

Bucki Safety Documentation Motorama 2022

Scope:

Bucki is a “flipper”-style combat robot made by the Robojackets organization at the Georgia Institute of Technology during the 2021-2022 academic year. This document compiles all relevant information on the robot’s pneumatic system and presents the various design considerations made to prepare it for use, including instructions for safe operation.

System Design:

As a “flipper”, Bucki launches its opponents into the air using rapid, impulsive force. To this end, it utilizes a liquid CO2 system to power an air cylinder and actuate its flipping motion. The liquid CO2 is stored in pre-filled 20 gram cartridges, which are inserted into a specialty regulator to reduce the operating pressure to an amount manageable by the most fragile elements of the design.

Upon exiting the regulator, the decompressed CO2 is held upstream of a 3 port/2 state solenoid valve, which allows for intake of air into the piston and exhaust following the end of its stroke. This solenoid is controlled using signals from a standard RC controller interpreted by a microcontroller.

Also upstream of the solenoid valve, the system features a bleed valve to empty the system following operation and a pressure gauge to monitor the regulator’s output. These components are connected with a variety of connectors and lengths of tubing.

Figure 1 elaborates on specific fittings and their placement within the system, with further details explaining each element included in the following section.

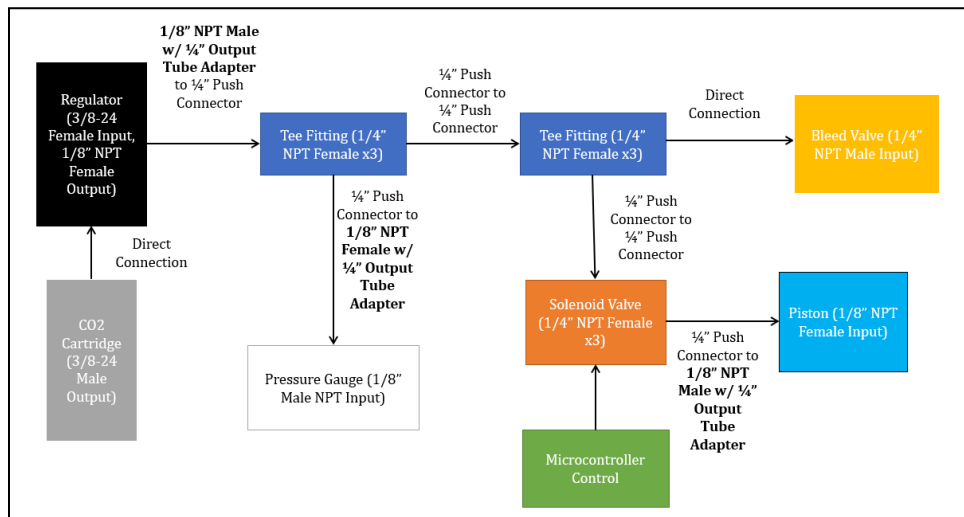
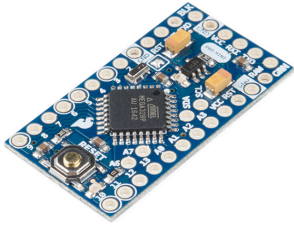
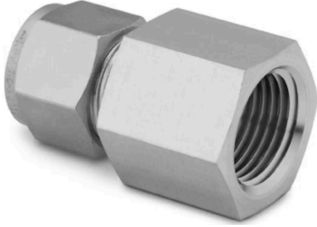
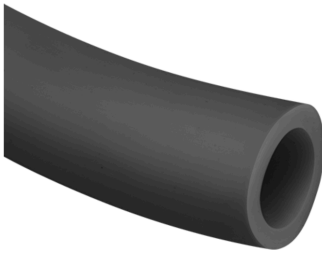


Figure 1. Bucki Pneumatics Diagram

System Components:

Component	Purpose	Relevant Specifications
CO2 Cartridges 	Used to store pressurized air that provides power to the system	• Output: $\frac{3}{8}$-24 Threaded Male • Safely holds 20 grams of liquid CO2 with thick solid metal walls
Regulator 	Pierces cartridges and reduces pressure input to amount manageable to remainder of system	• Input: $\frac{3}{8}$-24 Threaded Male • Output: 2x$\frac{1}{8}$" NPT Female • 0-250 PSI regulatable pressure • Set to release <145 PSI • Includes pressure relief valve when input exceeds manageable amount
Pressure Gauge 	Provides readable output to describe pressure of air downstream of regulator and upstream of solenoid valve	• Input: $\frac{1}{8}$" NPT Male • 0-300 PSI readout
Bleed Valve 	Empties system of pressurized air at safe rate upon opening following a match	• Input: $\frac{1}{4}$" NPT Male • 250 PSI limit

Solenoid Valve 	Allows for actuation of piston by allowing air from regulator to flow in when activated and exhausting air out after it deactivates	• 3x1/4" NPT Female Port • 145 PSI limit • 3 Port/2 State solenoid valve
Microcontroller 	Controls the solenoid valve's actuation by interpreting signals from controller	• Arduino Pro Mini
Piston 	Performs the flipping motion by taking in uncompressed air from upstream of solenoid	• 250 PSI Limit • 1" Stroke, 1.5" Bore • Input: 1x1/8" NPT Female
Tee Fitting 	Uses 3 ports to allow for additional elements to be added to system	• Input: 3x1/4" NPT Female • 500 PSI Limit
Threaded Push Connectors 	Allows for easy removal and connection of tubing to various components	• Input: 1/4" NPT Male • Output: 1/4" Tube • 290 PSI Limit

Tube Adapters 	Provides more permanent and stable connections to more mobile parts	• Extremely high limit due to SS material • Input: Various $\frac{1}{8}$" NPT • Output: $\frac{1}{4}$" Tube Adapter
Elbow Push Connectors 	Allows for parts to be connected around tight corners and reduce bends in tubing	• Input: $\frac{1}{4}$" Tube • Output: $\frac{1}{4}$" Tube • 290 PSI Limit
Tubing 	Connects all components in system	• 330 PSI Limit • $\frac{1}{4}$" OD

Additional Safety Features:

Software-Level Control:

The microcontroller controlling the solenoid valve will not provide power unless the controller sends the appropriate signal, protecting the operator from any potential misfires.

Weapon Lock:

Bucki was designed with a weapon lock in mind, consisting of 4 A36 steel bars that constrain the weapon by flats on its top surface and the bottom plate of the robot. This lock has the capacity to handle 10x the amount of force expected in a standard actuation, which prevents the weapon from activating when not desired.

Operation:

Pre-Match Procedure:

1. Assemble weapon lock to prevent motion
2. Insert LiPo battery into robot
3. Move robot to arena with air cartridge and hex set to activate switch
4. Insert air canister and monitor pressure with gauge
5. Turn on controller
6. Activate switch
7. Insert air cartridge
8. Remove weapon lock

Post-Match Procedure:

1. Replace weapon lock
2. Open bleed valve
3. Turn off power
4. Turn off controller
5. Remove from arena
6. Remove LiPo battery

Rule Adherence:

Official rules involving pneumatics are relatively sparse from the NERC, but three requirements are outlined:

1. The system must have a pressure gauge to display operating pressure
2. The specified ratings of all parts must not be exceeded
3. The system must be approved by an NERC official prior to the competition

Bucki adheres to all these requirements, as shown by the system overview above and the attached conversation with Alan Young in which Bucki was cleared to compete.

Appendix:

[Link to Product Page for Each Component](#)



[Link to Rules](#)



[Link to Communications with Motorama Officials](#)

