CT&I Spindle Drill Controller

WCP04

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Sponsor: IEEE Binghamton Section

Client: Center for Technology and Innovation (CT&I)

External Advisor : Art Law

Faculty Advisor: Jack Maynard

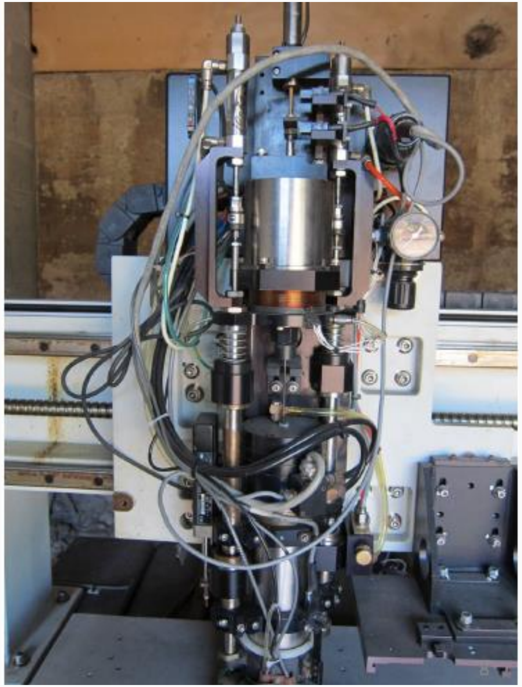
Agenda

- CT&I/WCP04 Project goals
- Spindle drill composition/operation
- Major findings
- Detailed Controller Diagrams
- Design explanation
- Project finances
- Fall/Spring schedule

CT&I Project Goals

- CT&I is creating a museum demonstrating Southern Tier technology
- They acquired 2 vintage spindle drills that will be placed in an exhibit
- Use the Spindle Drill to develop a platform for games and demonstrations
- 2 year Project:
  - First year (WCP04) will be research & developing a controller
  - Next year’s team will take our research and controller to make a game

Executive Summary



Our main objectives are:

- Repurpose a vintage spindle drill
- Develop a Theory of Operations Manual
- Build a Proof of Concept Controller for the Spindle Drill

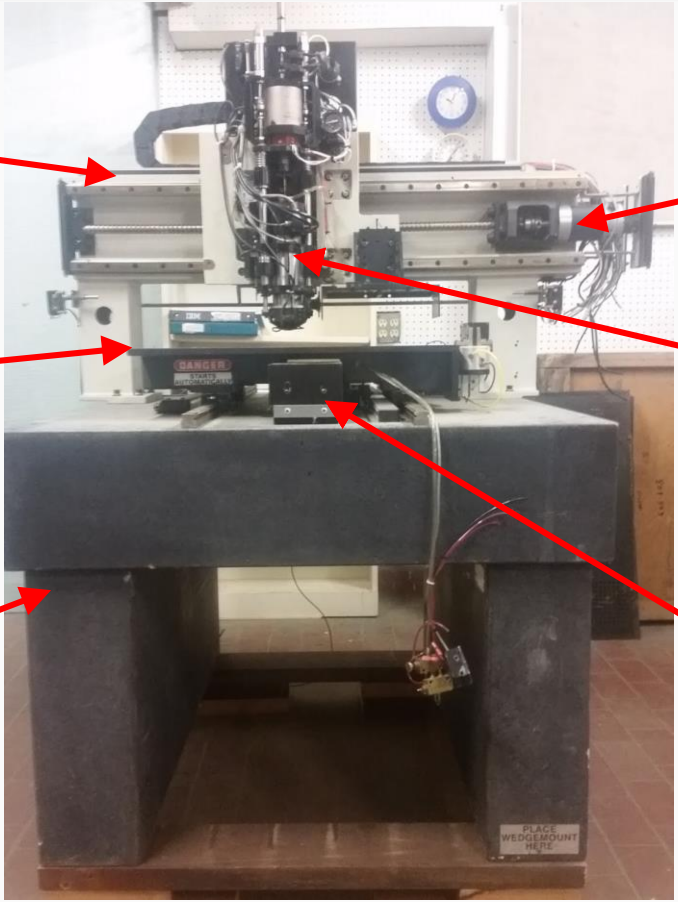
Constraints:

- Our Drill hasn’t undergone required maintenance
- Hasn’t operated in 5 years

WCP04 Goals

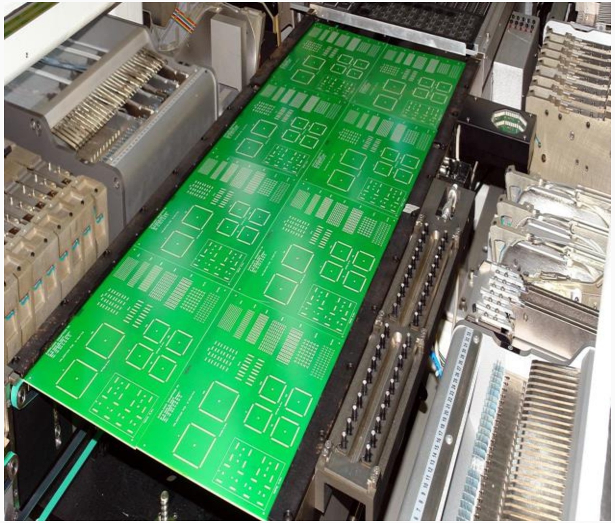
- We will get a critical subset of functions operational
- Design a controller to control X-Y movement of the Spindle Drill
- Document independent functions of the drill
- User Manual will describe the operation of the drill
- The next WCP group will implement our controller in their designs

Drill Layout



Drill Information

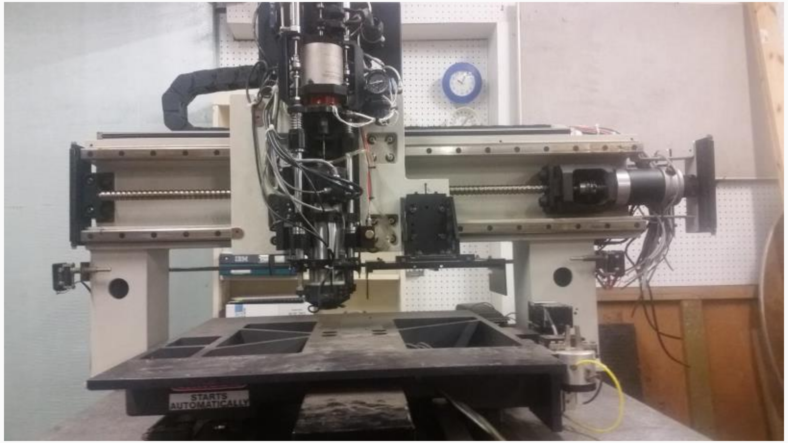
- Manufactured by Electro Scientific Industries
- Used by i3 electronics, an IBM successor
- Used to drill holes in PCBs with up to 40 layers
- Some boards require 40,000 holes
- Each hole takes 4-5 “hits”
- One PCB could require over 150,000 “hits” from the drill



An example of a large PCB

How The Drill Works

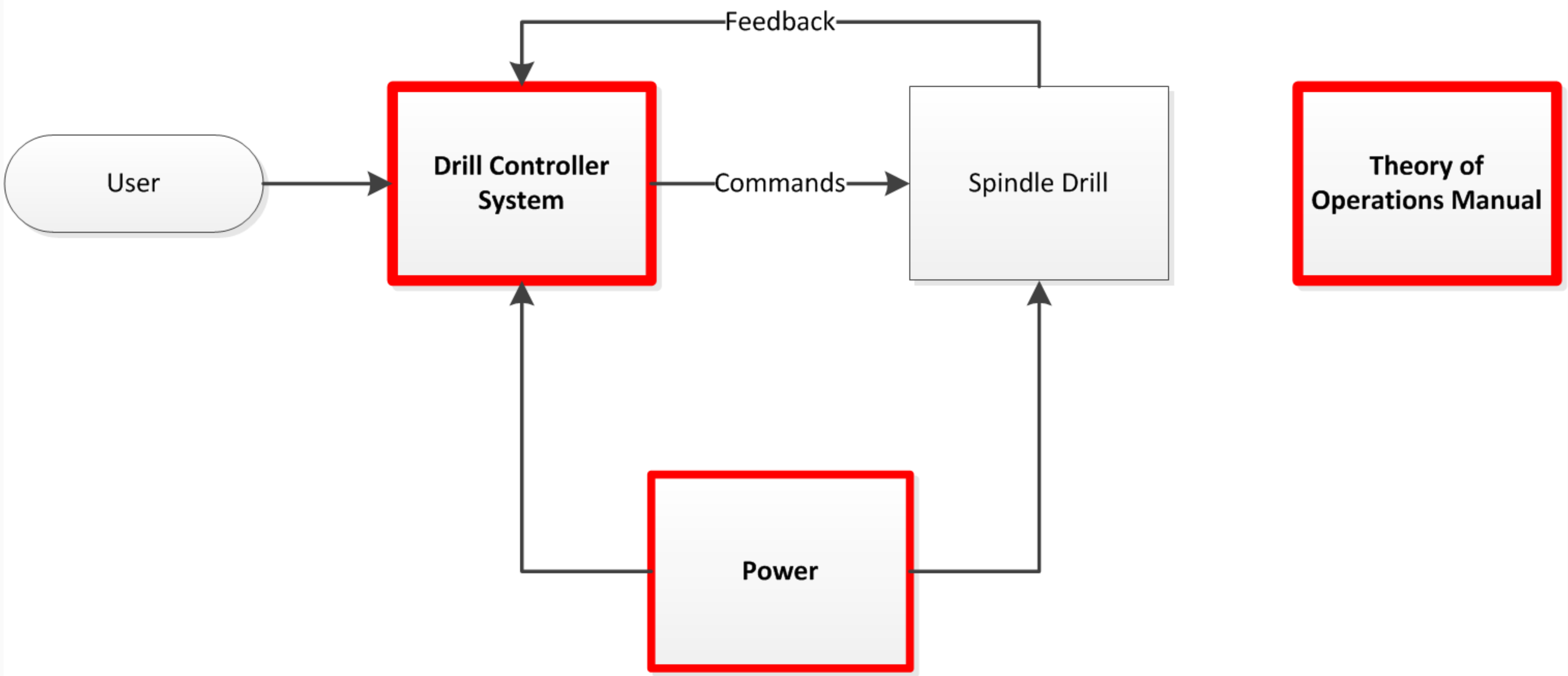
- X-Y directions controlled by DC brushed motors
- Z Direction controlled by linear motor
- Sensors detect drills location to increase accuracy
- Pneumatics control drill bit and circuit board clamps



Major Findings

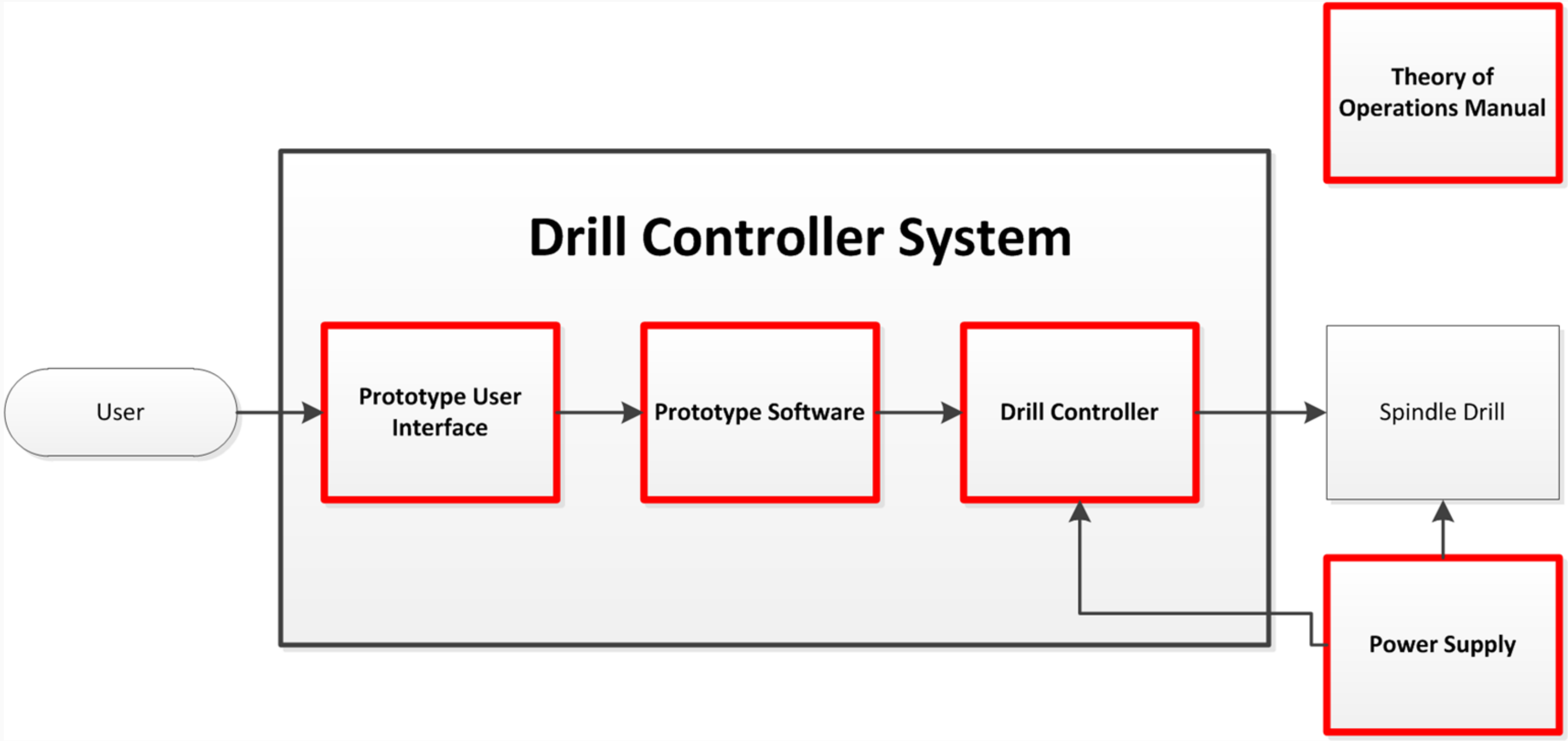
Constraints	Positives
Motors have been out of use	Motor data-sheet acquired
Vintage controller chassis not operable	We have designed our own controller
Drill wires have been severed	Drill motor wires labeled
Drill spinning requires cooling	Cooling not necessary in X-Y movement
Drill has complex pneumatics	Our controller doesn’t require pneumatics

Operational Context Diagram



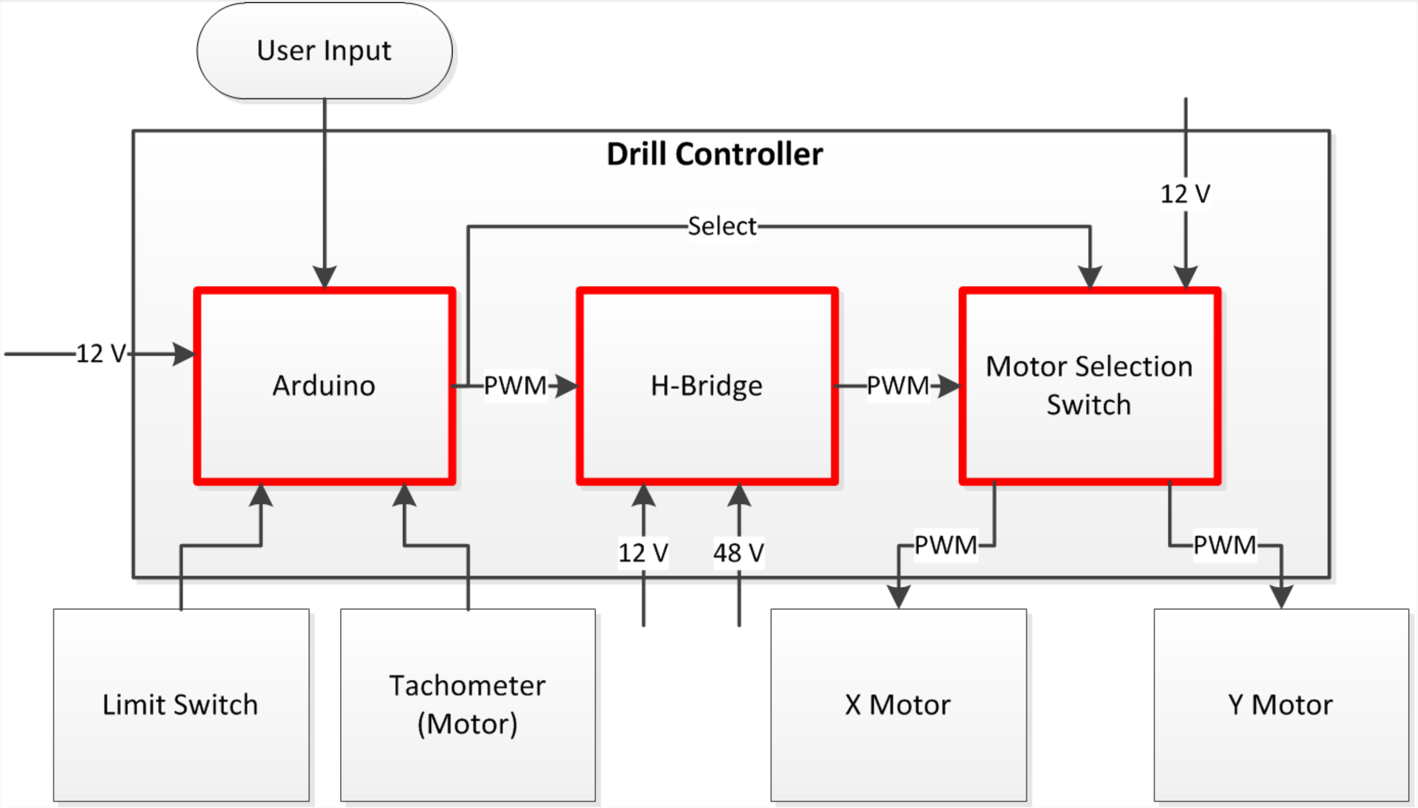
Legend — WCP04 — Supplied by CT&I

Controller System Diagram



Legend — WCP04 (red) — Supplied by CT&I (black)

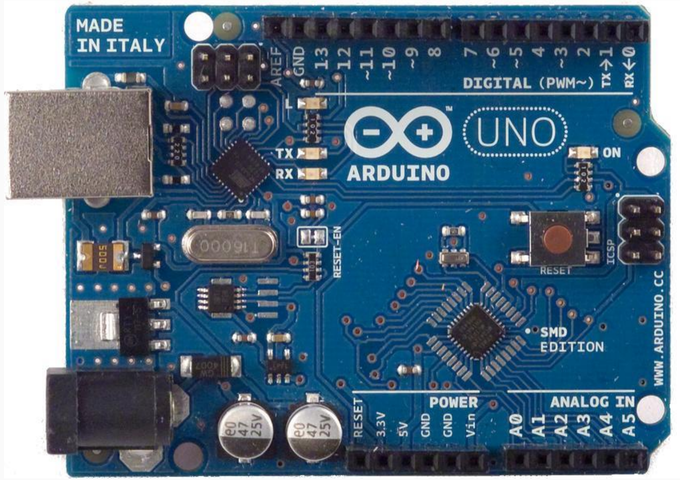
Controller Diagram



Legend — WCP04 — **Supplied by CT&I**

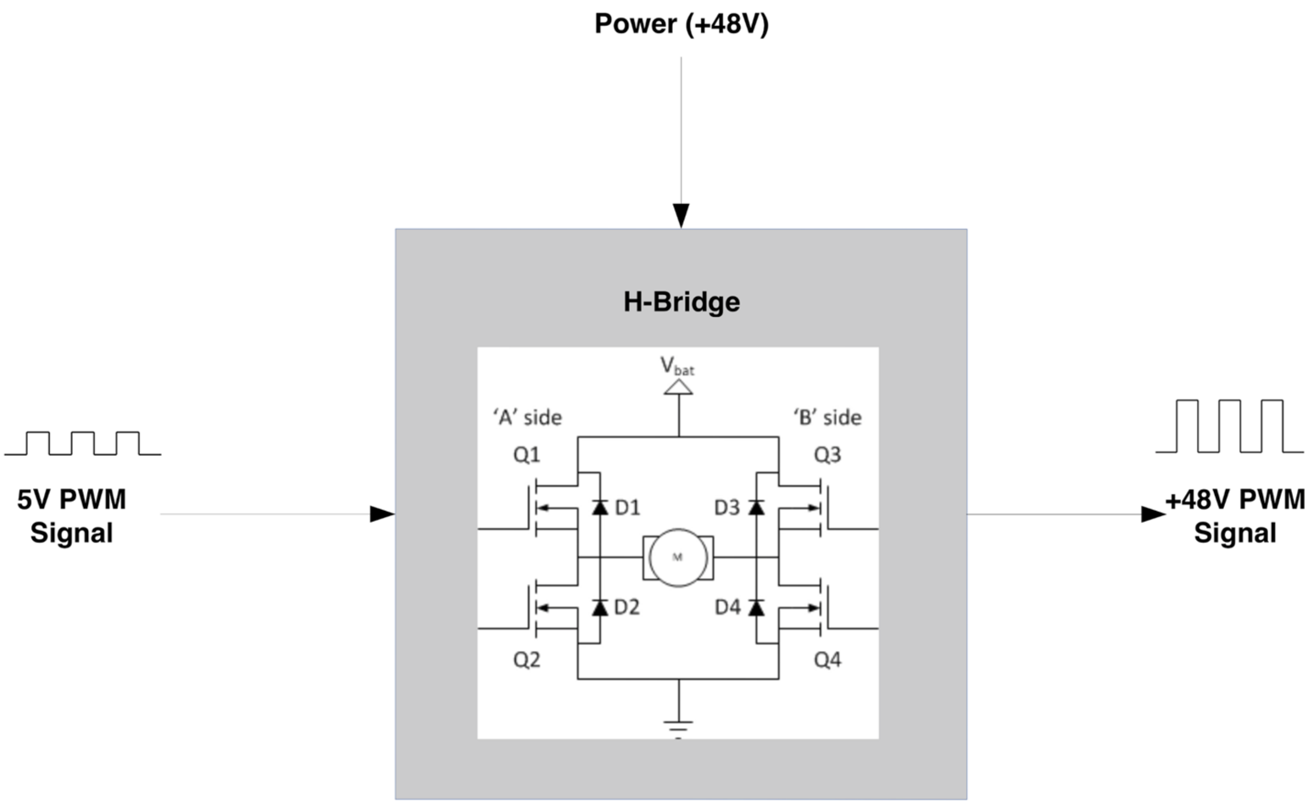
Arduino Controller

- Has the capabilities required for this project
- Easy and affordable to replace
- Built in Power Regulator
- Strong online community of support
- Inspirational



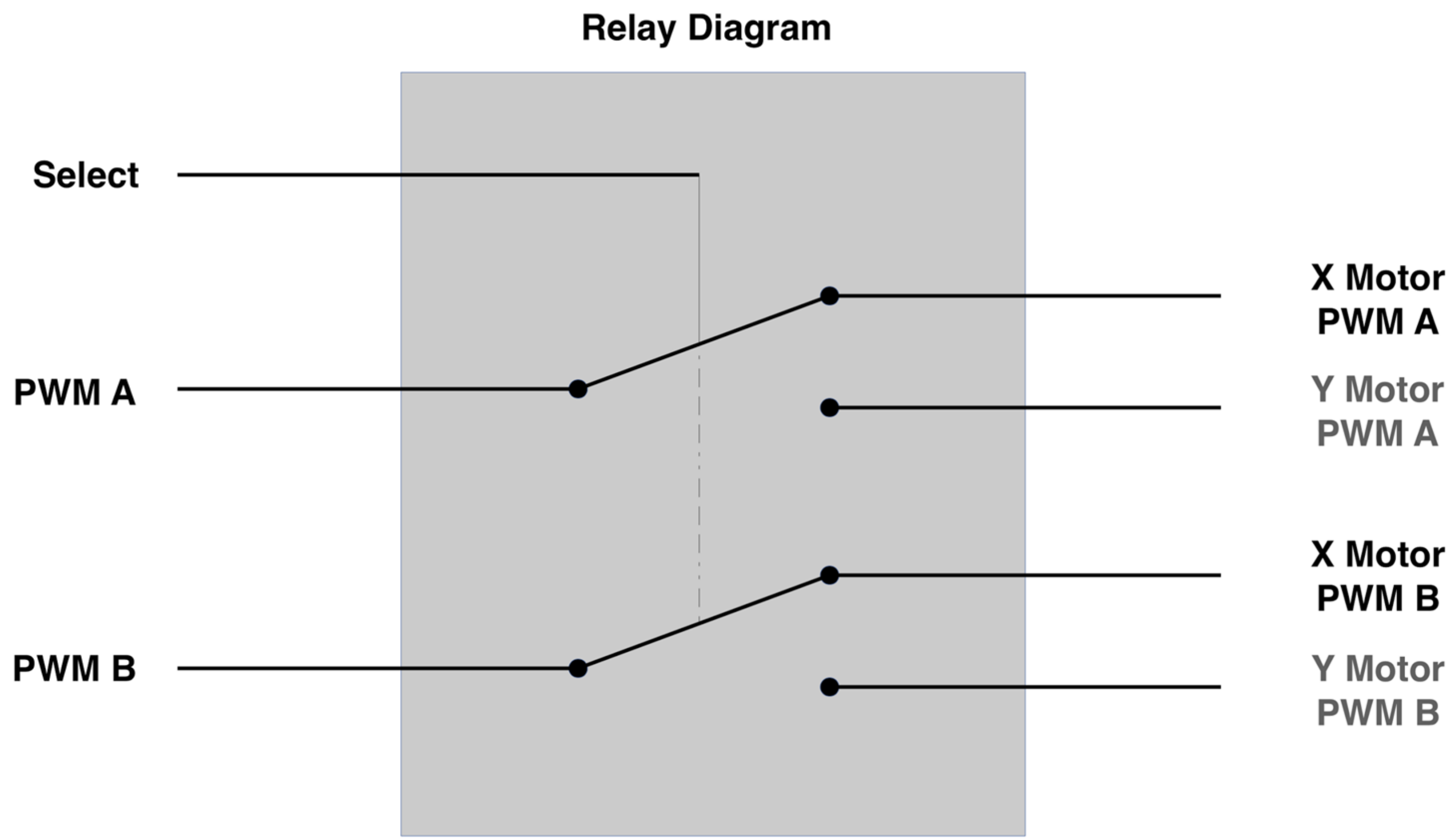
Arduino UNO

H-Bridge

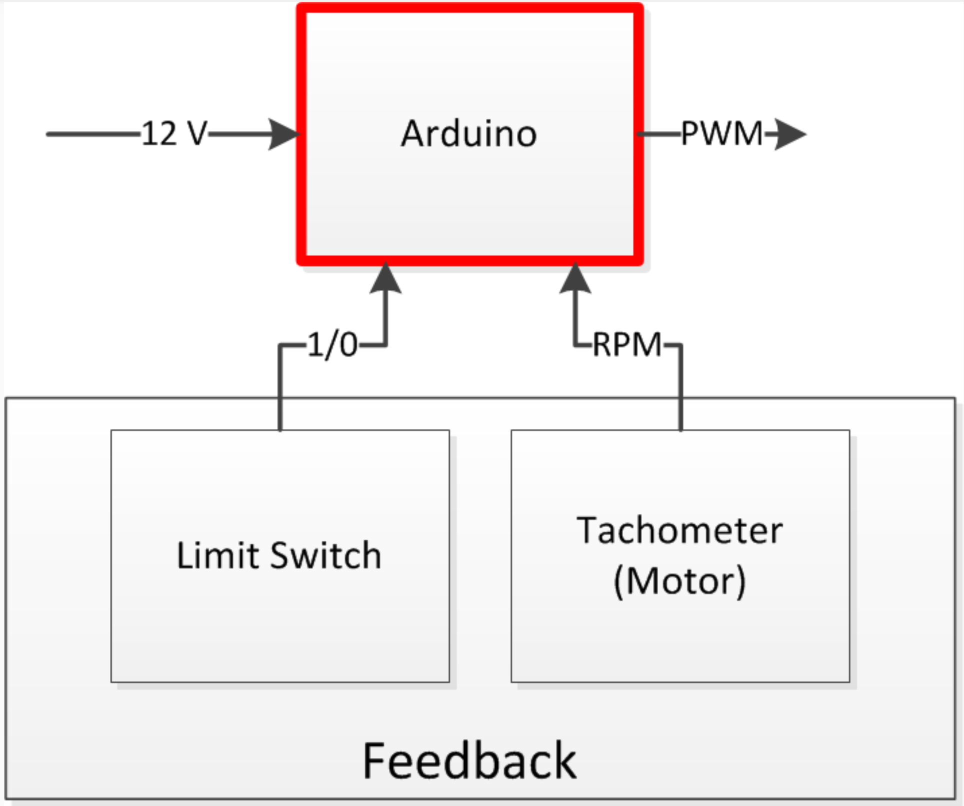


Power (+48V)
H-Bridge
V_{bat}
'A' side
'B' side
Q1
Q3
D1
D3
M
D2
D4
Q2
Q4
5V PWM
Signal
+48V PWM
Signal

Motor Selection Diagram

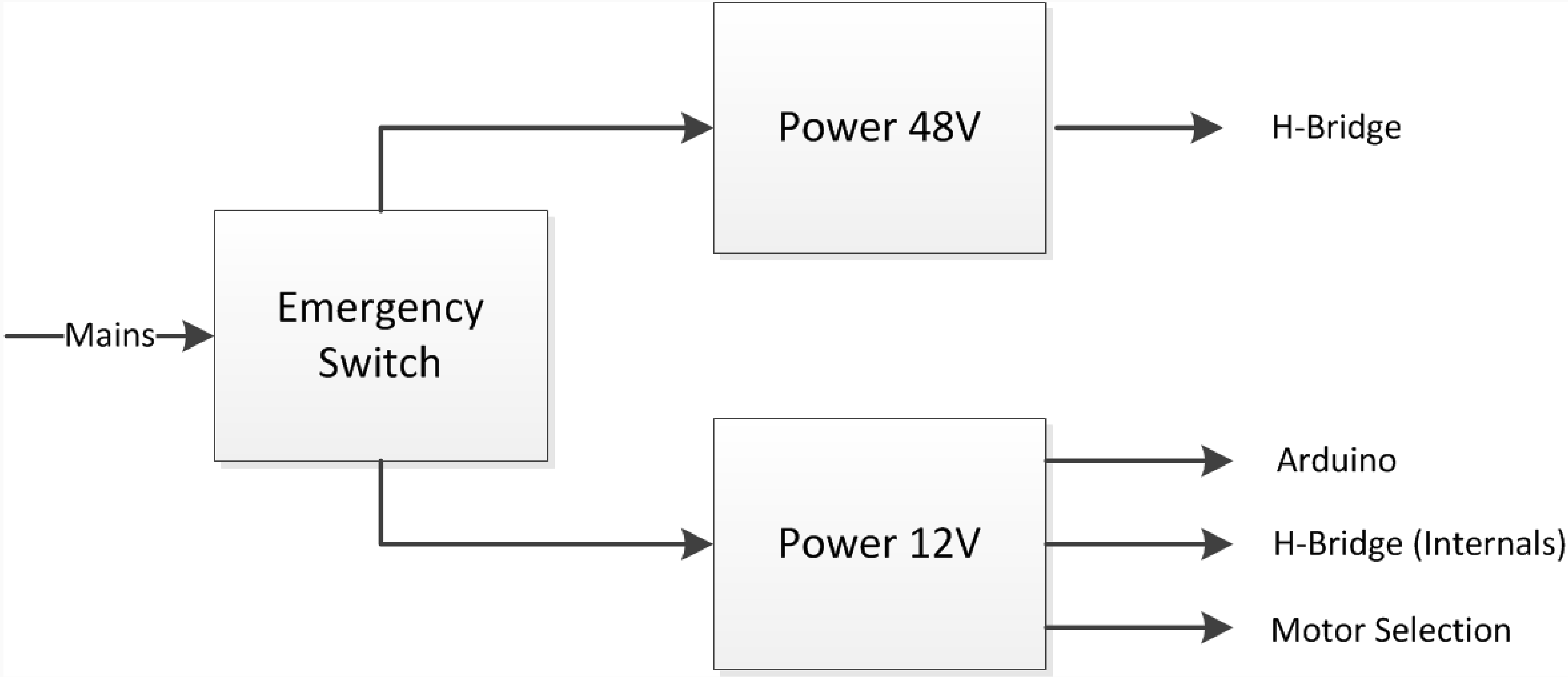


Drill Feedback



Legend		WCP04		Supplied by CT&I

Power



Power 48V
H-Bridge
Mains
Emergency Switch
Power 12V
Arduino
H-Bridge (Internals)
Motor Selection

Project Finances

Items	Original Estimate $	Actuals to date $	Estimate to Completion $	Estimate at Completion $
Control Parts	150	0	250	250
Drill Parts	100	0	100	100
Pneumatic Parts	100	0	0	0
Total	350	0	350	350

Funding Limit $	**500**		**Reserve $**	**150**

Top-level Schedule: Fall

Description	Percent Complete	Date Completed
Project Launch	100	September 9, 2015
Requirements Analysis	100	October 10, 2015
Venture Capitalist Presentation	100	November 13, 2015
Interim Presentation	100	December 11,2015
Reverse Engineering	50	IN PROGRESS
Theory Of Operations Manual	10	IN PROGRESS
Proof of Concept Controller	40	IN PROGRESS

Top-Level Schedule: Spring

Item	Percent Completed	Estimated Date of Completion
Reverse Engineering	50	February 15, 2016
Theory of Operations Manual	10	March 1, 2016
Testing	0	March 15, 2016
Proof of Concept Controller	40	April 15, 2016
Prototype Software	0	May 1, 2016
Prototype User Interface	0	May 1, 2016

Acknowledgments

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- Professor Jack Maynard, Faculty Advisor, Binghamton University
- Art Law, External Advisor, CT&I
- Susan Sherwood, CT&I Executive Director
- Duane Stanke, i3 employee
- Chris Mann, i3 employee
- All the CT&I staff that provided us with their knowledge and help moving the drill

Questions?

References

[1] A. Tantas. (2011). H-Bridges-The Basics [Online]. Available:

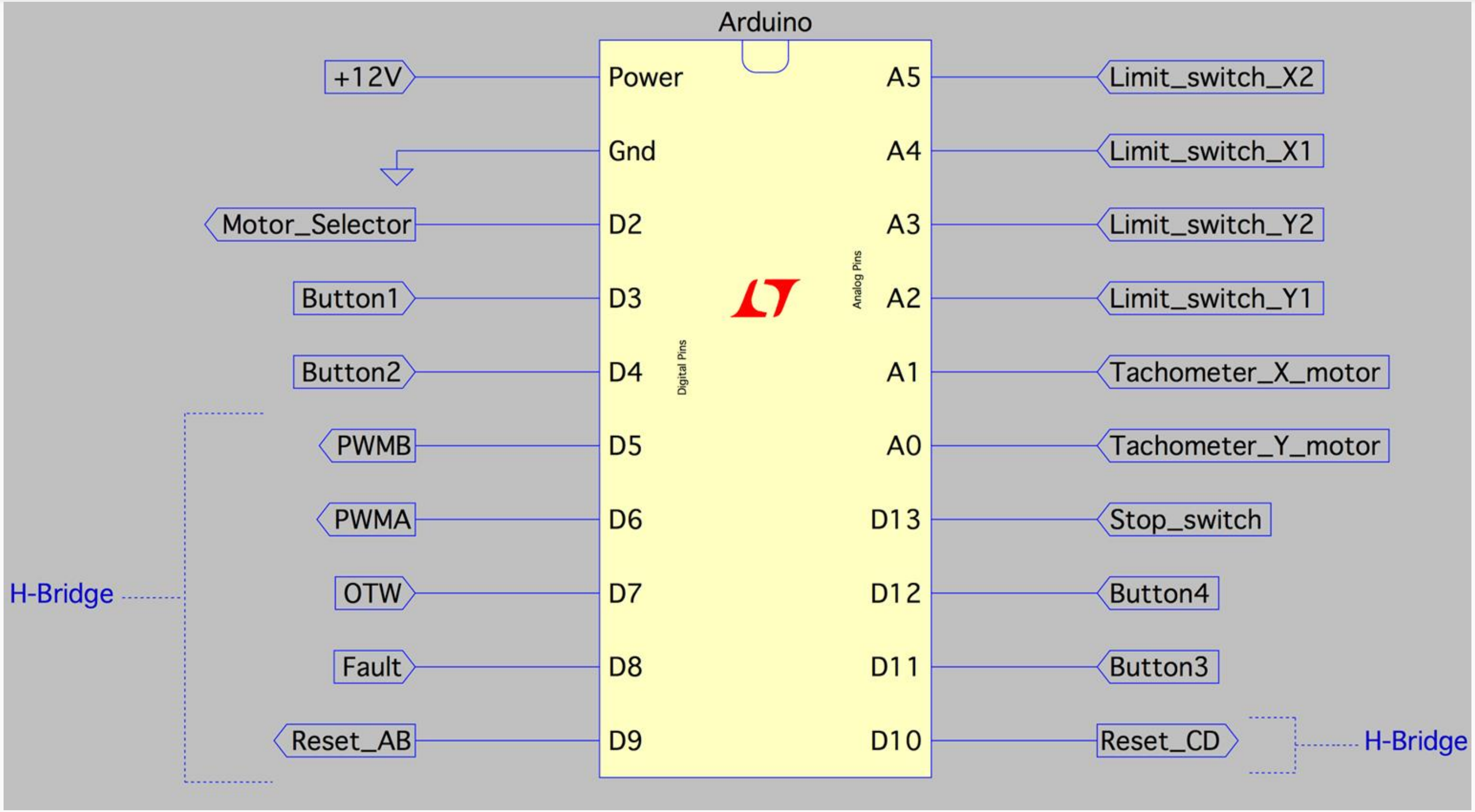
http://www.modularcircuits.com/blog/articles/h-bridge-secrets/h-bridges-the-basics/

[2]100MD Series Maintenance Manual, 3rd ed., ESI-Advanced Packaging Products Division., Santa Ana, CA, 1998, pp. 1–150.

[3]Dynamotion Series Maintenance Manual, 1st ed., Dynamotion., Unlisted, USA, 1993, pp. 1–200

Supplementary Information

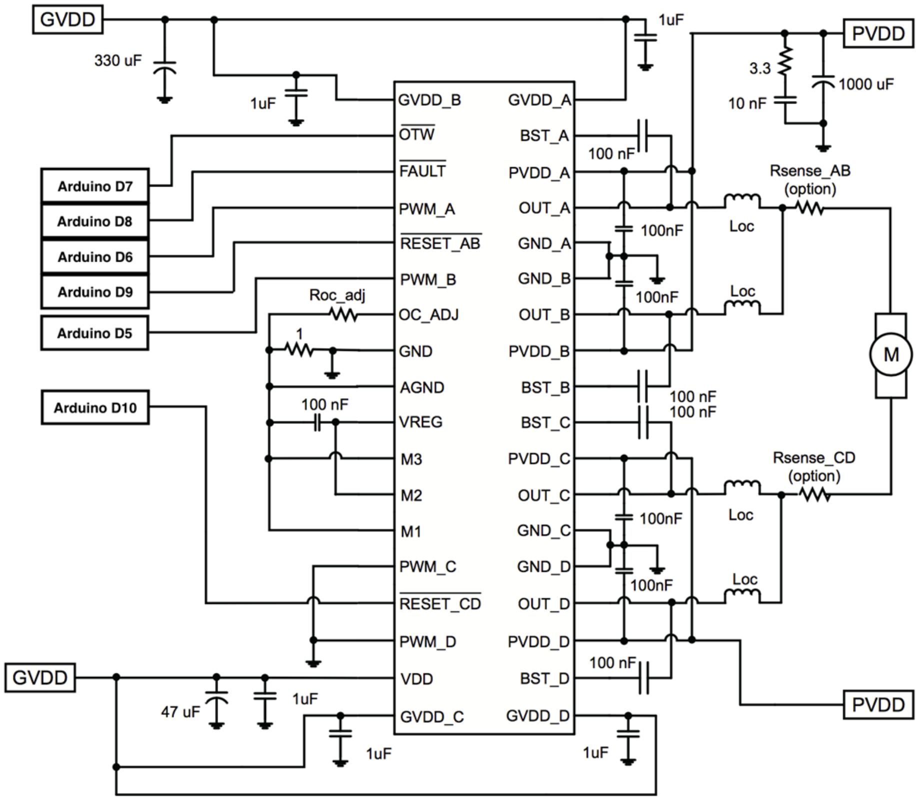
WCP04 Drill Spindle Controller
Arduino Pinout



WCP04 Drill Spindle Controller

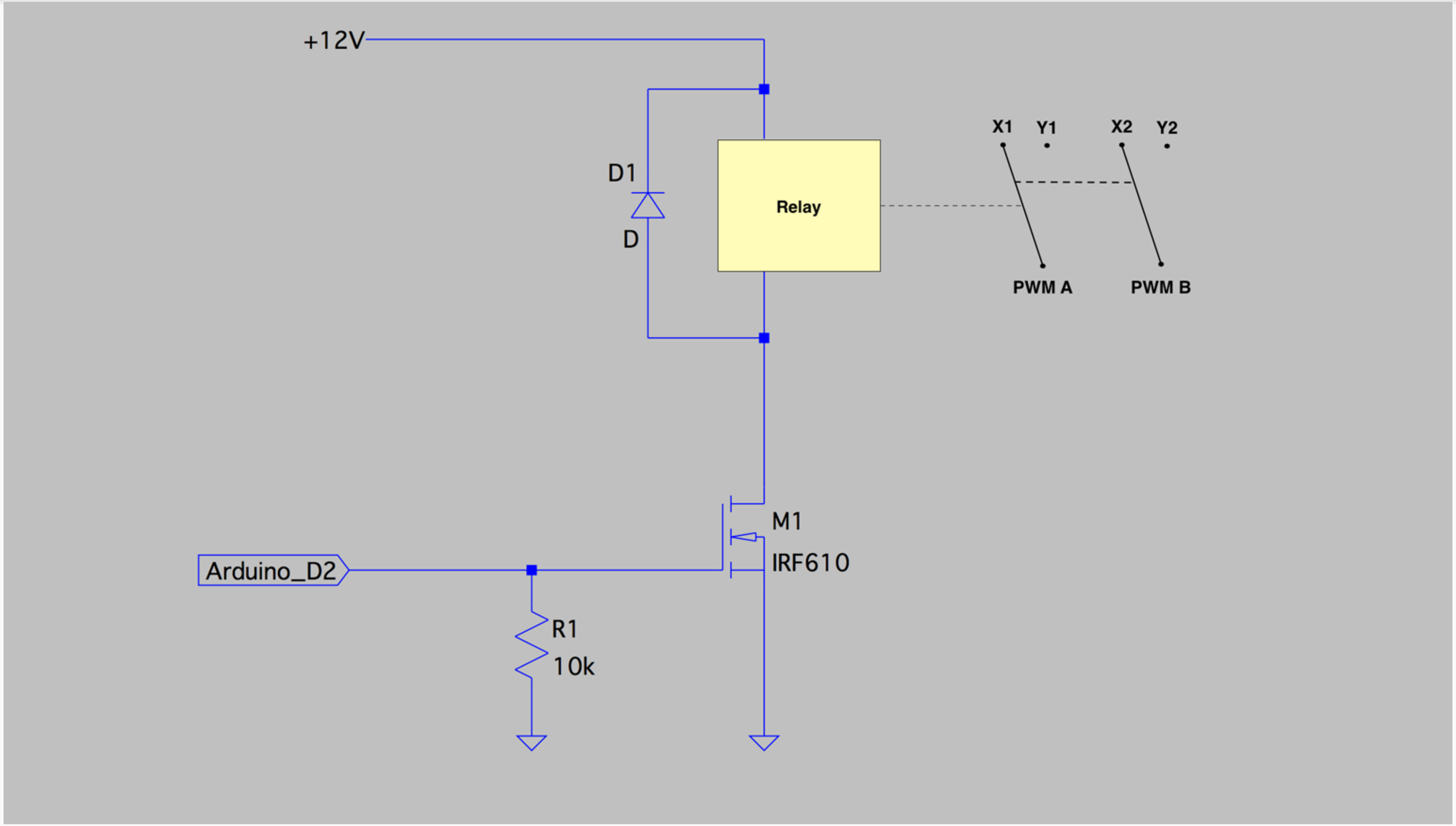
H-Bridge Circuit

8.2.2 Parallel Full Bridge Mode Operation

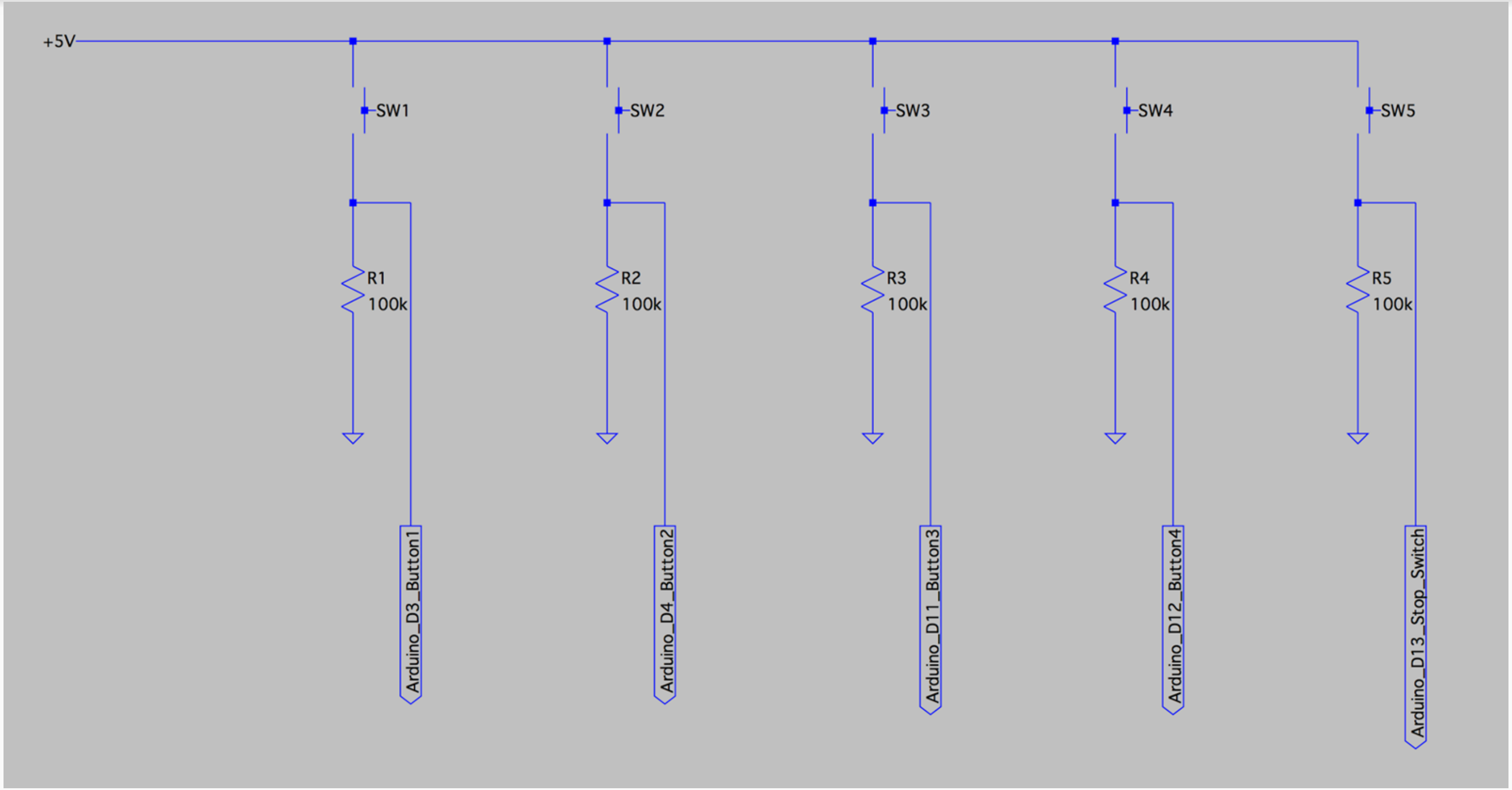


PWM_A controls OUT_A and OUT_B; PWM_B controls OUT_C and OUT_D.

WCP04 Drill Spindle Controller
Relay Circuit



WCP04 Drill Spindle Controller
User Input



WCP04 Drill Spindle Controller
Limit Switches