problematic issues and offered solutions in the current literature for servo drive systems are defined and systematized.**

**Keywords: Servo Drive Mechanics, Mechanical Servo Issues, Filtering in Servo, Servo Control**

**INTRODUCTION**

**A well tuned servo system is robust and has the fastest possible response with (negligible or) no overshoot and steady state error. But, a well tuned servo system can lose its accurate response with disturbances that come from the mechanical dynamics of operated drive train. Drive train of a servo system contains controller-driver, motor and load. Controller-driver can be defined as white box, motor can be defined as grey box and load can be defined as black box. In this manner, tuning of the whole system can be done by controller-driver via motor with reflection from load to motor shaft.**

**The main principle in tuning a servo system is detecting the unwanted situations from motor and controller side and to suppress them. For this purpose, we have to define the unwanted situations with using mathematical models and their effects on the parameters of the system for starting the tuning process. In this manner, there are two strategies for operating the tuning process as known Off-line and On-line. Off-line tuning the servo system means that defining process is done under the zero or no-load (dummy) motions []. This type tuning can be done by using some previous information (commision) or without any information (self-commision) about any part of the system. The other type On-line tuning the servo system means that defining process is done during the loaded motions. This type tuning is more complicated than Off-line tuning because it needs dynamic measurements and decision mechanism in parallel with the work done by servo system []. Both strategies are shown in flowcharts as in figure1. Possible useful methods are demonstrated for each step.**

**Offline (self commission or commision)**

**1. detection of the disturbance of the system**

**From speed error, torque error, position error etc. or manual observation**

**2. stop or halt or pause the system**

**3. Start pre defined routine**

**4. calculate parameters**

**5. reactivate the load again**

**Online**

**1. detection of the disturbance of the system**

**From speed error, torque error, position error etc.**

**2. detection of the frequency of the disturbance**

**Fft, iteration, state variables, ..**

**3. detection of the amplitude and bandwidth of the disturbance**

**4. Filter setting with respect to detected f, q, BW**

**MECHANICAL ISSUES**

**Definitions (with figures), Sourced what**

**Reflection to motor and driver side (speed error, torque ripple, current error, phase difference ...)**

**Characterized of issue – frequency, peak and width definition of disturbances, shapes in time and freq domain.**

**1 periodic characteristic**

**2 non periodic characteristic**

**Parameters**

**Electrical Parameter (PMSM)**

|  |
| --- |
| **Electrical Parameters:** |
| : Series resistance |
| : d-axis inductance |
| : q-axis inductance |
| : Back EMF constant |
| : Rotor PM flux linkage |

**Mechanical Parameter**

|  |
| --- |
| **Mechanical Parameters:** |
| : Electromechanical torque |
| : Disturbance load torque |
| : Torque constant |
| : Rotor and load inertia |
| : Viscous friction coeff. |

|  |
| --- |
| **Variables:** |
| : rotor pole number |
| : rotor electrical speed |
| : rotor mechanical speed |
| : Laplace operator |
| : Back EMF+Cross coupling |

**Modelling**

**Motor types (DC, Induction Machine, PMAC) math model**

**Model of 2 and 3 mass system**

**Matlab models – real models (conveyor belt, gear wheel, fly wheel, robotic arms motions)**

**Nonlinear mechanical models and mathematical expressions**

**Controller and drivers**

**Current Controller**

**Speed Controller**

**Position Controller**

**DETECTION METHODS**

**How to find disturbance time duration and peak value ? (disturbance freq detection system)**

**-Adaptive approach : Adaptive notch filter ANF Regalia’s algorithm, MRAS**

**-Prior knowledge required: Disturbance observer, Inertial model control**

**-FFT, shifted discrete Fourier translations (SDFT), discrete wavelet transform (DWT), frequency weighting functions**

**-Kalman Filter (EKF)**

**++freq, amplitude, damping coeff**

**--Require appropriate model, computational requirement (real time implement difficult)**

**-Dissipative control + fitering techniques**

**ESTIMATORS & OBSERVERS**

**Kalman Filter based estimators**

**Extended kalman filter (EKF)**

**Reduced order kalman filters**

**Model referenced observers estimators (MRAS)**

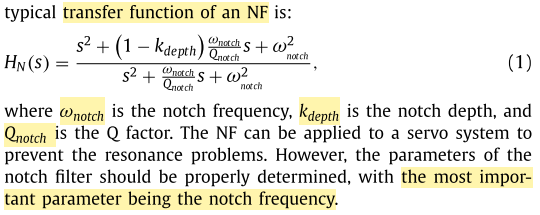
**Measured signals based estimators**

**Others**

**AI, Neural Network, Particle Swarm, Fuzzy Logic**

**FILTERs**

**Notch filter (adaptive notch, robust adaptive notch)**

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**Biquad Filter (easy digital implementation)**

**Low pass in which conditions**

**Band pass in which conditions**

**SYSTEM MANAGEMENT**

**Detection algoritmaları nasıl çalışıyor, hangi donanımda hangi yazılım koşuyor, Implementasyona uygun methodlar, ne kadar İşlem gücü gerekli?**

**DSP + FPGA**

**DSP: Speed loop, position loop, Robust Adaptive Notch Filter**

**FPGA: Current control loop, FFT, EKF**

**CONCLUSION**

**A servo system has unique and non-unique mechanical issues.**