Robotic Positioner

UNIVERSITY OF SASKATCHEWAN
College of Engineering
ENGINEERING.USASK.CA

DOEPKER INDUSTRIES LTD.

PRESENTED BY GROUP 5:
Thomas Hu, Jordan Smith,
Jason Wong

Agenda

- Doepker Industries Ltd
- Problem Description
- Requirements Analysis
- System Alternatives
- System Design

DOEPKER INDUSTRIES LTD

About Doepker Industries

- Provides value in the transportation industry in North America
  - Agriculture
  - Flat decks
  - Oil & gas
  - Forestry
  - Gravel
  - Heavy haul

PROBLEM DESCRIPTION

Problem Statement

“There exists a need for a low-cost system that can electrically rotate a load for welding applications to increase efficiency and safety.”

Why is this important?

- Currently only uses mechanical rotators.
- Advancing mechanical machines forward with electronics.
- Provides a safer environment for the users.
- Improves efficiency.

REQUIREMENTS ANALYSIS

Design Constraints

The System Must:

- retrofit Doepker’s existing support frames
- use an electric motor
- not exceed $10,000 Canadian Dollars to build
- be controlled using physical buttons on a control panel

Design Requirements

The System Shall:

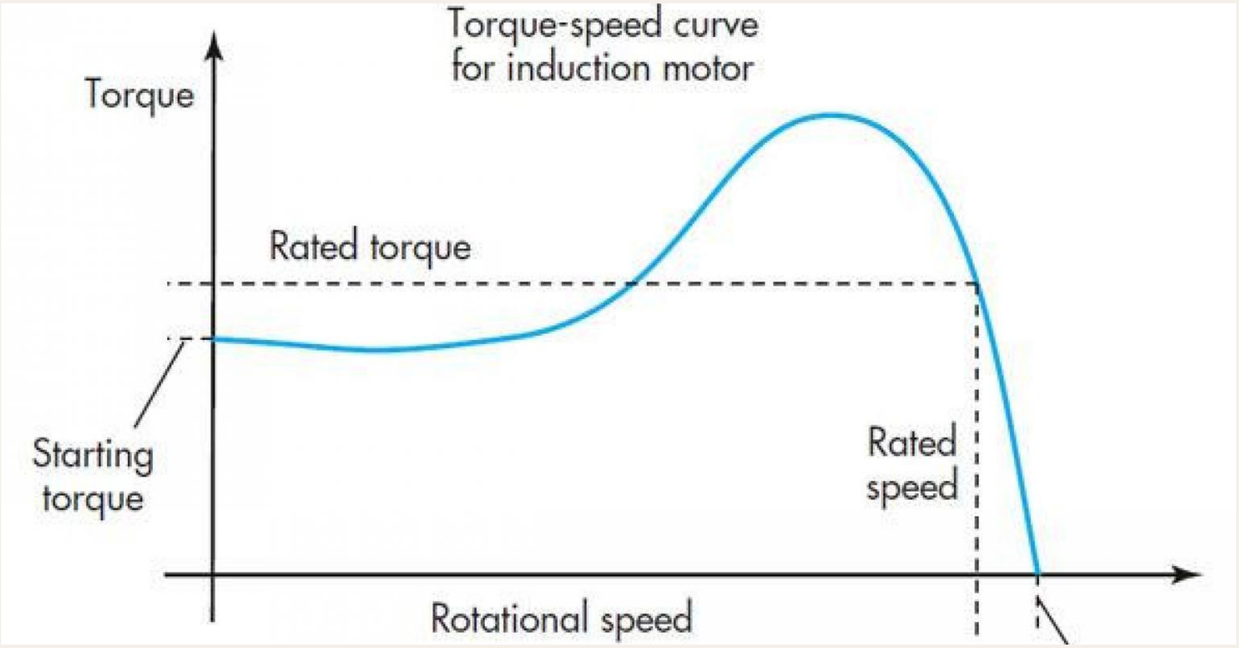
- have a rotation speed between 1-5 rpm
- recall and rotate to a preset angular position
- require a safety button to be depressed to operate the system
- be operated from a control panel separated from the rotating portion of the system
- support up to max load of 500 kilograms
- rotate a load 360˚ around the horizontal axis

SYSTEM ALTERNATIVES

Motor Alternatives

Induction Motors

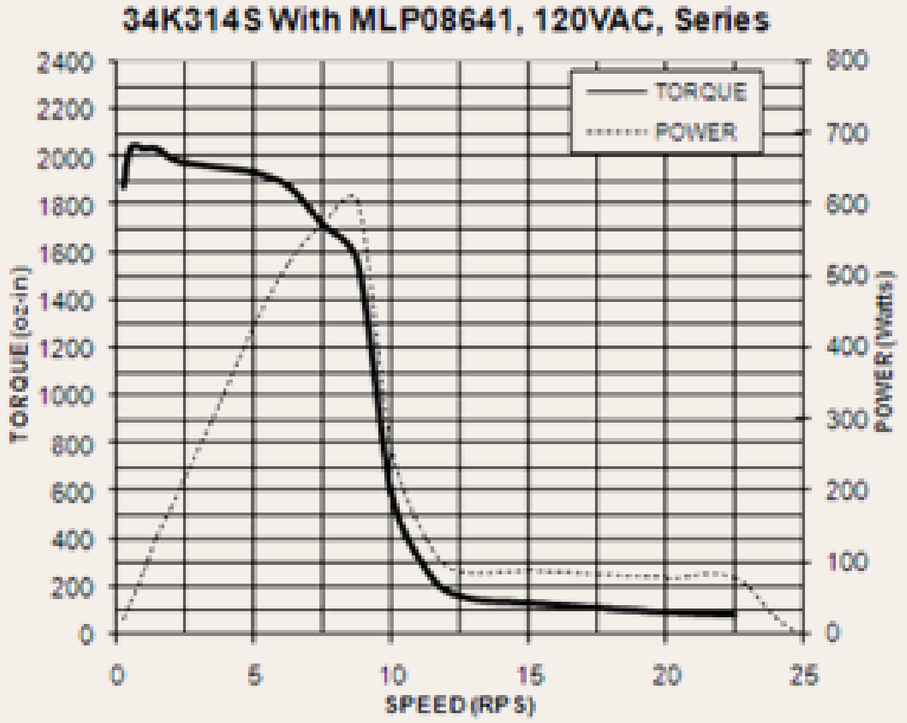
- Pros
  - Inexpensive
  - Easy to maintain
- Cons
  - Speed control is very limited and expensive via variable frequency drive
  - High in rush current when heavy loaded
  - Requires external positioning sensors



Motor Alternatives

Stepper Motors

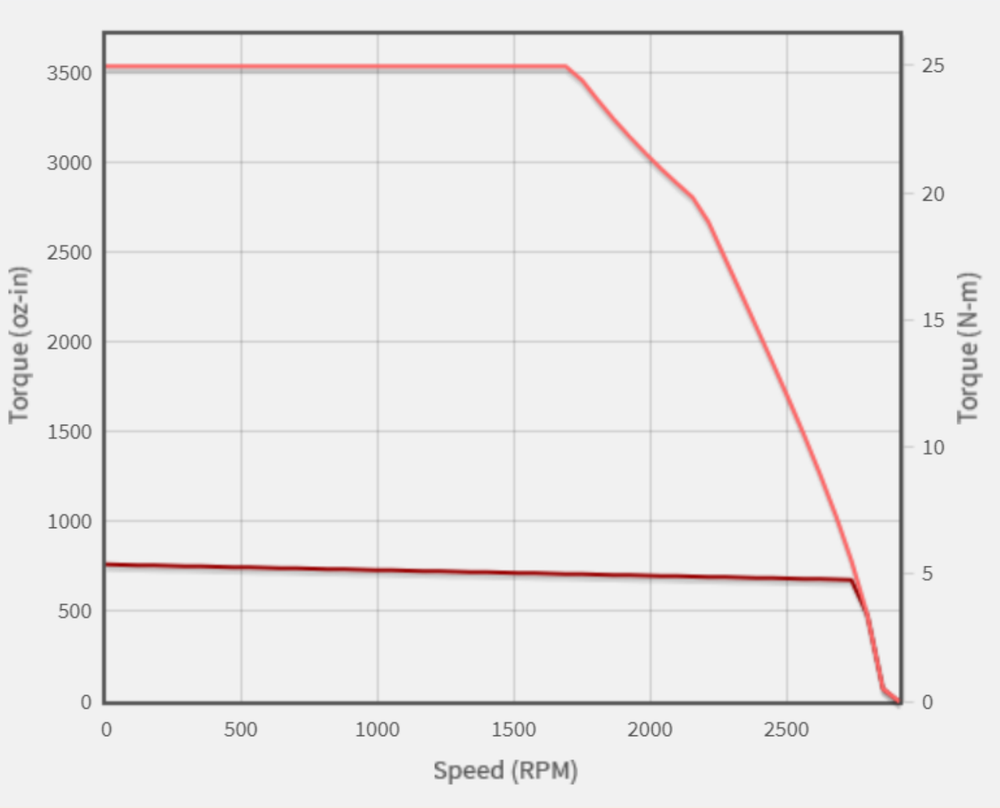
- Pros
  - High torque at lower speeds
  - Relatively simple operation
  - Possible to operate in closed loop feedback eliminating external sensor
- Cons
  - Sudden drop off in torque as speeds increase
  - Noisy
  - Requires external driver



Motor Alternatives

Servo Motors

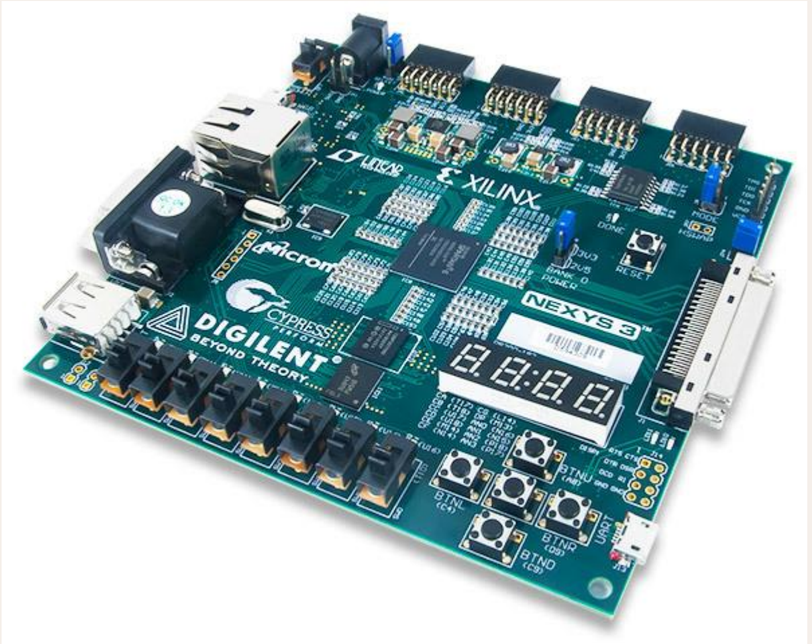
- Pros
  - Encoder allows for a closed loop feedback operation
  - Near constant torque within operational speeds
  - Integrated encoder for high precision position tracking
- Cons
  - Expensive



Control System Alternatives

FPGA

- Pros
  - Precise PWM motor control
  - Optimal performance
- Cons
  - Time intensive software development
  - Difficult memory management
  - Can be expensive



Control System Alternatives

Programmable Logic Controller (PLC)

- Pros
  - Reliability
  - Remote control
  - Possible to operate in closed loop feedback eliminating external sensor
- Cons
  - Expensive
  - Not much benefit for this application

Control System Alternatives

Microcomputer

- Pros
  - Simple learning curve
  - Powerful in terms of processing power
- Cons
  - Analog to digital conversion
  - Less accurate timing control
  - SD card will wear out

Control System Alternatives

Microcontroller

- Pros
  - Quickly prototype projects
  - Robust memory management
  - Abundant or expandable pins & ports
  - Reasonable learning curve
  - Inexpensive
- Cons
  - Reliability

SYSTEM DESIGN

Key Components

- **MICROCONTROLLER**

  A compact integrated circuit designed to operate the motor.

- **SERVO MOTOR**

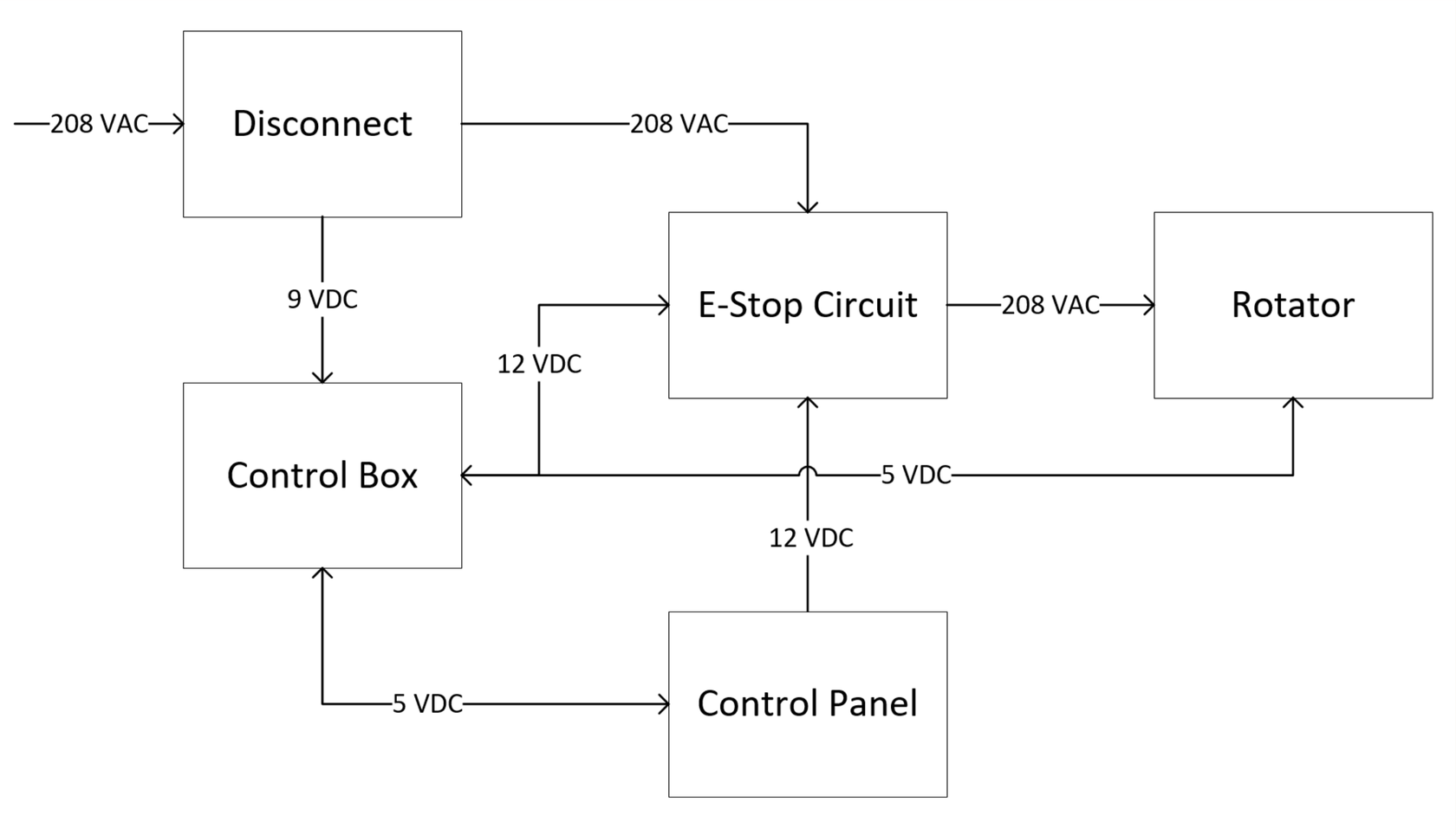
  A rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration.

- **ENCODER**

  A motor mounted encoder provides closed loop feedback signals to communicate the speed and position of the motor shaft.

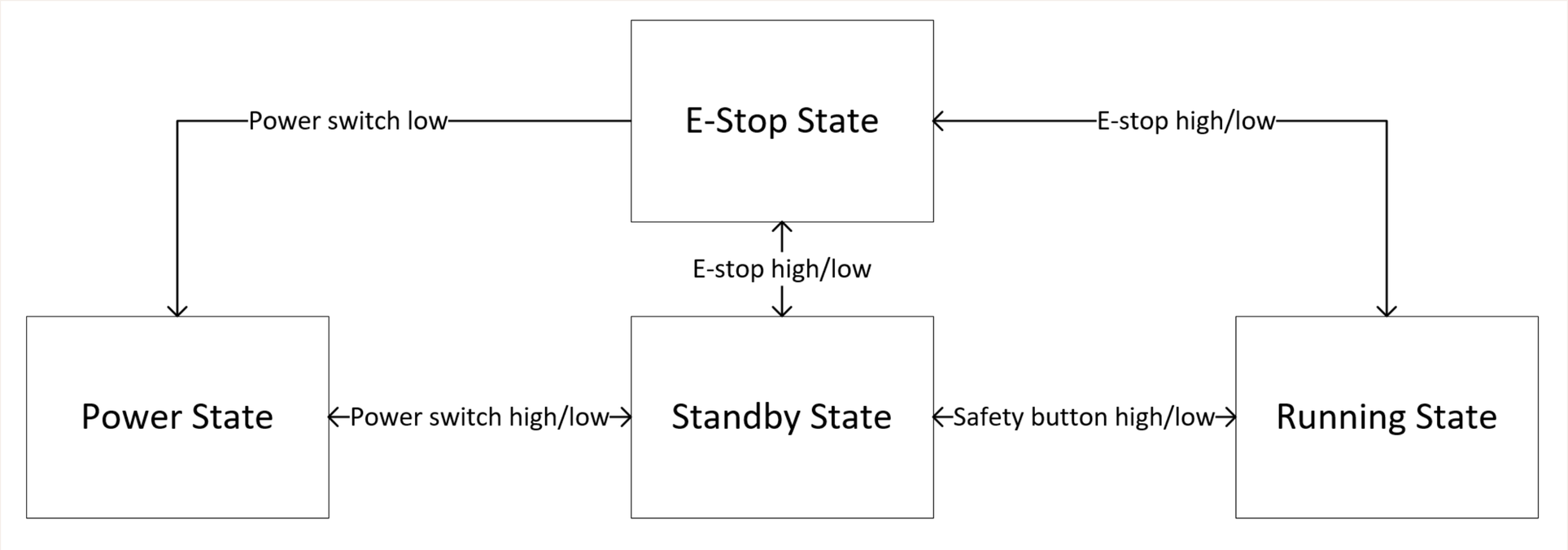
- **GEARBOX**

  A mechanical drive to step down the speed of rotation from the motor shaft to the output drive, proportionally increasing the torque.



System-Level Block Design

Hardware Design



System-Level Block Design

Software Design

Q&A

Choosing A System

- Employed a weighted decision matrix based on requirements and safety considerations:

Requirement	Weight	FPGA	PLC	Microcomputer	Microcontroller
Cost	20%	2	1	3	4
Memory Management	20%	1	2	3	4
Compatibility	20%	4	2	1	3
Reliability	20%	4	3	1	2
Development	20%	1	3	2	4
TOTAL	**100%**	**2.4**	**2.2**	**2**	**3.4**

BOM

Single Phase, 208V Operation w Slewing Drive

Description	Item #	Supplier	Unit	Price	Qty	Total
E-Stop Relay 1ph	653-MKSITI-10AC240	Mouser	Each	$ 50.86	1	$ 50.86
DC Power Supply, 12V 1ph input	495-T1b120-112EX	Mouser	Each	$ 193.40	1	$ 193.40
12 Channel Control Cable	662-1181C-100	Mouser	100ft spool	$ 247.44	1	$ 247.44
4 Conductor 12AWG SOOW	https://www.homedepot.ca/product/s	Home Depot	Meter	$ 9.73	10	$ 97.30
1Ph 15A Plug	562-Q720	Mouser	Each	$ 8.02	1	$ 8.02
1Ph 15A Receptacle	562-Q-722	Mouser	Each	$ 9.80	1	$ 9.80
Momentary Push Buttons	https://www.amazon.ca/dp/B01MR0E1	Amazon	pack of 6	$ 12.99	1	$ 12.99
E-Stop NC Latching Push Button	123-61-6461.4047	Mouser	Each	$ 43.84	1	$ 43.84
Diode	583-R5000F	Mouser	Each	$ 0.40	10	$ 4.00
LED	606-5111F1	Mouser	Each	$ 2.36	5	$ 11.80
Resistors			Each			$ -
AND Gate	595-SN74Ls08N	Mouser	Each	$ 0.92	5	$ 4.60
Transistor	610-TIP29C	Mouser	Each	$ 1.62	5	$ 8.10
Voltage Regulator, 9V	511-L7809ACV	Mouser	Each	$ 0.85	3	$ 2.55
1ph 240V Disconnect and enclosure	https://www.homedepot.ca/product/s	Home Depot	Each	$ 33.85	1	$ 33.85
Enclosure for Remote	EPOD10X10X4	Westburne	Each	$10.99	1	$ 10.99
Servo Motor 1.8HP with Integrated Drive	CPM-MCVC-N0562P-RLN	Teknic	Each	$ 965.90	1	$ 965.90
Gear Reducer(10:1 or 60:1)		Princess Auto	Each	$159.00	1	$ 159.00
Slewing Drive	WD-L 0343/3-04557	IMO	Each	$ 1,718.00	1	$ 1,718.00

Total	$ 3,582.44
Without Slewing Drive	$ 1,864.44