**Literature Planner – Instructions**

Delete this page when submitting this document online for assessment.

**Reference Number:** Number your references starting from 1

**Authors:** If one or two authors list their names. If more than two list the first author followed by et. al.

**Title of Article:** The title of the research paper / book etc.

**Type:** State if it is a conference, journal, book etc.

**Publication:** The name of the publication that the work was published in.

**Year Published:** What year was article published

**Number of citations:** The number of citations that the publication has received to date. Also mention the source of data (e.g. Scopus or Google Scholar)

**Publication Rating:** Use Scopus to determine the CiteScore and ranking information for each publication. Not all publications are rated, use 'N/A' if there is no score. See notes on how to extract this from lecture 2, and the document ‘How to measure impact - CiteScore and citation counts’

**Primary or Secondary:** State if the research conducted in the article is primary or secondary research (see lecture notes week 2)

**What themes were discussed in the Literature Review:** Use keywords to discuss the major themes in the article

**What was the research question:** What was the question the article was trying to find the answer to?

**Design:** How did they try and answer the question: What did they do? E.g. simulation, experimental design, statistical analysis etc.

**What was the finding:** What answers were found from undertaking the research in the article?

**What were the gaps:** What limitations occurred in the research design or where outlined in the results or discussion?

*Note: When this work is submitted into Turnitin, it is ok if the similarity percentage is high due to the similarity in headings. What the markers will be concentrating on is the similarity in the text that you write*

**Literature Planner**

**Student Name: Student Number:**

**Topic:**

**Reference Number: Authors:**

**Title of Article:** Investigation of the micro-step control position system performance affected by random input signals

**Type:** Journal **Publication:**

**Year Published:** 2005 **Number of citations:**

**Primary or Secondary:**

**Publication Rating:**

*CiteScore: Rank: Percentile: In-Category: CiteScore Year:*

**What themes were discussed in the Literature Review?**

**What was the research question?**

**Design:** Experimental design; they created a microstepping driver and control unit using a ID controller.

**What was the finding?**

**What were the gaps?**

**Reference Number: Authors:**

**Title of Article:** H-infinity feedback control of a permanent magnet stepper motor

**Type:** Journal **Publication:**

**Year Published:** 1997 **Number of citations:**

**Primary or Secondary:**

**Publication Rating:**

*CiteScore: Rank: Percentile: In-Category: CiteScore Year:*

**What themes were discussed in the Literature Review?**

* Stepper motors originally designed to provide precise positioning without using sensors
* Stepper motor in open loop configuration results in very low performance
* Step response has significant overshoot and long settling time

**What was the research question?** Provide feedback control to PM stepper motor

**Design:**

**What was the finding?**

* Linear model is derived
* Model is used to design a controller
* Control technique uses H-infinity control
* This technique guarantees robustness to overcome effect of non-linearities, parameter variations and changes in load torque.

**What were the gaps?**

**Reference Number: Authors:** Liu

**Title of Article:** compensation of load-dependent position error for a hybrid stepper motor

**Type:** conference **Publication:**

**Year Published:** 2017 **Number of citations:**

**Primary or Secondary: primary**

**Publication Rating:**

*CiteScore: Rank: Percentile: In-Category: CiteScore Year:*

**What themes were discussed in the Literature Review?**

**What was the research question?**

**Design:**

**What was the finding?**

* Low efficiency of motor due to maximum currents through winding to ensure that a step command is not missed
* As torque increases the error increases in the motor positioning
* Stepper motor torque is a function of the winding currents
* Coil currents can be adjusted according to the torque applied to the motor to improve efficiency
* Error decreased 2.5 degrees per Nm to 0.2 degrees per Nm with rotary encoder
* Field oriented control

**What were the gaps?**

* Large position sensor used

**Reference Number: Authors:**

**Title of Article:** The efficiency of hybrid stepping motors: analysing the impact of control algorithms

**Type:** Journal **Publication:**

**Year Published: 2014** **Number of citations:**

**Primary or Secondary:**

**Publication Rating:**

*CiteScore: Rank: Percentile: In-Category: CiteScore Year:*

**What themes were discussed in the Literature Review?**

**What was the research question?** Impact of control algorithm on the motor efficiency is analysed

**Design:**

**What was the finding?**

* Well known that energy efficiency is low
* Most stepper motors are driven inefficiently with maximum current to avoid step loss
* Full step/half step result in poor torque/current ratio
* Efficiency of fractional horsepower drives (stepper motors) is unaddressed in literature
* Worldwide market for stepper motors is 17%
* Energy savings is rather low, but motors emit lots of heat
* Open loop drives torque and speed ripples
* Using sensorless control for steppers is not common
* Contains torque-position curves
* Optimum current/ torque curves
* Full step and microstepping reduces current required due to higher average torque available
* Theoretical efficiency can be predicted but only considers copper losses
* Efficiency can be improved up to 900% by controlling the current better
* Proposed simple formula to estimate optimum current (add 20% safety margin)
* Vector control algorithm increases efficiency up to 62%

**What were the gaps?**

* Actual efficiency is unknown
* Algorithm accuracy not addressed

**Reference Number: Authors:**

**Title of Article:** Aperiodic and chaotic dynamics in hybrid step motor – new experimental results

**Type:** **Publication:**

**Year Published:** 2010 **Number of citations:**

**Primary or Secondary:**

**Publication Rating:**

*CiteScore: Rank: Percentile: In-Category: CiteScore Year:*

**What themes were discussed in the Literature Review?**

**What was the research question?** Deals with non-linearaties that lead to chaotic behaviour

**Design:**

**What was the finding?**

* Stepper motors are non-linear (as frequency increases motor will come to a stall)
* Chase current formulas

**What were the gaps?**

**Reference Number: Authors:**

**Title of Article:** Spontaneous speed reversals in stepper motors

**Type:** Journal **Publication:**

**Year Published:** 2006 **Number of citations:**

**Primary or Secondary:**

**Publication Rating:**

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**What themes were discussed in the Literature Review?**

**What was the research question?** Explanation of why stepper reverses speed (up to 3 times)

**Design:**

**What was the finding?**

* Steppers in open-loop are susceptible to renonances at step rates the same as subharmonics and resonance frequency (susceptibe to errors)
* Microstepping and closed loop avoids resonances/speed reversals

**What were the gaps?**

**Reference Number: Authors:**

**Title of Article:** Development of microprocessor, time optimised stepper motor driving algorithm

**Type:** **Publication:**

**Year Published:** 2017 **Number of citations:**

**Primary or Secondary:**

**Publication Rating:**

*CiteScore: Rank: Percentile: In-Category: CiteScore Year:*

**What themes were discussed in the Literature Review?**

**What was the research question?**

**Design:**

**What was the finding?**

* Microstepping provides smooth motion and provices good torque and excellent resolution
* Equations for maximum motor velocity, motor resolution, commutation frequency
* Sample rate of 10ms/sample CC of 5000Hz
* Driver shifts into full step mode at higher frequency and produces higher torque
* If high precision and smooth motion is desired use maximum commutation frequency
* If high torque is required use low commutation frequency

**What were the gaps?**

**Reference Number: Authors:**

**Title of Article:** intelligent microstepping system for bipolar stepper motor control with step and direction interface

**Type:** **Publication:**

**Year Published:** **Number of citations:**

**Primary or Secondary:**

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**What themes were discussed in the Literature Review?**

**What was the research question?**

**Design:**

**What was the finding?**

* Shows torque equations for a motor with currents through coils

**What were the gaps?**

**Reference Number: Authors:**

**Title of Article:**

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**What themes were discussed in the Literature Review?**

**What was the research question?**

**Design:**

**What was the finding?**

**What were the gaps?**

**Reference Number: Authors:** Le, Van Hoang, Wook Jeon

**Title of Article:** Advanced closed-loop control to improve the performance of hybrid stepper motors

**Type:** Journal **Publication:**

**Year Published:** 2017 **Number of citations:**

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**What themes were discussed in the Literature Review?**

**What was the research question?** Presents a closed-loop control for a stepper motor

**Design:**

**What was the finding?**

* Uses a PI current control method for current tracking
* Able to remove resonance at low speed and reduce vibration at high speed
* Key to improving performance is to reduce resonance at low speed and vibration at high speed
* Problem is that only one is usually able to be solved at a time
* Outlines intelegent control algorithms dampen resonance and vibration but generally require a high computing load
* Provides effective method for dampening speed and eliminating resonance
* PI controller used has a compensation gain component which is determined by the motor operating speed (formula in paper for Kc)
* Speed of most stepper motors is up to 500k pulses per sec or 3000 rpm
* Considers position error AND speed error in the control loop
* Uses optical encoder
* Proposed control method prevents stalling at higher step rates leading to increased speed and torque
* Can potentially upgrade motor control systems by considering life identification to adapt for varying loads

**What were the gaps?**

* The damping method proposed requires an identification process for resonances
* Damping method is limited to applications with varying loads

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