B.A.R.K. Door

Bluetooth Activated Remote Key Door

Mechatronics and Robotics

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ABSTRACT

The **Bluetooth Activated Remote Key (B.A.R.K.)** is a smart dog-door control system designed to combine convenience, security, and flexibility for pet owners. Using an RFID tag on our dog's collar and a corresponding sensor at the door, the system automatically opens the door for tagged pets. For guest pets without a tag, the door can be unlocked manually via Bluetooth by sending a simple binary signal. This system is powered by a BS2 microcontroller and integrates an ultrasonic distance sensor, Bluetooth transceiver, servo motor, and LCD screen for real-time feedback and system monitoring.

Construction materials, including 3D-printed parts and aluminum rods, ensure durability and reliability. The design combines mechanical and electronic systems to create a functional and easily scalable prototype.

B.A.R.K. redefines smart pet access by offering a secure, efficient, and user-friendly solution tailored to modern needs while showcasing practical engineering and innovation.

INTRODUCTION

Pet ownership comes with its share of challenges, and one of the most common issues is managing pet access to the home, especially in an increasingly interconnected world where a Pet's owner may be required to be away many hours or several days at a time. Traditional pet doors, while convenient, are vulnerable to the entry of unwanted animals or even Human intruders. As smart technologies in the home become more commonplace and affordable, there is an opportunity to rectify this situation.

The **Bluetooth Activated Remote Key (B.A.R.K.) Door** aims to create a secure, automated, and user-friendly dog-door system that addresses these issues. The system leverages RFID technology to grant automatic access to pets with a registered tag and incorporates Bluetooth connectivity to allow manual control for unregistered or guest pets. This dual functionality ensures convenience for pet owners while maintaining control over who—or what—enters the home. The system is streamlined and well suited to being scaled up or down for mass production in alternative applications such as Human-scale garage doors, scanning packages at mail delivery hubs, or verifying part functionality at quality assurance centers.

Built on the BS2 microcontroller, the system integrates core components such as an ultrasonic rangefinder, bluetooth transceiver, servo motor, and an LCD for user feedback. These components form a streamlined core to the system and are mounted on a frame combining 3D Printed components, Aluminum rods, and Stainless Steel Bearings. However, thanks to the overall simplicity of design, the frame can be easily customized in terms of scale, material, and aesthetics to suit a given user's needs and preferences without appreciable loss of functionality.

By providing both automation and manual override features, B.A.R.K. delivers a **functional, scalable, and customizable** solution for pet owners who value security, convenience, and modern innovation.

DESIGN & WORKING PRINCIPLE

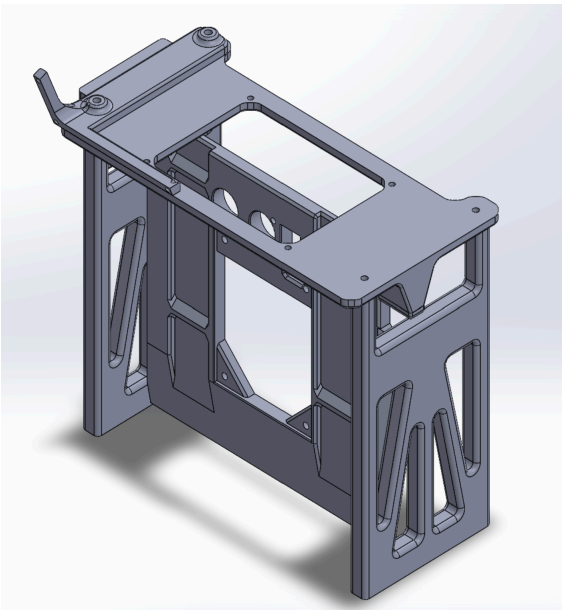
The **Bluetooth Activated Remote Key (B.A.R.K.)** system integrates mechanical, electronic, and software components to create a functional, scalable, and customizable smart dog-door. The design focuses on secure automation with manual override capabilities, utilizing accessible and durable materials.

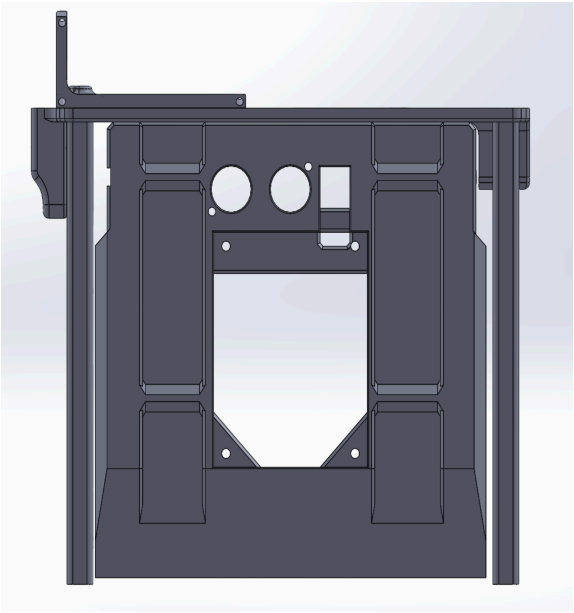
1. Mechanical Design

The mechanical structure of B.A.R.K. incorporates 3D-printed components, hand-fabricated wooden components, aluminum rods, and stainless-steel bearings for reliable and smooth operation. The door mechanism is actuated by a servo motor, which is housed within a durable 3D-printed frame to ensure precise alignment.

Key mechanical elements include:

- **3D-Printed Parts**: Custom-designed to fit the servo motor, bearing, support the door's weight, and provide mounting positions for all circuit components.
- **Aluminum Rods**: Used as structural supports to add durability and lightweight properties.
- **Stainless Steel Bearing:** Used in conjunction with the servo motor to actuate the door.
- **Wooden Base Plate:** Hand cut board which accommodates the mounting of the 3D Printed components to provide a durable and cheap base for the system.
- **Test Subjects “Gilligan Sr.” and “Gilligan Jr.”:** 3D Printed example dogs to demonstrate the functionality of the Dog-Door.





2. Electronic Design

The electronic system is built around the BS2 microcontroller, which coordinates the input from sensors and outputs to actuators. The prototype design utilized the following components:

- **BS2 Microcontroller**: Acts as the brain of the system, processing signals and executing commands.
- **RFID Module**: Used for pet identification. The tag worn by the Pet communicates is read by the RFID Module mounted on the door and its programmed Key is validated.
- **HM-10 Bluetooth Module**: Enables manual control via Bluetooth, allowing the homeowner to grant or deny access to unregistered/untagged pets.
- **Ultrasonic Distance Sensor**: Detects objects approaching the door, activating the system once an object is within a certain range.
- **2x16 LCD Display with Piezoelectric Speaker**: Provides real-time feedback, such as access status or system messages, for easy user monitoring.
- **Servo Motor**: Actuates the door between open and closed states depending on input either from the RFID or Bluetooth Modules.
- **Normally-Open Pulldown Button**: Killswitch Trigger, used to immediately terminate the program and stop all actuation in an emergency.

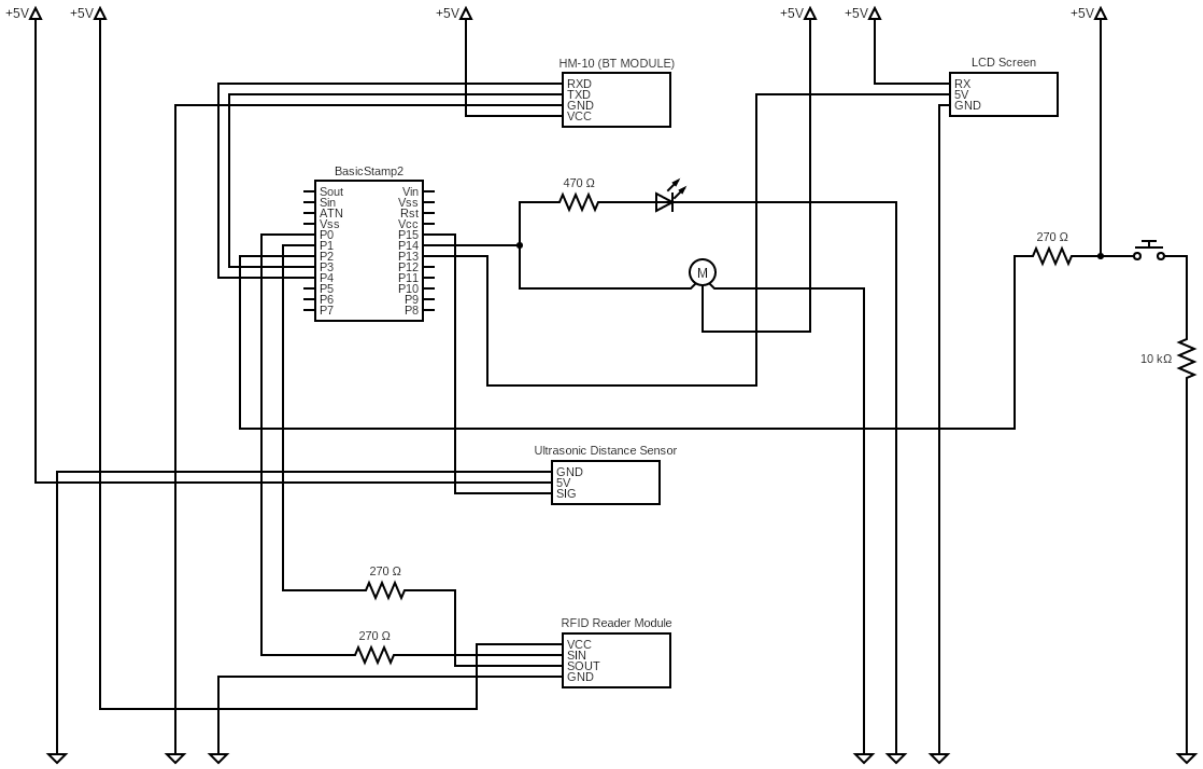
The choice of components for the prototype was primarily influenced by 2 factors:

Ease of Acquisition: Almost all of our components (RFID Module, Basic Stamp 2, Ultrasonic Distance Sensor, etc) were intentionally sourced from Parallax Inc. to ensure mutual compatibility as well as access to references and example implementation.

- The HM-10 was chosen as our Bluetooth Module as one was readily available and the overwhelmingly simplicity of our implementation meant that the specific model of chip was irrelevant.

Utility: In the case of the Servo Motor, the Standard Servo was chosen over a Continuous Servo as precision was required, rather than spin speed. In the case of the specific LCD display, ours was chosen because of its combined functionality as display and speaker, which allowed us to optimize pin-utilization while also implementing both visual and audio cues for testing purposes.

3. Circuit Diagram



4. Working Principle

The B.A.R.K. system operates through a combination of automation and manual control, offering flexibility and security.

Idle:

- The system initializes in an idle state, with the ultrasonic distance sensor continuously monitoring the area in front of the door.

Ultrasonic Detection:

- When the ultrasonic sensor detects an object within range, the BS2 microcontroller shifts to the Authentication State for the RFID reader to scan for tags.
- In order to calculate the distance detected, in inches, the following math is performed (as per reference [8] 344.8 m/s is the speed of sound of air at room temperature):

  $S_{obj-cm} = 344.8 * t_{pulsin-BS2} \div 10,000 = 0.03448 * t_{pulsin-BS2}$

  ... or, in BS2 language, 2260 * t (2260 being 65536 * 0.03448) which yields the equation in Basic...

  cmDistance = CmConstant ** time

Since we want our distance in inches, we simply divide by 2.54 (2.54 cm/inch) to get our new constant InConstant = 890.

Authentication:

- If the scanned RFID tag matches the stored credentials, the BS2 sends a signal to the servo motor to unlock the door. The LCD displays "Access Granted," and the LED lights up as feedback for successful authentication. It then shifts to the Door Actuation State.
- If no tag is detected within a predetermined amount of time or the detected tag has incorrect credentials, the system displays “Unwanted Guest” and outputs an audio cue. Then BS2 returns to the Idle State.

Bluetooth Override:

- The HM-10 Bluetooth module allows the homeowner to override the system. During both the Idle State and the RFID Scanning period, the Bluetooth module is passively scanning for a Bluetooth Signal. Upon receipt of a trigger signal, the servo opens the door regardless of other inputs.

Door Actuation:

- Once the servo motor unlocks the door, it waits for a predetermined amount of time for the Pet to pass through the opening. At the end of the predetermined time, the servo returns the door to the closed state.
- After the door is closed, the system returns to the idle state and resumes ultrasonic distance detection.

Kill Switch:

- In the event of an emergency, the press of the Kill Switch button will immediately halt all operations and terminate the current program in-place.

5. Function States

The operations of the B.A.R.K. door was broken into the following activity cases, with accompanying States for ease of testing and checking purposes.

Normal State

- The Normal State is defined as when an object is detected, the correct RFID is scanned, and the welcome message is displayed and the door opens.

Bluetooth Override States:

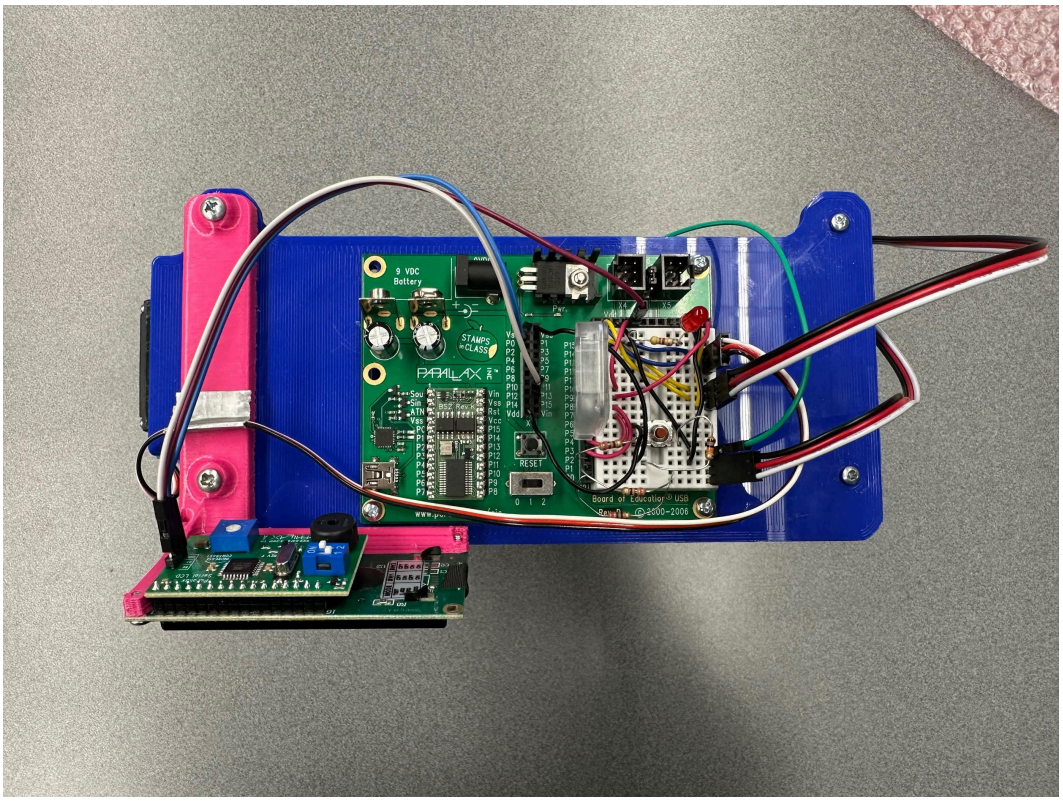
- The Bluetooth Override State is defined as when a Bluetooth Signal is detected during normal Distance Detecting operations and the door is opened.
- The Second Bluetooth override State is defined as when a Bluetooth Signal is detected during the RFID Detecting operations and the door is opened.

Fail States

- The First Failure State is defined as when an object is detected, but the incorrect RFID key is provided, causing the failure message to display and the failure audio cue to play.
- The First Failure State is defined as when an object is detected, but no key is provided, causing the failure message to display and the failure audio cue to play.

Kill States

- The First Kill State is defined as when the Kill Button is pressed during either the Distance or RFID Detection loops and the process is halted with the Emergency Stop message being displayed.
- The Second Kill State is defined as when the Kill Button is pressed during Door Actuation and the process is halted with the Emergency Stop message being displayed.



COST ANALYSIS

Component	Prototype Cost	Mass Production Bulk Cost
HM-10 BLE	11.00$	5.00$
Parallax Standard Servo	17.95$	14.36$
RFID R/W Module	49.99$	44.99$
RFID R/W 30mm Tag	2.79$	2.66$
Ultrasonic Distance Sensor	34.95$	31.46
Basic Stamp 2 Microcontroller	49.00$	25.48$
Board of Education Dev Board	69.99$	55.99$
7.5 VDC 1.6 AMP Power Supply	14.99$	14.99$
2x16 Backlit LCD w/ Piezo Speaker	34.95$	31.46$
M1.6 Screws	0.01$	Negligible
3mm Aluminum Rod	1.10$	Negligible
3mm ID, 8mm OD Stainless Steel Bearing	0.50$	Negligible
Approx. 400 cm^3 ABS Filament	10.44$	4.49$
Total Costs:	265.62$	230.88$

Comparison

Compared to similar products on the market, the going rate for related products nears around 400 dollars USD. This provides a heavy cushion for profit and market demand that would allow us to sell our product for 300-350 dollars USD.

Cost

Due to the above reasonings for acquiring the components that we did, B.A.R.K. 1.0 is not as cost efficient as it could be. Some components have more complexity than required or may simply be cheaper when acquired from a different vendor. The non-circuit materials (Filament, Bearings, Rods) are also heavily variable as the assembly is not specific to them and they can be customized to suit the specific desires of the customer, with accordingly different costs.

RESULTS & CONCLUSIONS:

The Bluetooth Activated Remote Key (B.A.R.K.) shows the feasibility of combining RFID and Bluetooth technologies to create a secure and automated smart dog-door system. The prototype produced for this report demonstrated several strengths and weaknesses of the system worth addressing in future prototype iterations and/or mass production version:

One of the key limitations encountered while developing the system was with the Basic Stamp 2 Microcontroller and accompanying PBasic Syntax. Certain processes operated through the BS2 could not be run in parallel and had to be manually allocated runtimes to operate within. For example, without the ability to use system interrupts, within a given programming loop the code which “searched” for an incoming Bluetooth Signal could only be allowed to search for a period of time, rather than continuously for the duration, as otherwise the serial nature of BS2 would otherwise halt reading further code until a signal had been received. The same limitation also hindered the operation of the RFID scanner and was further complicated by the need to run both Bluetooth and RFID detection in the same programming loops. In a future iteration, a different chip may be better suited to control the system.

In addition, we saw firsthand how our BS2 ‘slows down’ as we introduce more and more conditions and code to our program. This, again, illustrates the limitations of our microcontroller. However, working firsthand with the hardware, opened our eyes as to how powerful the tool can also be, with powerful sensing and actuating capabilities.

Special Thanks to Shantanu Ghodgaonkar for providing the HM-10 BLE used in this project

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“Chapter 3: Digital Input – Pushbuttons ACTIVITY #2: READING A PUSHBUTTON WITH THE BASIC STAMP.” *What’s a Microcontroller? Student Guide VERSION 3.0*, Parallax Inc., https://www.parallax.com/package/whats-a-microcontroller-text/. Accessed 2 Dec. 2024.

APPENDIX:

HM-10 BLE (11$ per)
https://a.co/d/7PSLYWw

Parallax Standard Servo (17.95$ per)
https://www.parallax.com/product/parallax-standard-servo/

RFID Read/Write Module - Serial (49.99$ per)
https://www.parallax.com/product/rfid-read-write-module-serial/

RFID R/W 30 mm Round Tag (2.79$ per)
https://www.parallax.com/product/rfid-r-w-30-mm-round-tag/

PING))) Ultrasonic Distance Sensor (34.95$ per)
https://www.parallax.com/product/ping-ultrasonic-distance-sensor/

Basic Stamp 2 Microcontroller Module (49.00$ per)
https://www.parallax.com/product/basic-stamp-2-microcontroller-module/

Board of Education Development Board (69.99$ per)
https://www.parallax.com/product/board-of-education-development-board-usb/

7.5 VDC 1.6 Amp Power Supply (14.99$ per)
https://www.parallax.com/product/7-5-vdc-1-6-amp-power-supply/

Parallax 2x16 Serial Backlit LCD w/ Piezo Speaker (34.95$ per)
https://www.parallax.com/product/parallax-2-x-16-serial-lcd-with-piezo-speaker-backlit/

M1.6 Screws (Bulk set- 9$, 800 pcs, 0.01$ per screw - effectively negligible)
https://a.co/d/cWjG7rF

3mm Aluminum Rod (11$/10 pcs - 1.10$ per rod)
https://a.co/d/1S83Cic

3mm ID, 8mm OD Stainless Steel Bearing (10$/20 pcs - 0.50$ per Bearing)
https://a.co/d/5TvbNaq

3D Dog Source File (Free)
https://cults3d.com/:530937

SmartDoor™ Never Rust Connected Pet Door, Dog & Cat, Selective Entry & Exit, App-Enabled Pet Door, Smart Device, Control by Phone

https://a.co/d/9NKqsc5