

Robotic Positioner



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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

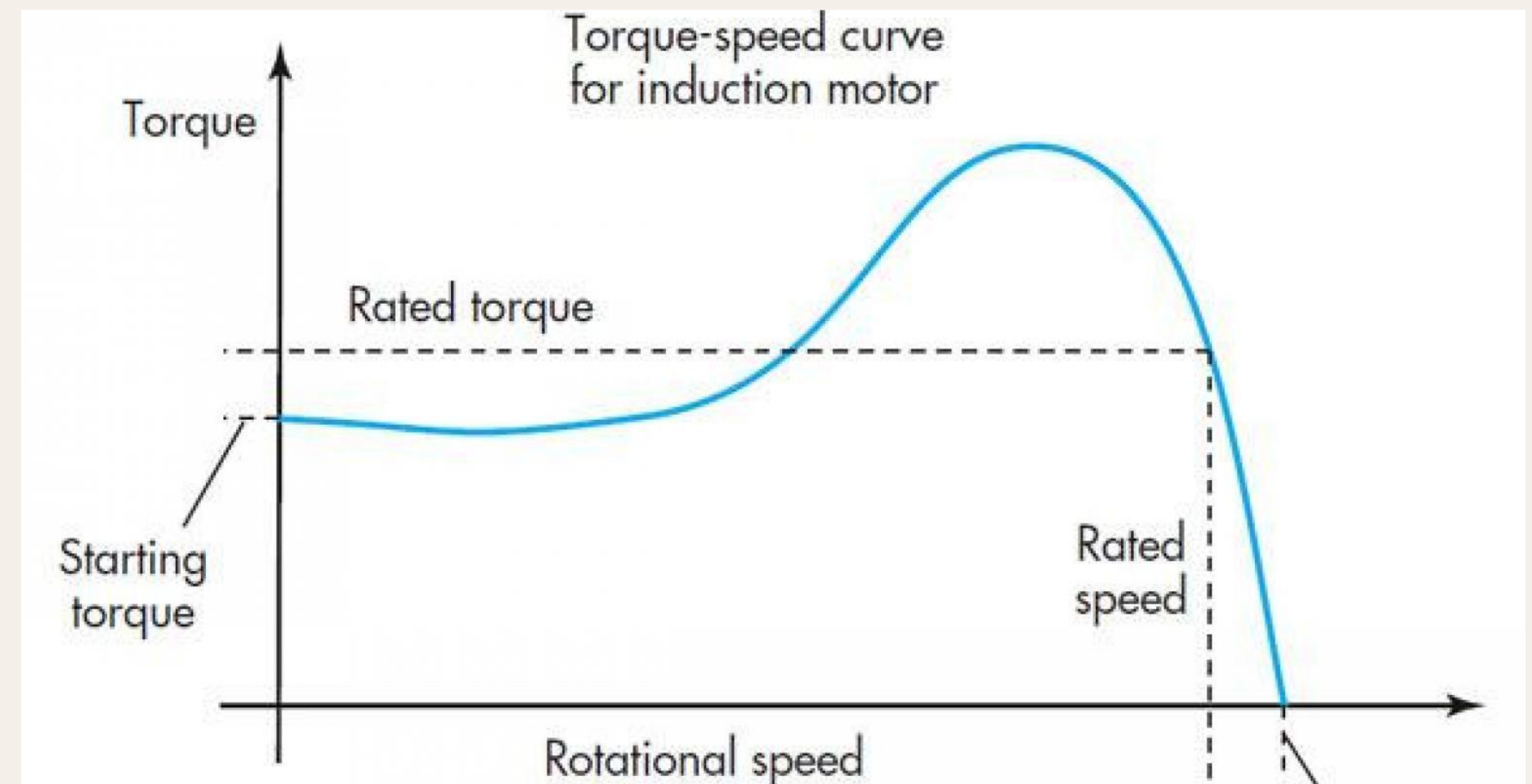
SYSTEM ALTERNATIVES

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

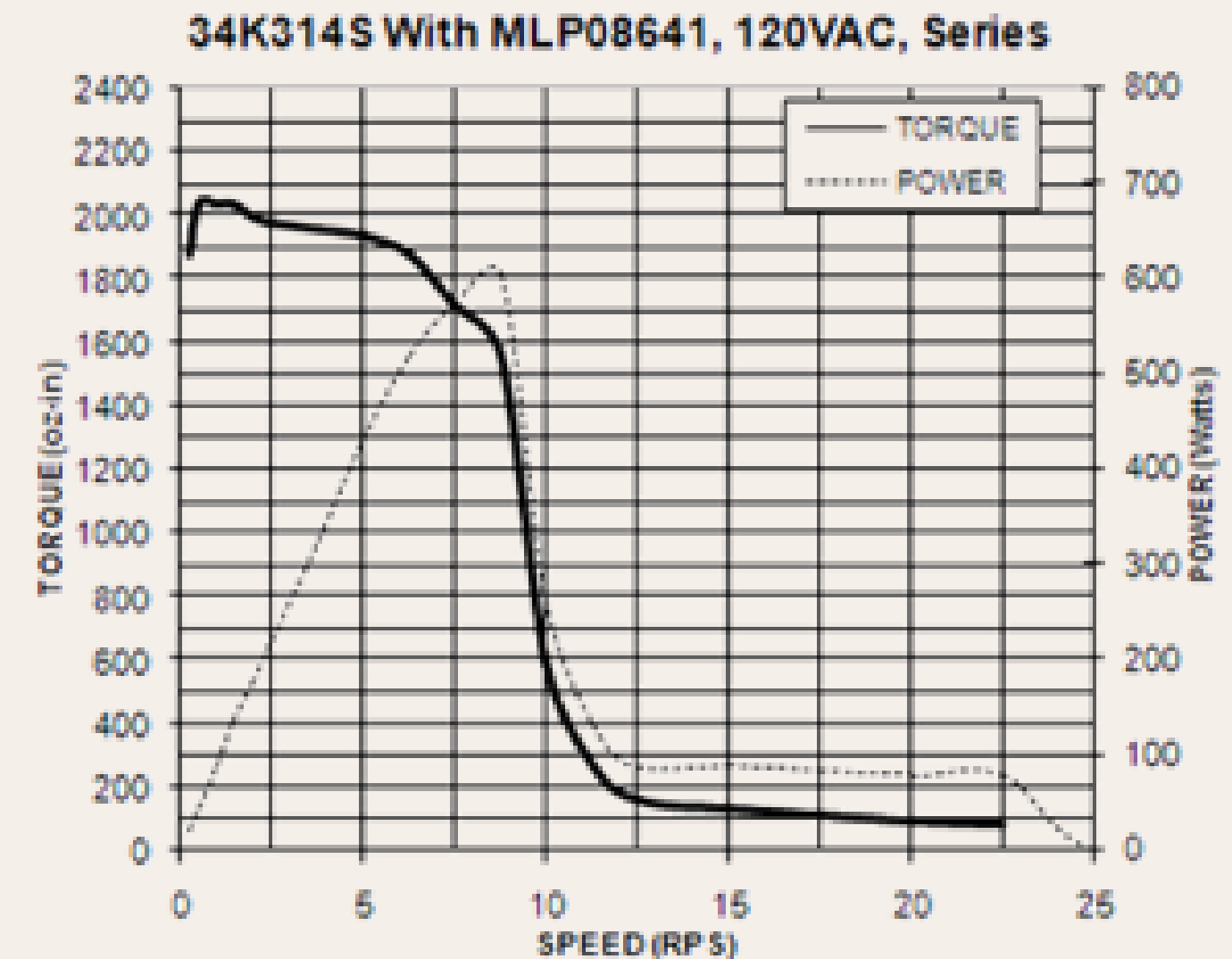


Motor Alternatives



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

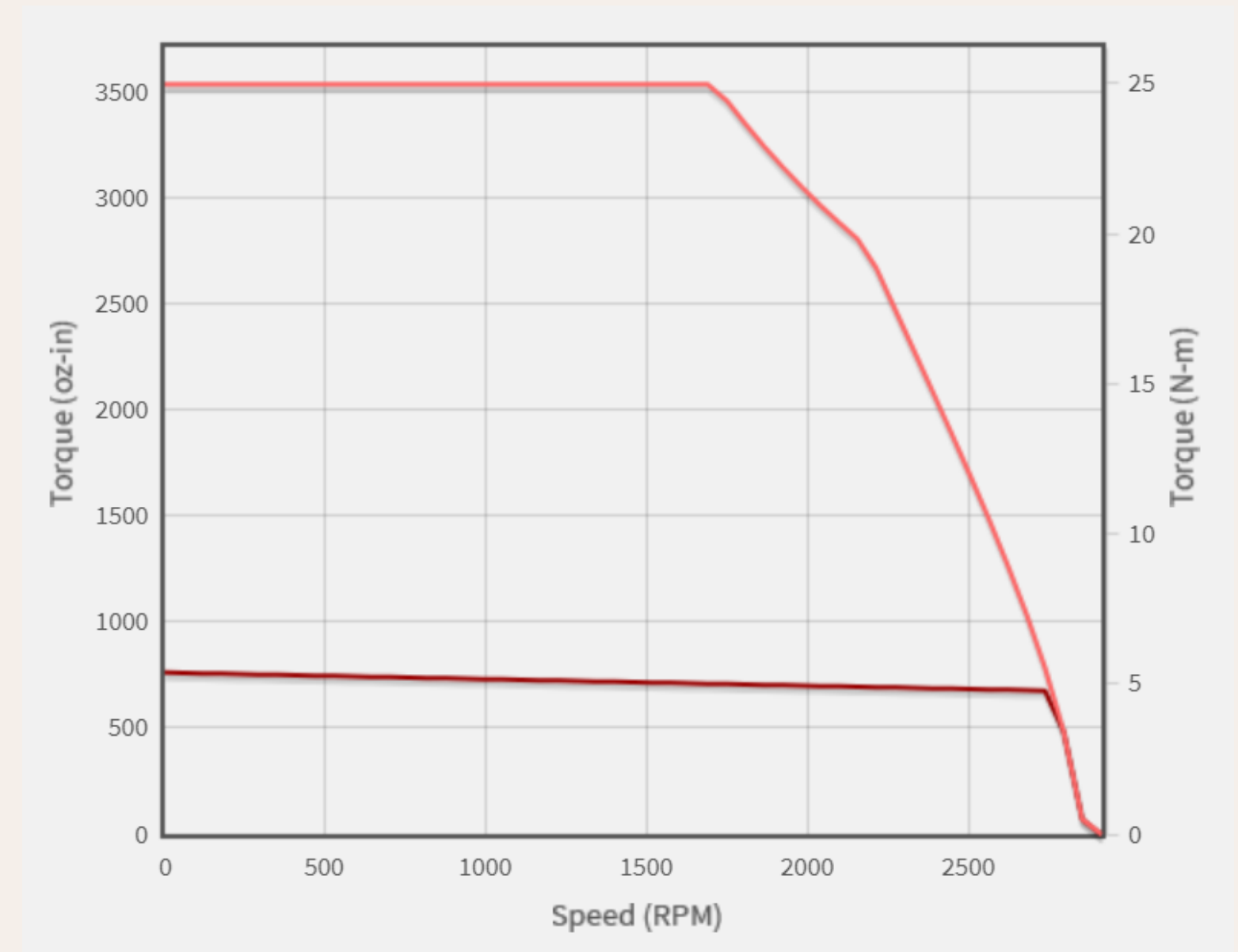


Motor Alternatives



Servo Motors

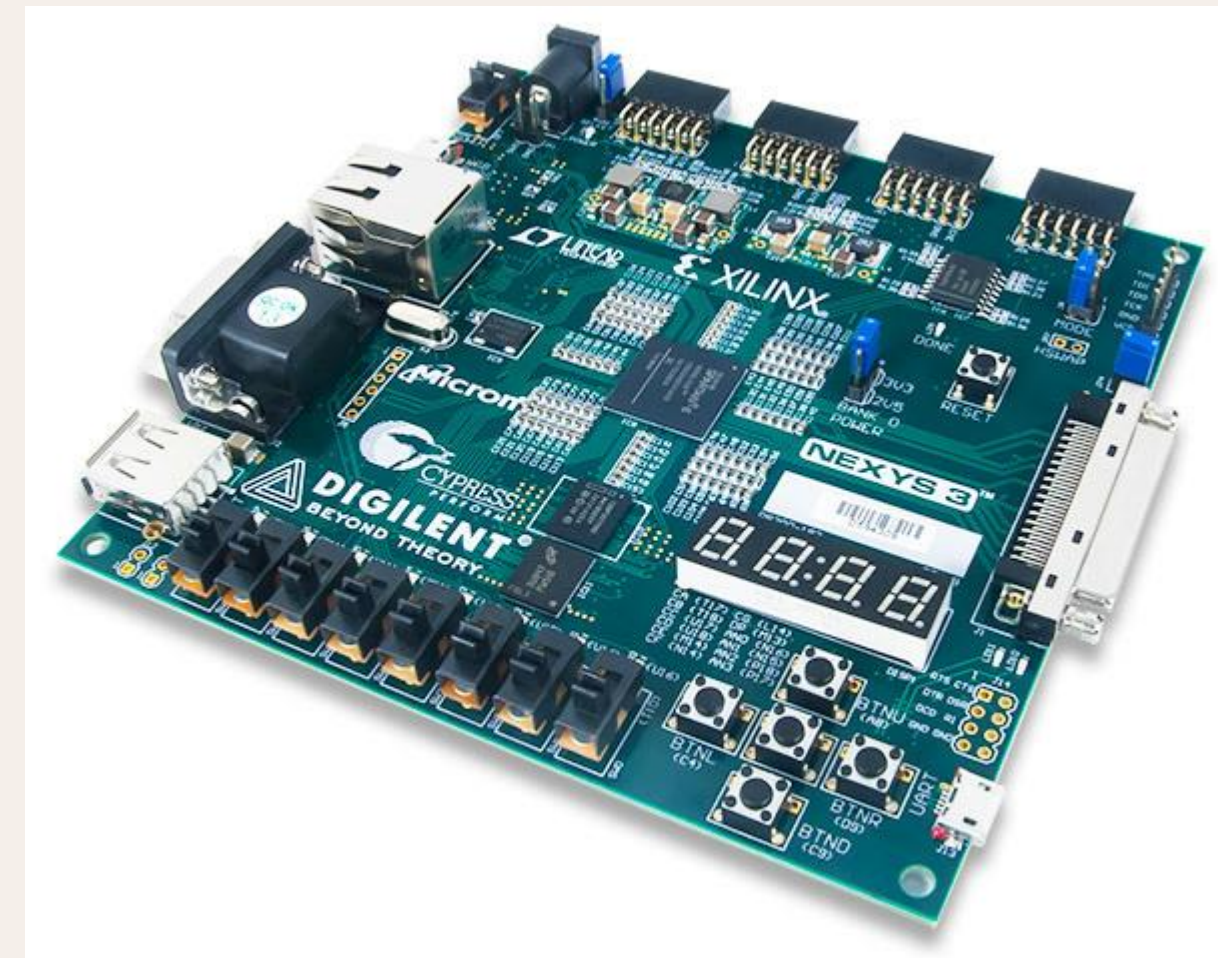
- Pros
 - Encoder allows for a closed loop feedback operation
 - Near constant torque within operational speeds
 - Integrated encoder for high precision position tracking
- Cons
 - Expensive



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

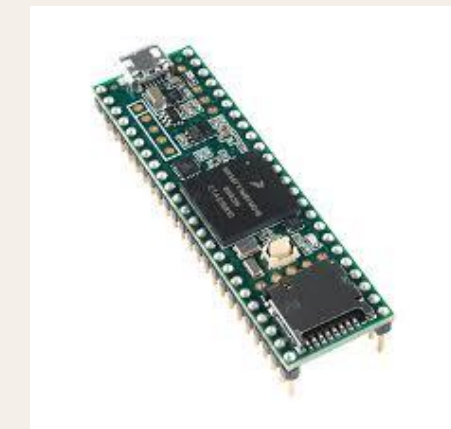
- Pros
 - Simple learning curve
 - Powerful in terms of processing power
- Cons
 - Analog to digital conversion
 - Less accurate timing control
 - SD card will wear out



Control System Alternatives

Microcontroller

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



SYSTEM DESIGN

- MICROCONTROLLER

A compact integrated circuit designed to operate the motor.

- ENCODER

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

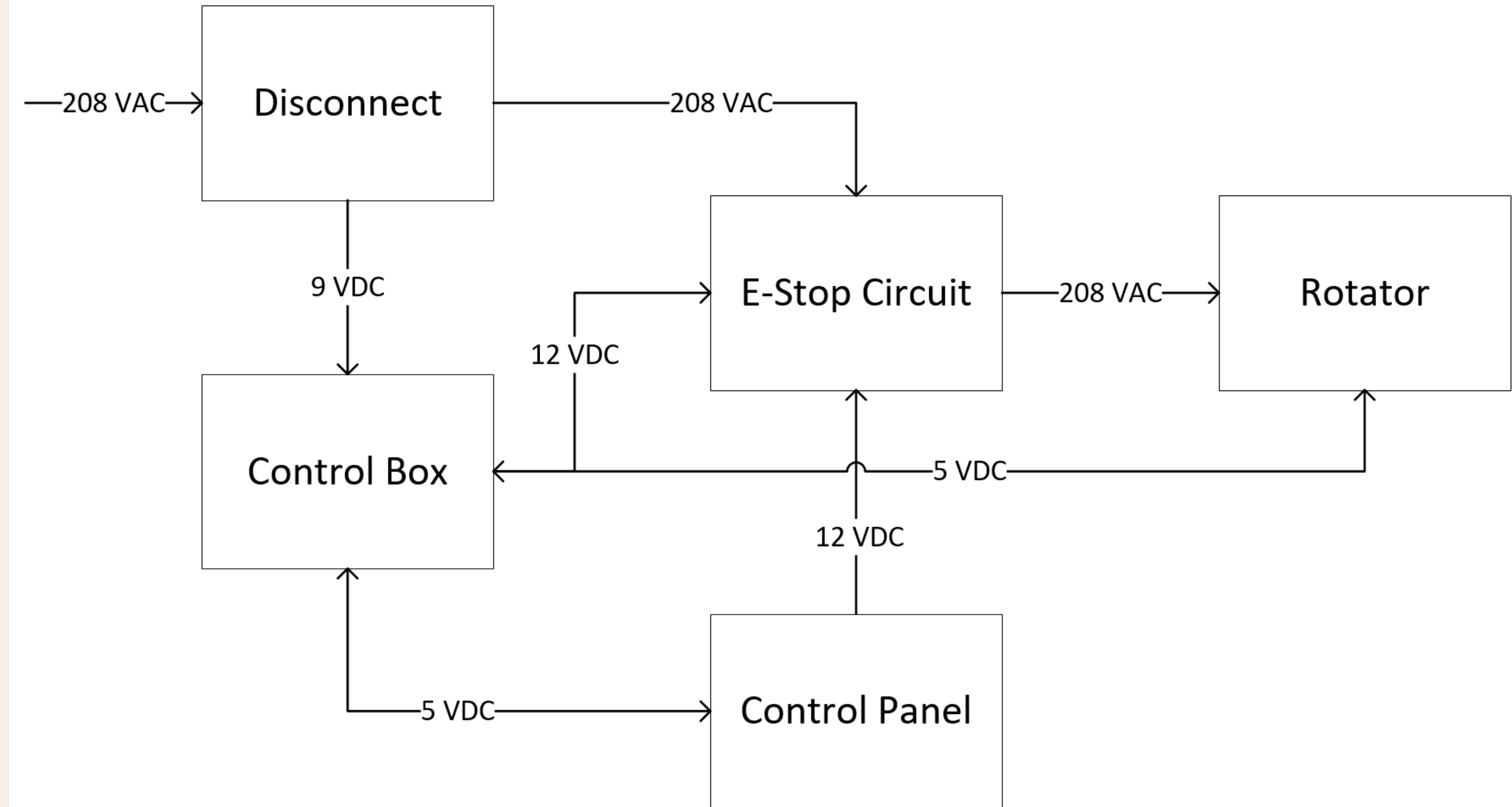
- SERVO MOTOR

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

- GEARBOX

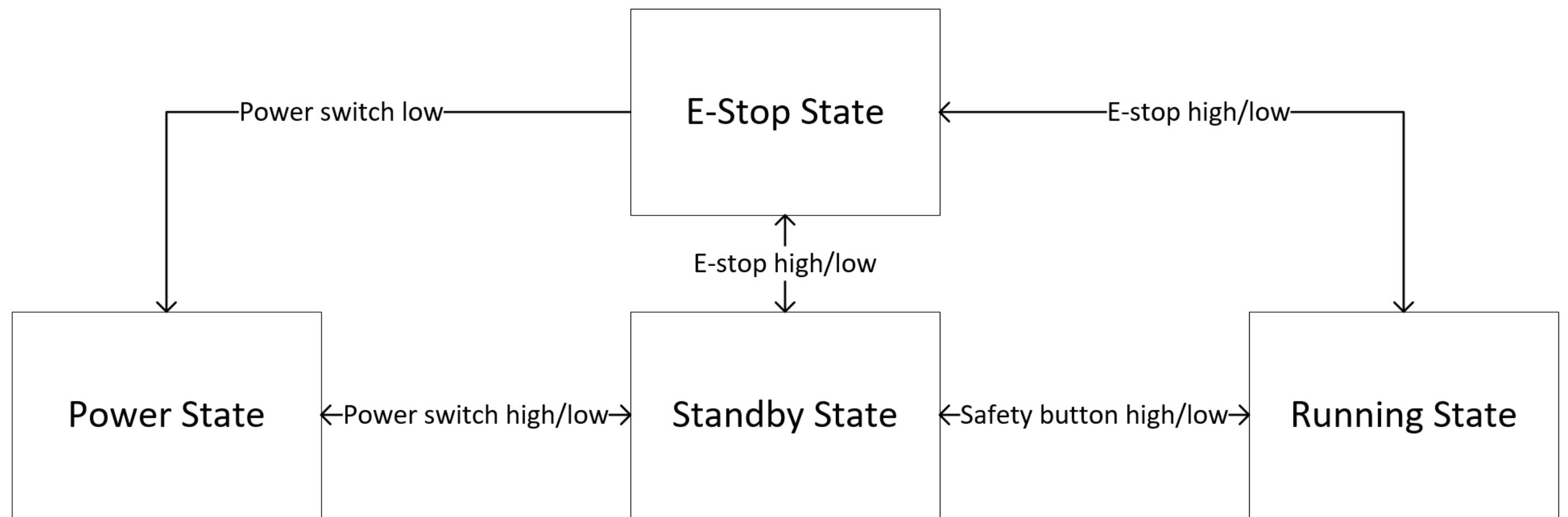
A mechanical drive to step down the speed of rotation from the motor shaft to the output drive, proportionally increasing the torque.

Key Components



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

BOM

Three-Phase, 575V Operation w Slewing Drive and SEW Motor

Description	Item #	Supplier	Unit	Price	Qty	Total
E-Stop Relay 3ph 575V	655-P25P42D22P1-12	Mouser	Each	\$ 175.03	1	\$ 175.03
DC Power Supply, 24V 3ph input	209-DNR240TS24-I	Mouser	Each	\$191.70	1	\$ 191.70
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
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
3ph 575V Disconnect	HUBHBLDS3	Westburne	Each	\$ 493.95	1	\$ 493.95
Enclosure for Remote	EPOD10X10X4	Westburne	Each	\$10.99	1	\$ 10.99
Geared Motor	RF27	SEW	Each	\$ 1,262.00	1	\$ 1,262.00
Slewing Drive	WD-L 0343/3-04557	IMO	Each	\$ 1,718.00	1	\$ 1,718.00
Adaptation		IMO	Each	\$ 209.30	1	\$ 209.30

Total	\$ 4,493.59
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