Backup Buddy:
Universal Backup Camera
Group 10

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Motivation

- According to the National Highway Safety and Traffic Administration, more than 18,000 backup-related injuries occur in the United States each year with more than 200 of these injuries being fatal
- This is due to driver visibility being limited during backup
- Average reaction time is 215ms, which is too slow to depend on humans alone to respond and act fast enough.
- By improving the driver's awareness of their surroundings and providing useful information on blind spots, the driver could have a better chance of avoiding an accident

Goals and Objectives

- Providing a live video-feed of the back of the vehicle with minimal latency and high resolution, as well as a wide field-of-view.
- With a series of sensors we can provide measurements to objects behind the vehicle along with audible collision warnings via a mobile app if the vehicle gets too close to them.
- A hardware assembly that is easy to install and durable without the need for long cables.
- Mobile application that interfaces with the system and offers configuration options.

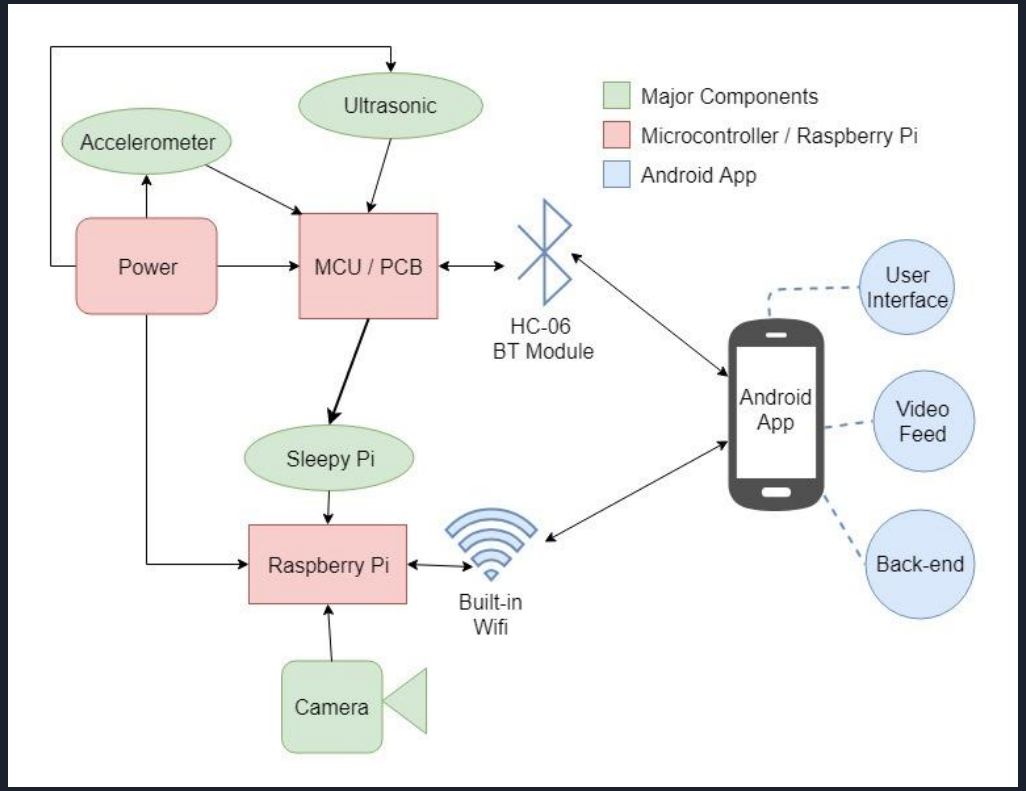
Hardware Requirement Specifications

1	The system will draw no more than 12V from its power source
2	The system will weigh less than 10 pounds
3	The face of the system will take up a space no larger than 16in x 10in
4	When mounted on the rear of a car, the assembly will have enough structural integrity to stay mounted at vehicle speeds of up to 45 mph

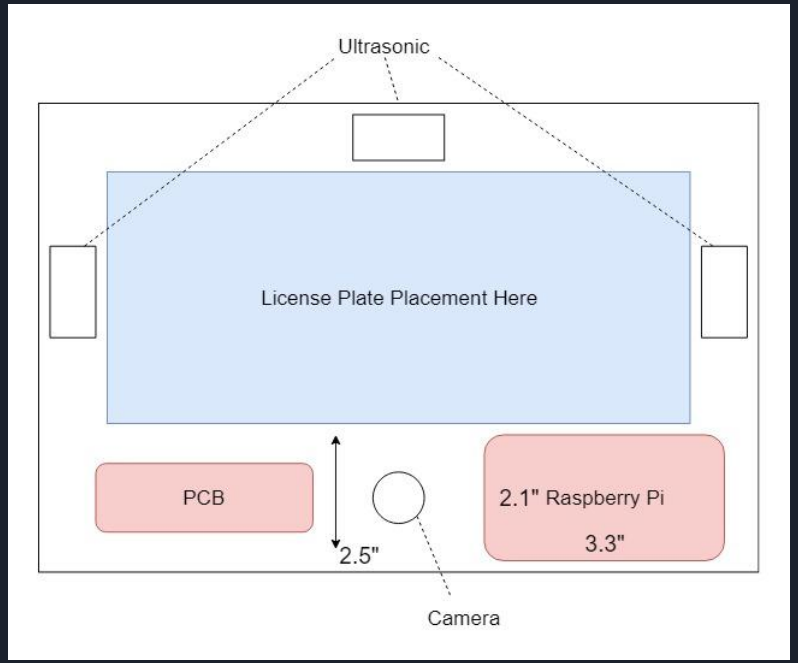
Software Requirement Specifications

1	The Android application will make an audible tone as well as provide a visual warning on screen, to alert the driver when the distance to an obstruction falls within an unsafe range
2	The system will alert the driver when obstructions that are behind the vehicle are within 4 feet and the size of 1 cubic foot
3	Using an accelerometer the system will detect once the car is moving forward and when the car reaches a speed of faster than 10mph the system will enter a low power state
4	The video feed of the rear facing camera will have a framerate of at least 15 fps at any given time

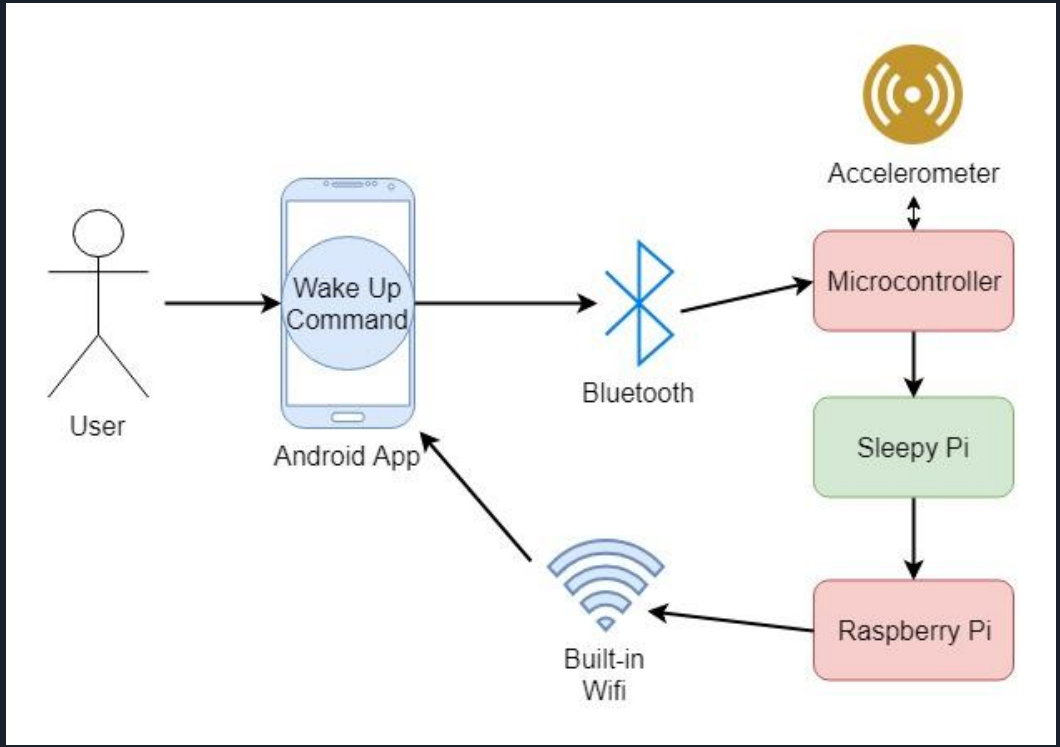
Overall Block Diagram



How it looks on the license plate



Start Up Diagram



Microcontroller: MSP430-FR5969

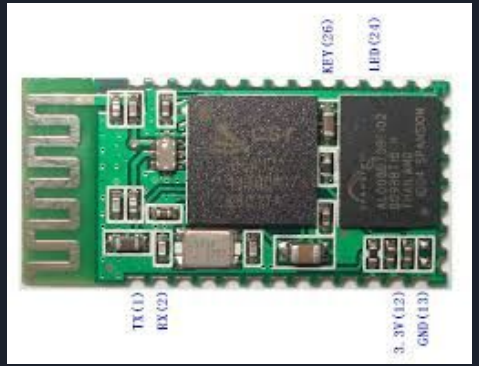
Clock Speed	1 to 16 MHz
I/O Pin Count	40
Storage	64 KB (FRAM)
Cost	$3.86
Power Consumption (in low-power mode)	0.72 µW

- Extremely low power consumption when placed into low-power mode.
- High number of I/O pins to support and interface with many sensors.
- Uses ferroelectric RAM for non-volatile storage (much faster read
and write speed, and much lower power compared to flash)
- Overall it has great speed and performance at a very low cost.

Wireless Technology Selected

Spec	Bluetooth	ZigBee	Wi-Fi
Transfer rate	3 Mbps	250 kbit/s	300Mbps
Power consumption	5-50ma	5-25ma	50-180mA
Range	25m	10-100m	50m

HC-06 Bluetooth Module



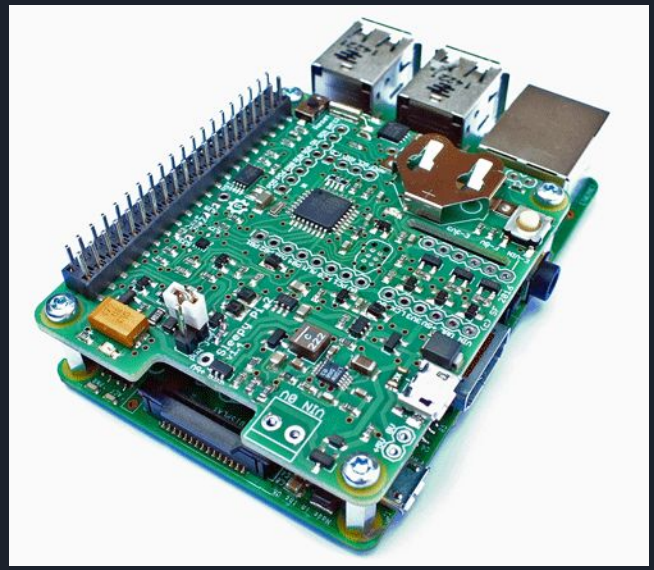
Component	HC-05	HC-06	HM-10	RN-42
Transfer rate	2 Mbps	2 Mbps	6 kbps	240 kbps
Power consumption	40ma / 8ma	40 / 8ma	50ma / 8.5ma 800ua	30ma / 3ma
Range	10m	10m	3m	20m
Price	2.00	3.50	8.99	$15.73

Microcomputer For Streaming Video

Component	Raspberry Pi 3B+	Banana Pi	TI-DaVinci (TMS320DM6446)
Transfer rate	300 Mbps	600 Mbps	100Mbps
Power consumption	600ma - 2.4A	600ma - 2A	5V - 2A
CPU	ARM 1.4GHz Quad Core	ARM 1.2 GHz Quad Core	600 MHz Quad Core 32bit
Ram	1 GB	1 GB	16KB
Price	$39.99	$54.99	$46.32 (chip only)

Raspberry Pi Low Power Mode (Sleepy Pi)

- Sleepy Pi is an arduino based power management system
- Reduces power draw of the raspberry pi to 500ua
- The sleepy pi features a custom raspbian operating system for safe shutdown and to prevent sd card corruption.

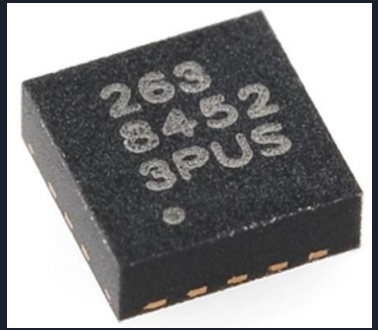


Camera Selection: OV5647 Wide Angle

Component	Raspberry Pi Camera	Omnivision 5647 (Wide angle Lens)	Omnivision 5647 With IR
Field of view	62	160	69.9
Power consumption	120ma	96ma	120ma
Price	$25	$26.99	$74.89

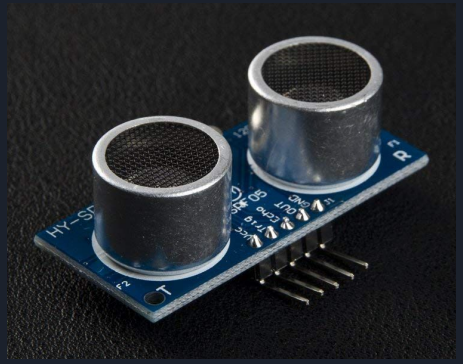
Accelerometer: MMA8452Q

Component	MMA8452Q	ADXL335
Output Data Rates	1.56Hz to 800Hz	0.5 to 1600Hz/550Hz
Digital Resolution	8-bits or 12-bits	None
Programming Interface	i2C	None
Cost	$2.95	$2.05



Ultrasonic Sensor: HC-SR05

Component	HC-SR05	HC-SR04
Range	2cm - 4m	2cm - 4m
Degree of View	15 degrees	15 degrees
Programming Interface	UART	UART
Pins	5	4
Cost	$3.95	$3.49



Power Options

		Device characteristics		
		System start-up time	Ease of installation	Battery Life
Power Option	Car Battery	▼▼	▼▼	▲▲
	PCB Battery	▲	▲▲	▼

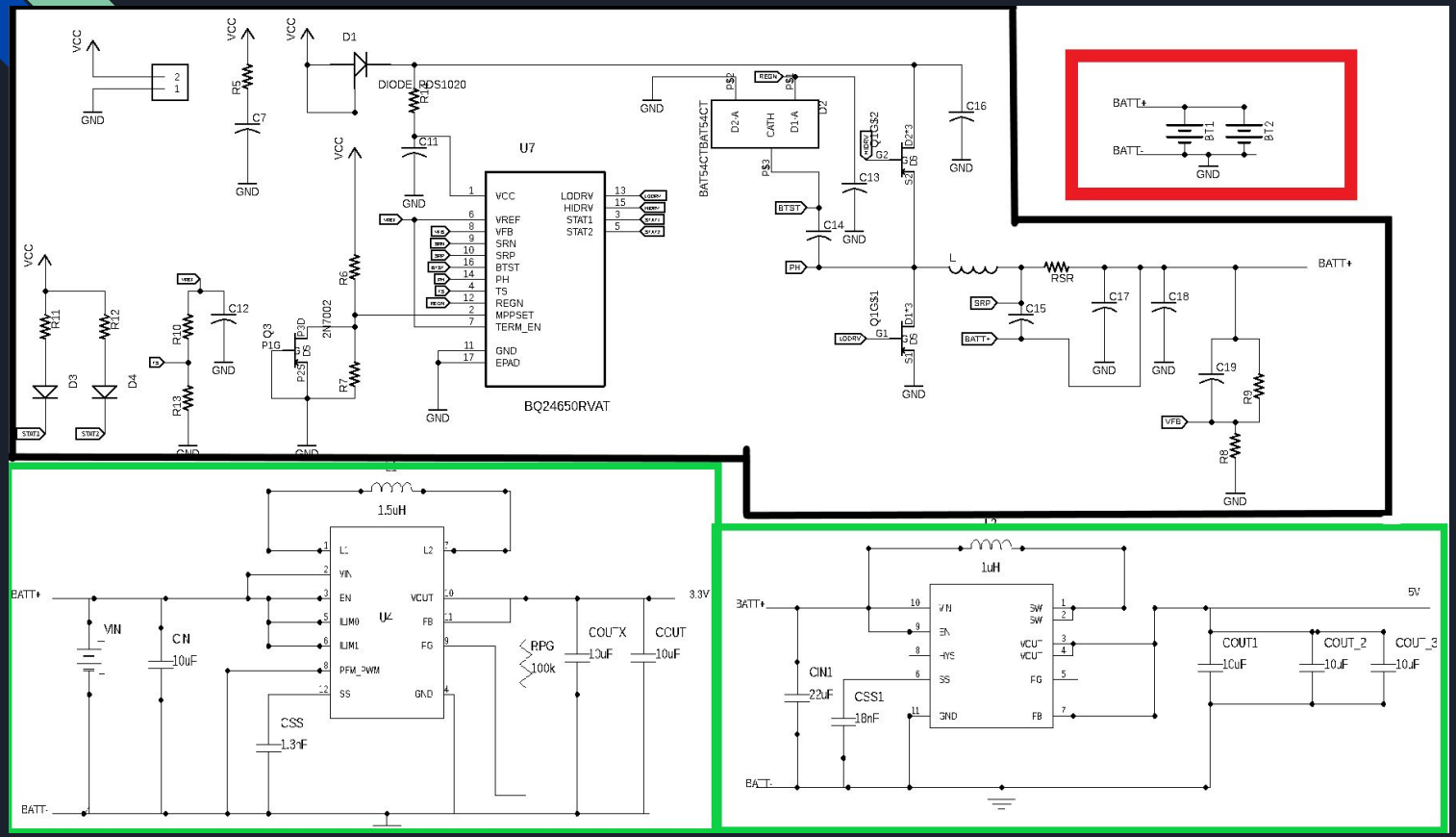
Battery Selection

NiMH vs Lithium-Ion

		Battery characteristics		
		Self-discharge per month	mAh/weight	Cost/mAh
Battery Types	Lithium ion (Li-Ion)	▲▲	▲▲	▲
	Nickel metal hydride (NiMH)	▼▼	▼	▲▲

- 3500 mAh LG MJ1 18650 x 2
- 3.6V Nominal voltage
- 2.5V - 4.2V Voltage range
- 10A Max discharge current
- 1C max charge current
- $15 for 2-pack

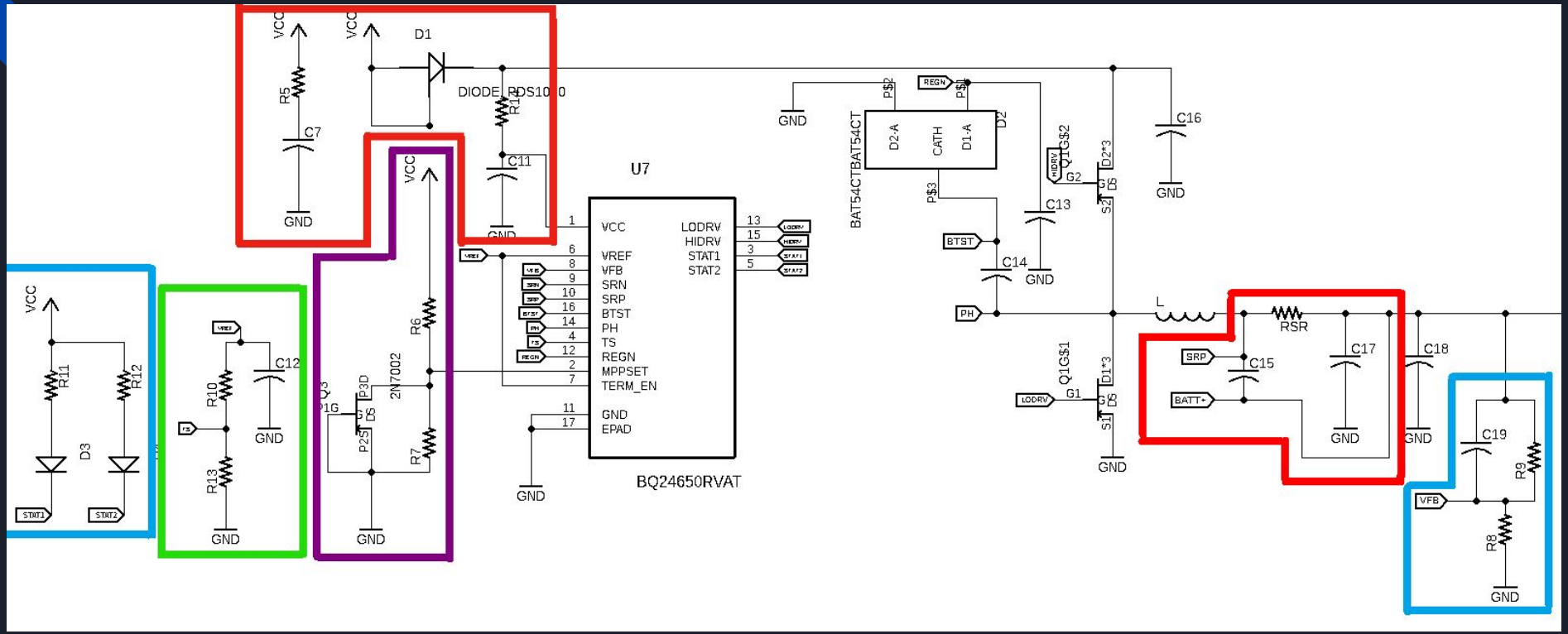
Schematic - Power



Charge Controller Selection

Component	Texas Instruments BQ24650	Microchip MCP73831	STMicroelectonics L6924D
Input Voltage	5-28V	3.75V-6V	2.5V-12V
Battery status indicator	3 states	3 states	2 states
Max. battery charge current	20 A	500 mA	1 A
Solar capable	Yes	No	Yes
Price	$4.43 from T.I.	$0.61 from Mouser	$1.87 from Mouser

Charge controller - BQ24650



- Input Over-voltage protection
- LEDs with charging status
- Temperature sensing
- Input voltage regulation
- Current feedback
- Battery voltage feedback

Voltage Regulator - 3.3V

TPS63051

Voltage input range	2.5V - 5.5V
Voltage output	3.3V
Max. current	1A
Operating Temp.	-40°C - 85°C
Efficiency	90%-95%
Switching frequency	2.5 MHz
Price	$1.66 from T.I.

TPS64203

Voltage input range	1.8V - 6.5V
Voltage output	1.2V - 6.5V
Max. current	3A
Operating Temp.	-30°C - 65°C
Efficiency	Up to 85%
Switching frequency	800 kHz
Price	$1.36 from T.I.

Voltage Regulator - 5V

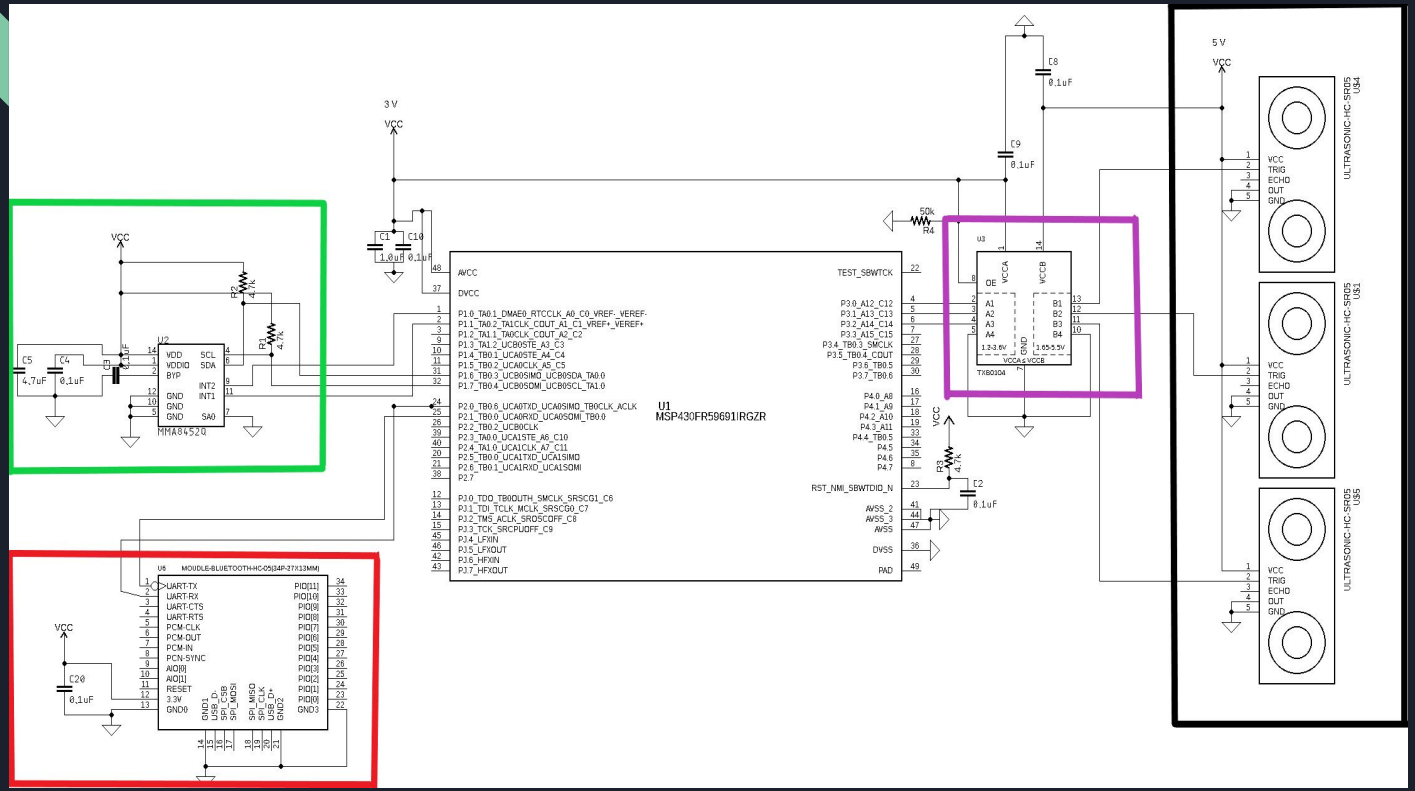
TPS61232

Voltage input range	2.3V - 5.5V
Voltage output	5V
Max. current	2.1A
Operating Temp.	-40°C - 85°C
Efficiency	Up to 94%
Switching frequency	2 MHz
Price	$1.66 from T.I.

TPS61253A

Voltage input range	2.3V - 5.5V
Voltage output	5V
Max. current	1.5A
Operating Temp.	-40°C - 85°C
Efficiency	Up to 95%
Switching frequency	3.5 MHz
Price	$1.18 from T.I.

MCU Schematic



HC-06
Bluetooth
-UART

MMA8452Q
Accelerometer
-i2C

TXB0104
Level Shifter
-GPIO

HC-SR05
Ultrasonic

Logic Level Shifter

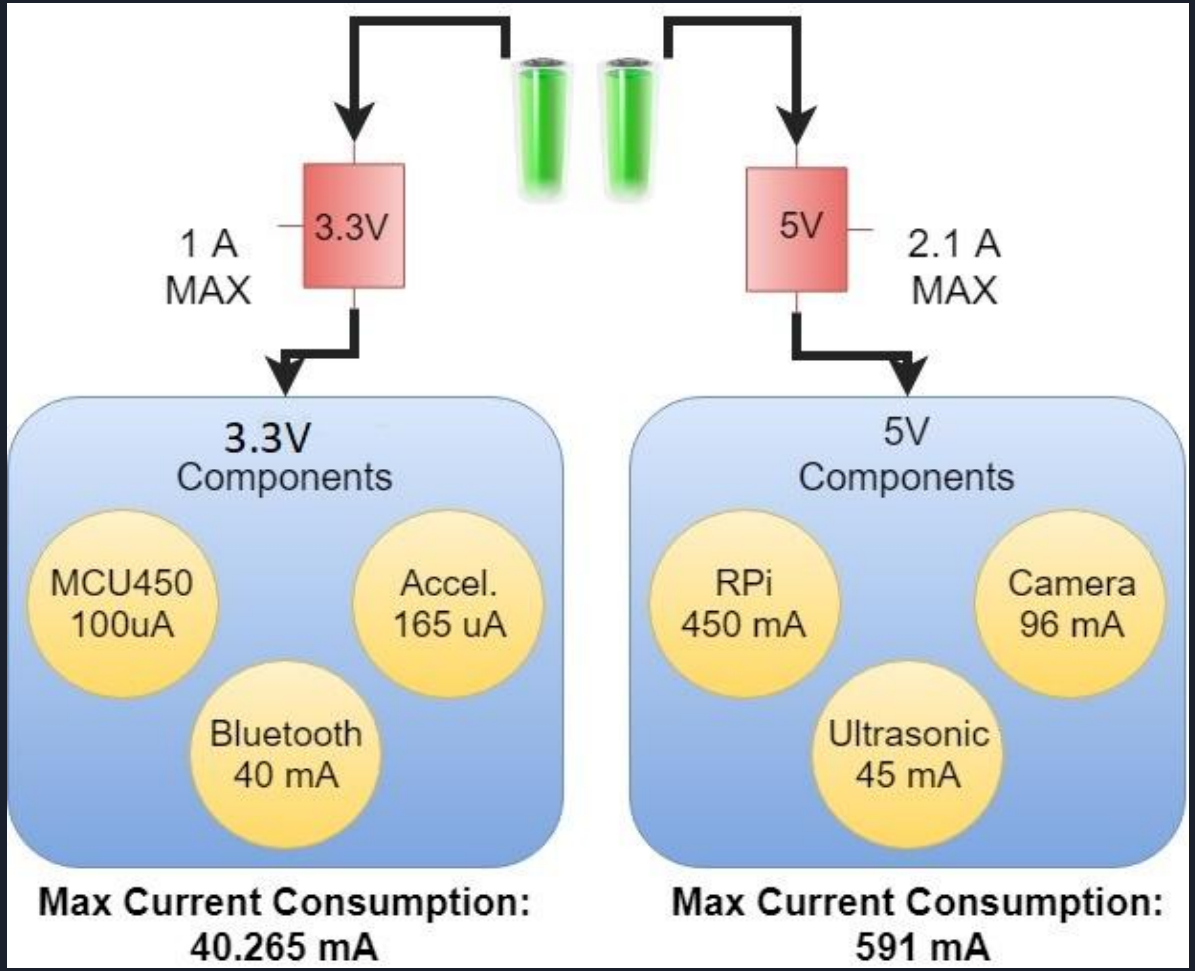
TXB0104

Bit size	4-bits Bi-directional
Logic Voltage capability	1.2V - 3.6V port A 1.65V - 5.5V port B
Propagation delay	1-4 nanoseconds
Max. logic output current	100mA
Clock skew	0.5 nanoseconds
Price	$1.25 from T.I.

LSF0204

Bit size	4-bits Bi-directional
Logic Voltage capability	1V - 4.5V port A 1.8V - 5.5V port B
Propagation delay	1.5 nanoseconds
Max. logic output current	64 mA
Clock skew	Depends on PCB
Price	$0.98 from T.I.

Current Consumption Flowchart



Battery Life

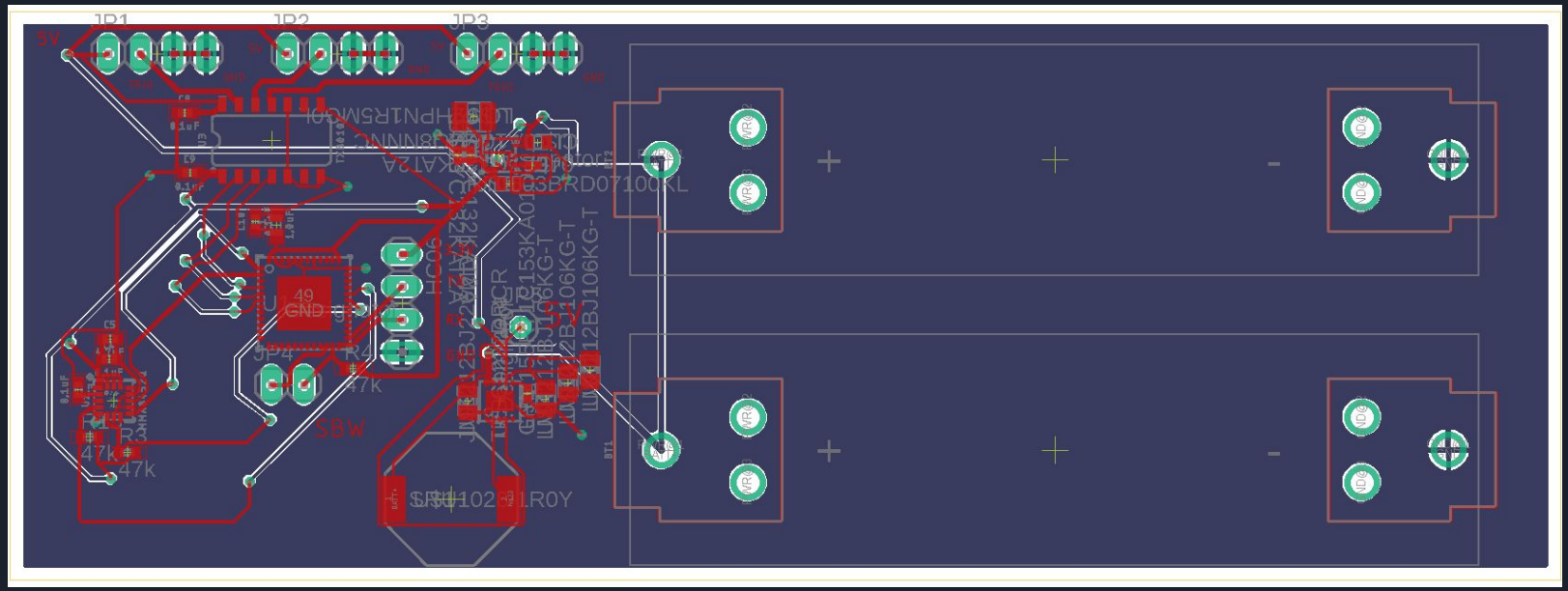
Component	Active mode current draw	Low-power mode current draw
MCU (MSP430FR59691)	100 µA	0.40 µA
Raspberry Pi module	450 mA	150 µA
Ultrasonic sensor * 3 (HC-SR05)	45 mA	0 mA (off)
Accelerometer ((MMA8452Q)	165 µA	6 µA
Bluetooth module (HC-06)	30 mA	1 mA
Camera module (Omnivision 5647)	96 mA	20 µA
All components together	599.765 mA	1.158 mA

In low power mode: (7000 mAh)/(1.158 mA) = 6044 hours = 251 days

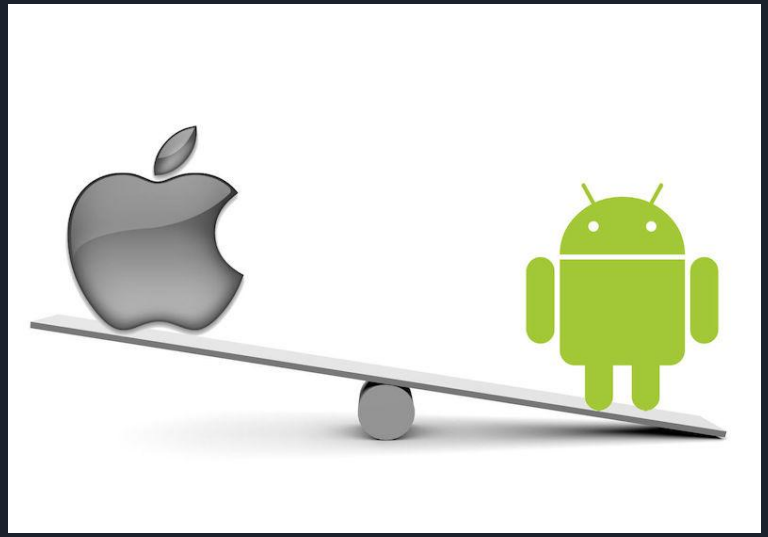
In active mode: (7000 mAh) / (599.765 mA) = 11.7 hours

PCB Drawing

4.72 inches x 1.57 inches

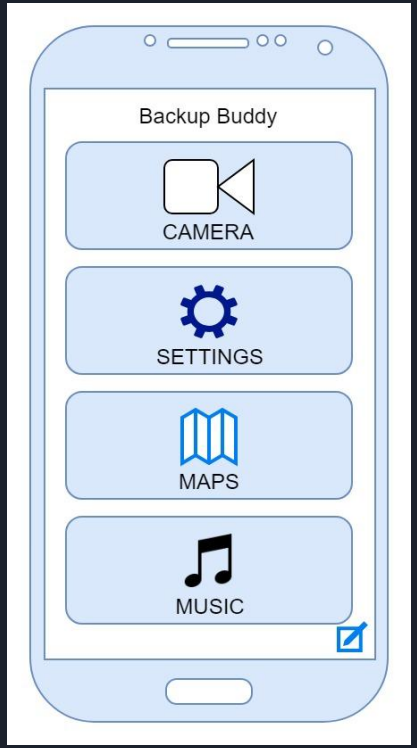


Mobile App Development: Android vs iOS

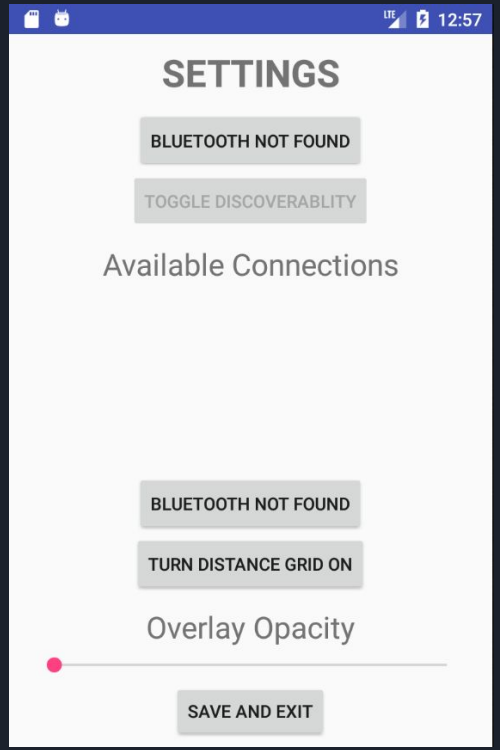


- Group members have more experience programming in Java.
- Tools like Android Studio allow for a quick and easy setup of the development environment and integrate version control directly into the IDE.
- iOS would require either Apple hardware or setting up a virtual machine to run iPhone emulation software.
- Android is mostly open-source and has detailed documentation and a wide-variety of easy-to-use APIs.

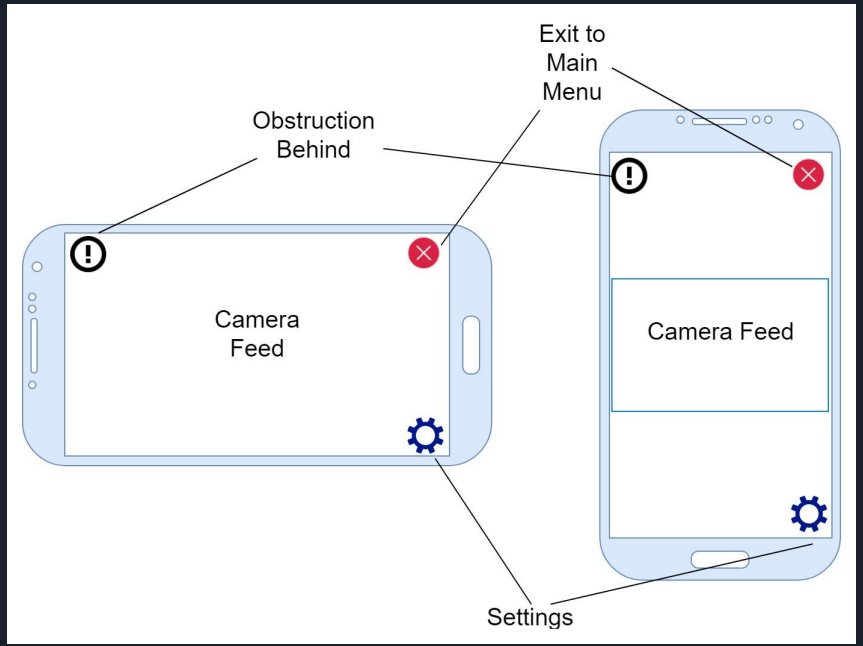
Mobile App - Main Menu



Mobile App - Settings Page



Mobile App - Camera View



Admin Content

Work Distribution

Member	Embedded	Android App	Circuit Design	PCB	Raspberry Pi Video
Coleman	X	X	X		X
Dylan	X		X		
Luca		X			X
Zak			X	X	

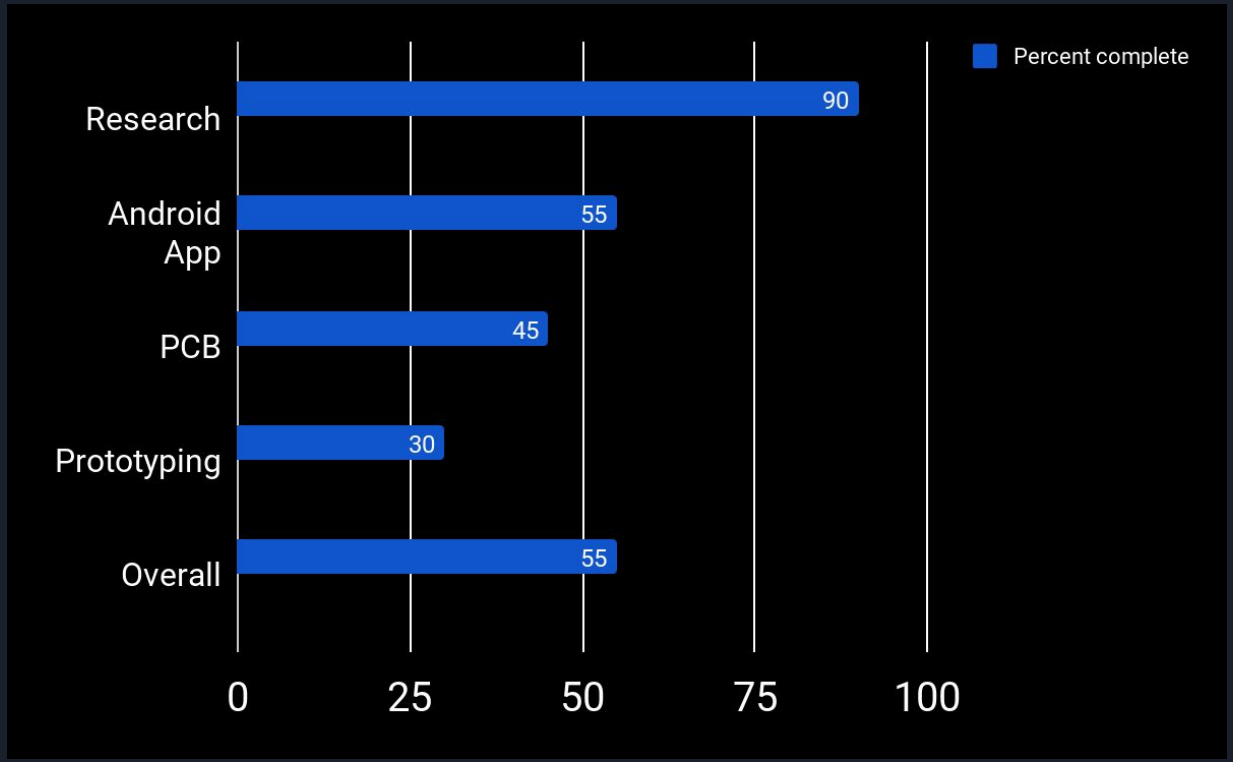
Financing

Item	Part Number	Quantity	Source	Cost
Ultrasonic Sensors	HC-SR05	4	Amazon	$15.98
Accelerometer	MMA8452Q	4	Karlson Robotics	$25.76
Microcontroller	MSP430FR5969	4	TI	$34.56
Bluetooth Module	HC-06	1	Amazon	$8.99
Sleepy Pi	Sleepy Pi	1	Spell Foundry	$55.95
Camera	Omnivision 5467	2	Amazon	$53.98
Raspberry Pi	Pi 3B	1	Amazon	$35.99

Development Cost: $255.69

Raw Parts: $194.76

Progress


Percent complete
Research
90
Android App
55
PCB
45
Prototyping
30
Overall
55
0
25
50
75
100

Issues

- Reading battery status to display in app
- Handling transmission errors over UART and how the app will update the UI to show them
- Testing the enclosure with weights vs testing with our actual hardware
- Testing smaller components on PCB

Questions ?