THE WI-FI SEEKER

GROUP 30

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SPONSORS:

LEIDOS

DUKE ENERGY

THE WI-FI SEEKER

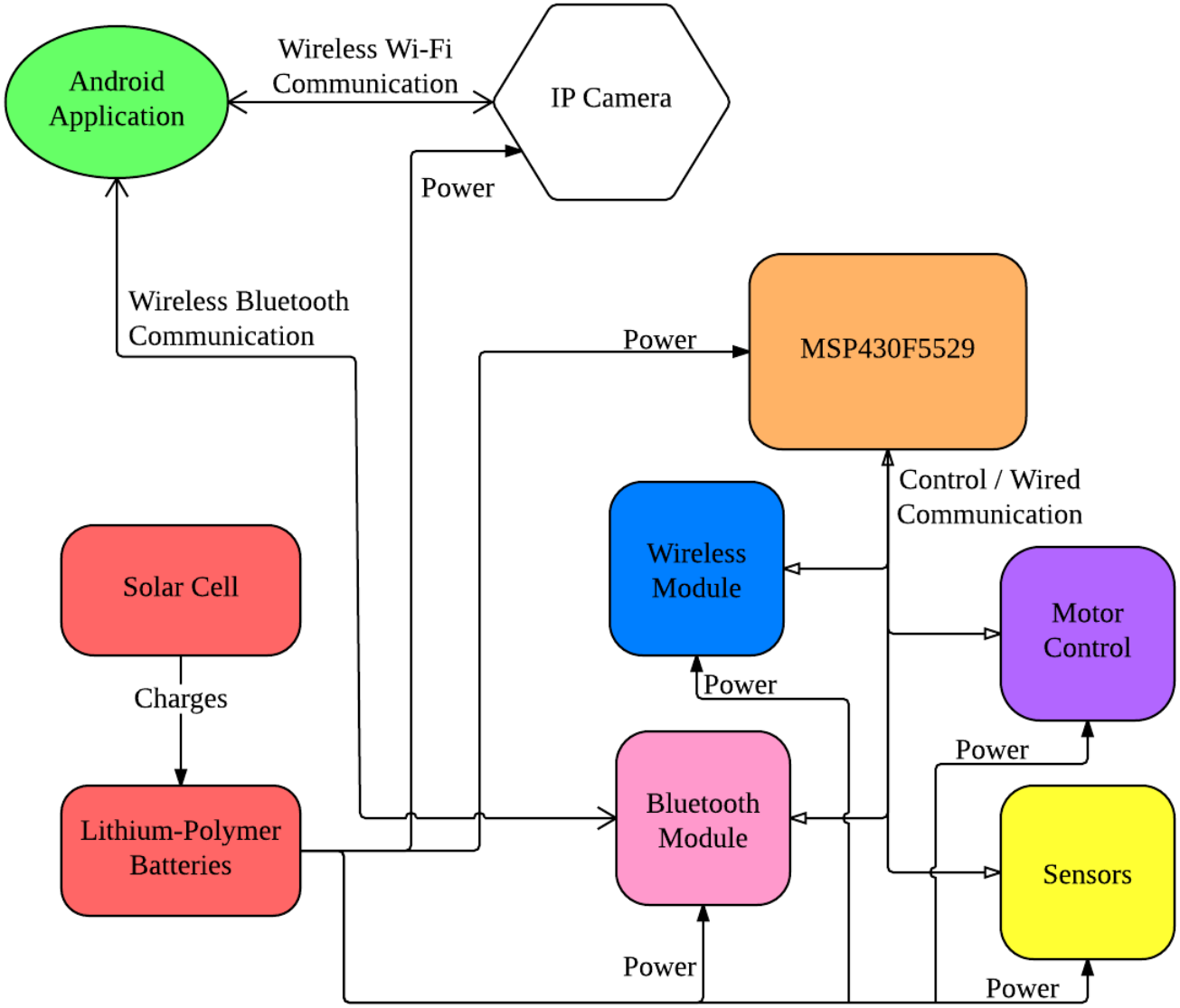
- **The Wi-Fi Seeker is a robot whose purpose is to determine the location where a Wi-Fi signal is strongest.**
- **This robot aims to solve the issue of locating where in an area the strongest connection to a network can be obtained.**
- **The robot features an autonomous algorithm to determine where this location is.**

GOALS AND OBJECTIVES

- **The robot will be controlled using a mobile application.**
- **The robot will have autonomous functionality, and be able to locate where in an area a wireless network is broadcasting the strongest.**
- **The robot will be powered by solar-charged batteries.**

SPECIFICATIONS

Component	Parameter	Design Specification
Battery	Charge time	8 hours
Battery	Average run time	45 minutes
Bluetooth	Minimum range	10 meters
Sensors	Sensing distance	1 ft
Motors	Maximum Speed	3.1 mph


Android Application
Wireless Wi-Fi Communication
IP Camera
Power
Wireless Bluetooth Communication
Power
MSP430F5529
Control / Wired Communication
Wireless Module
Motor Control
Solar Cell
Charges
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Lithium-Polymer Batteries
Bluetooth Module
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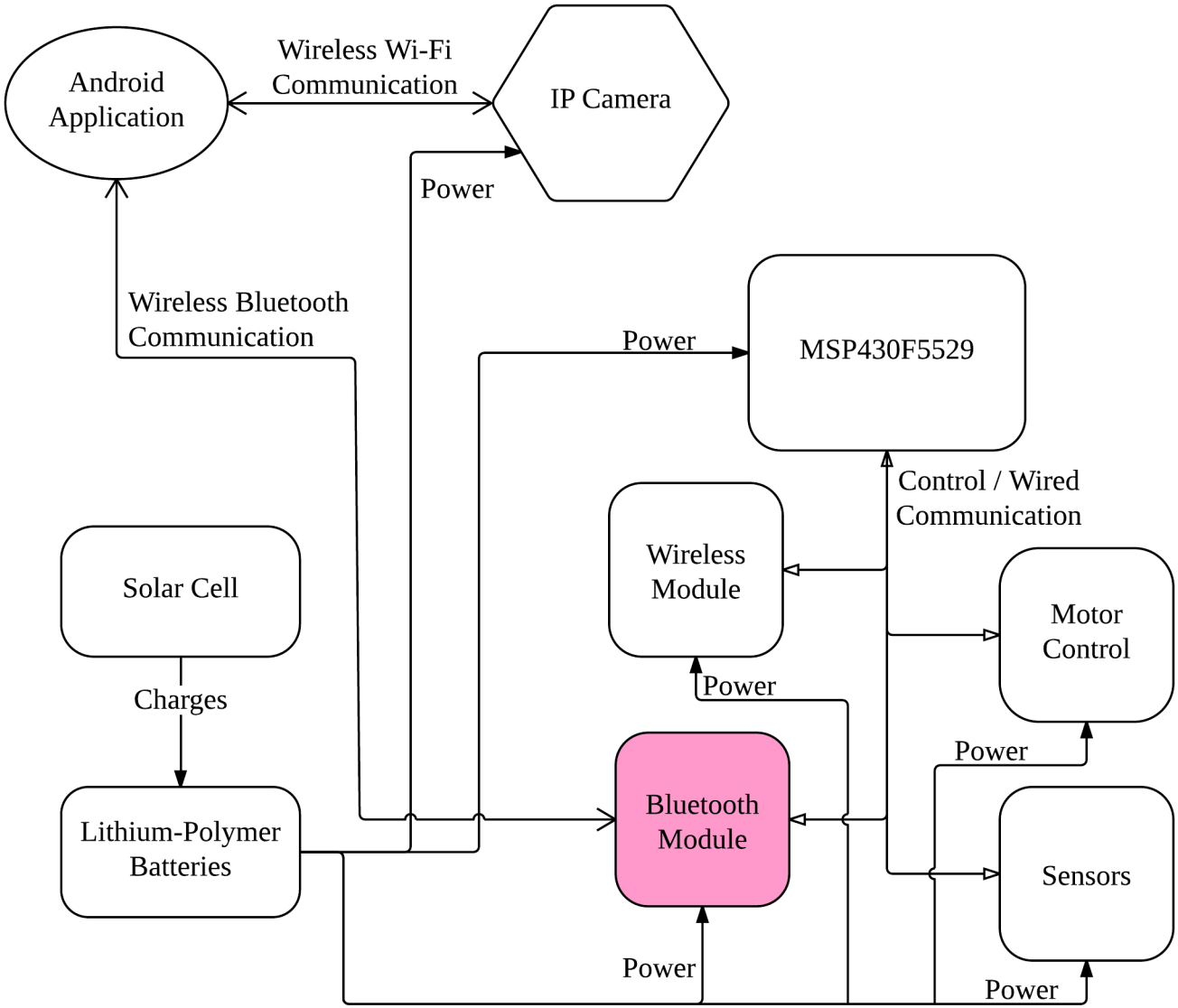
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MEANS OF WIRELESS TRANSMISSION

BLUETOOTH

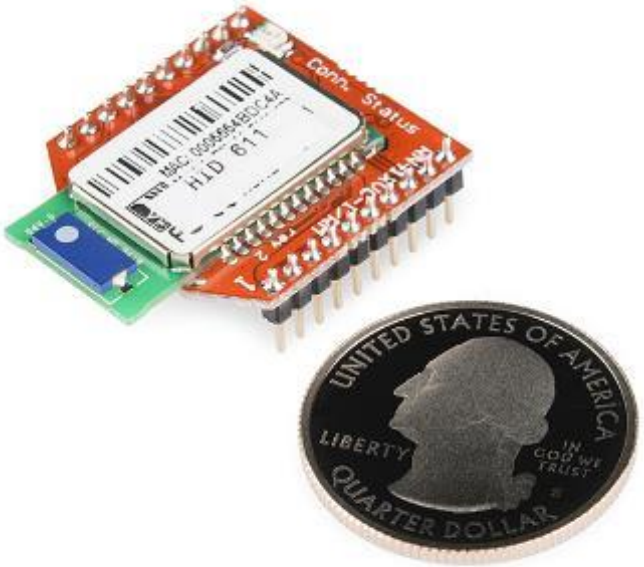
- Leading protocol for short range wireless transmission
- Vast documentation for Bluetooth usage in Android applications.
- Extremely power efficient

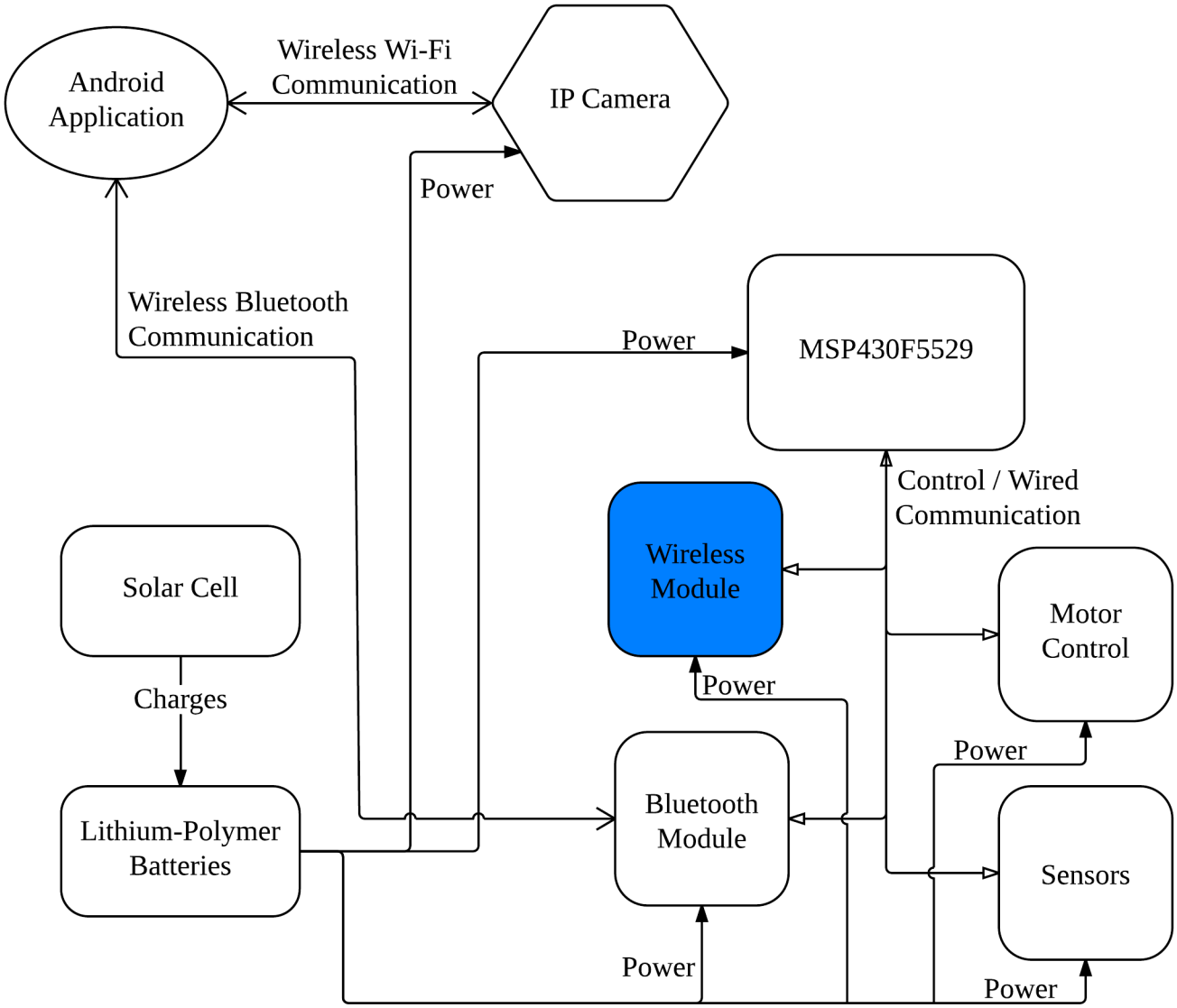
WI-FI DIRECT

- Newer, less frequently used protocol.
- Android developers documentation for Wi-Fi P2P
- Highly energy inefficient

BLUETOOTH MODULE

- **RN41-XV Bluetooth Module ($30, SparkFun)**
- **Operates at 3.3V, 30mA**
- **Bluetooth version 2.1**
- **Sustained data rate 240 Kbps**
- **115,200 baud**
- **Used to transmit data between the Android application and the MSP430F5529.**

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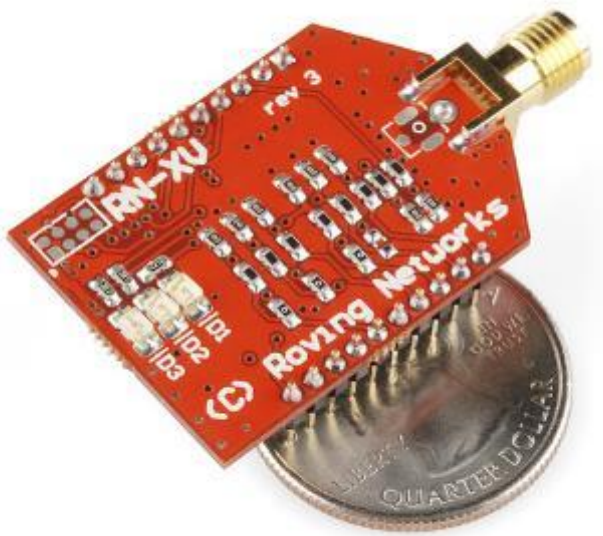
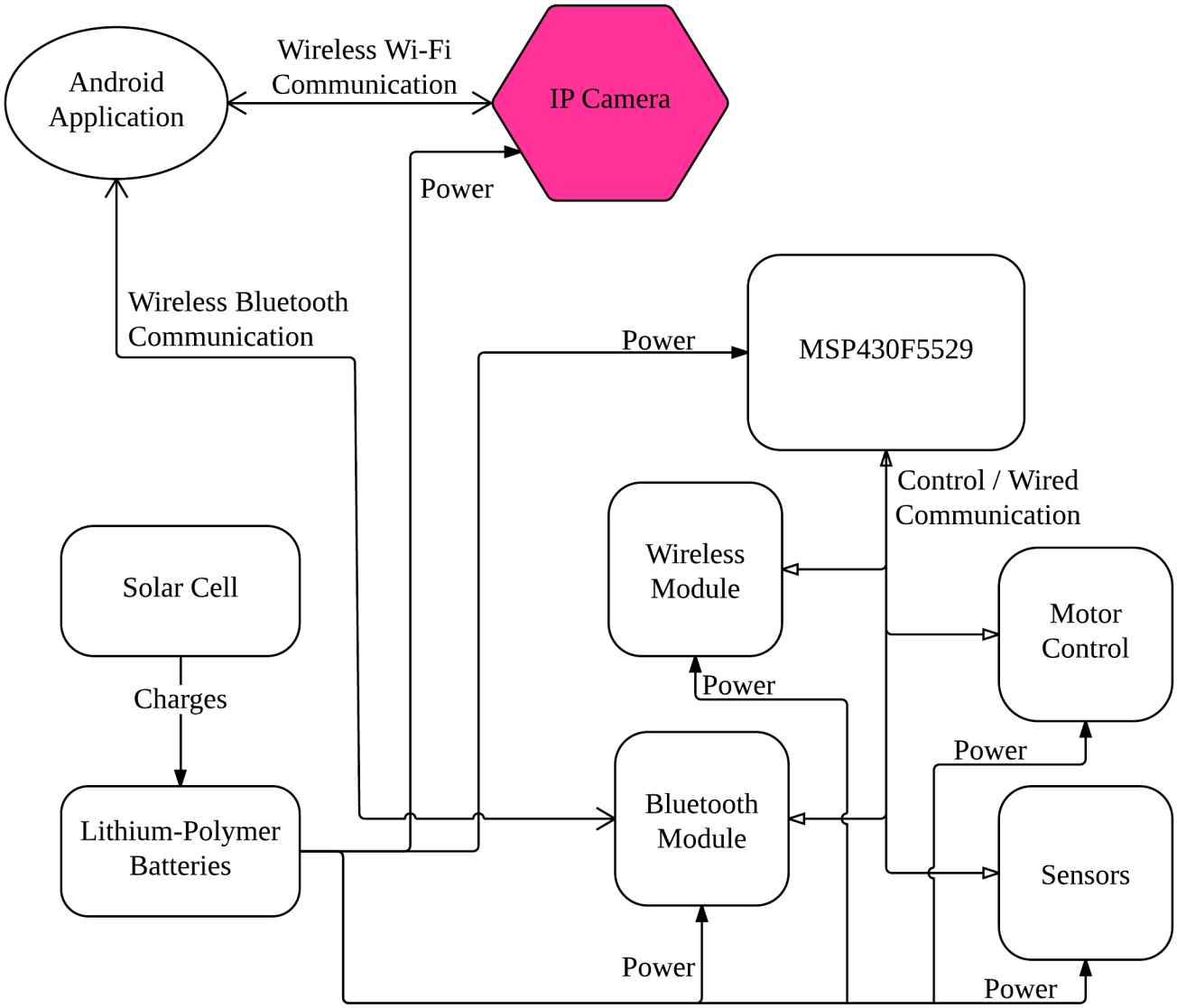
WIRELESS MODULE

- **RN-XV Wifly Module ($35, SparkFun)**
- **Operates at 3.3V, 38mA**
- **115,200 baud**
- **Used to scan for local networks, join a network, and show the RSSI of a selected network.**
- **Ex)**
  >> show rssi
  << RSSI =(-55) dBm



WIRELESS MODULE

- **The RN-XV Wifly Module comes equipped with its own command set.**
- **"scan" - discover local networks**
- **"join" - associate to a network**
- **"show rssi" - return measured RSSI of the currently selected network**
- **also various other commands to change settings or show other network statistics**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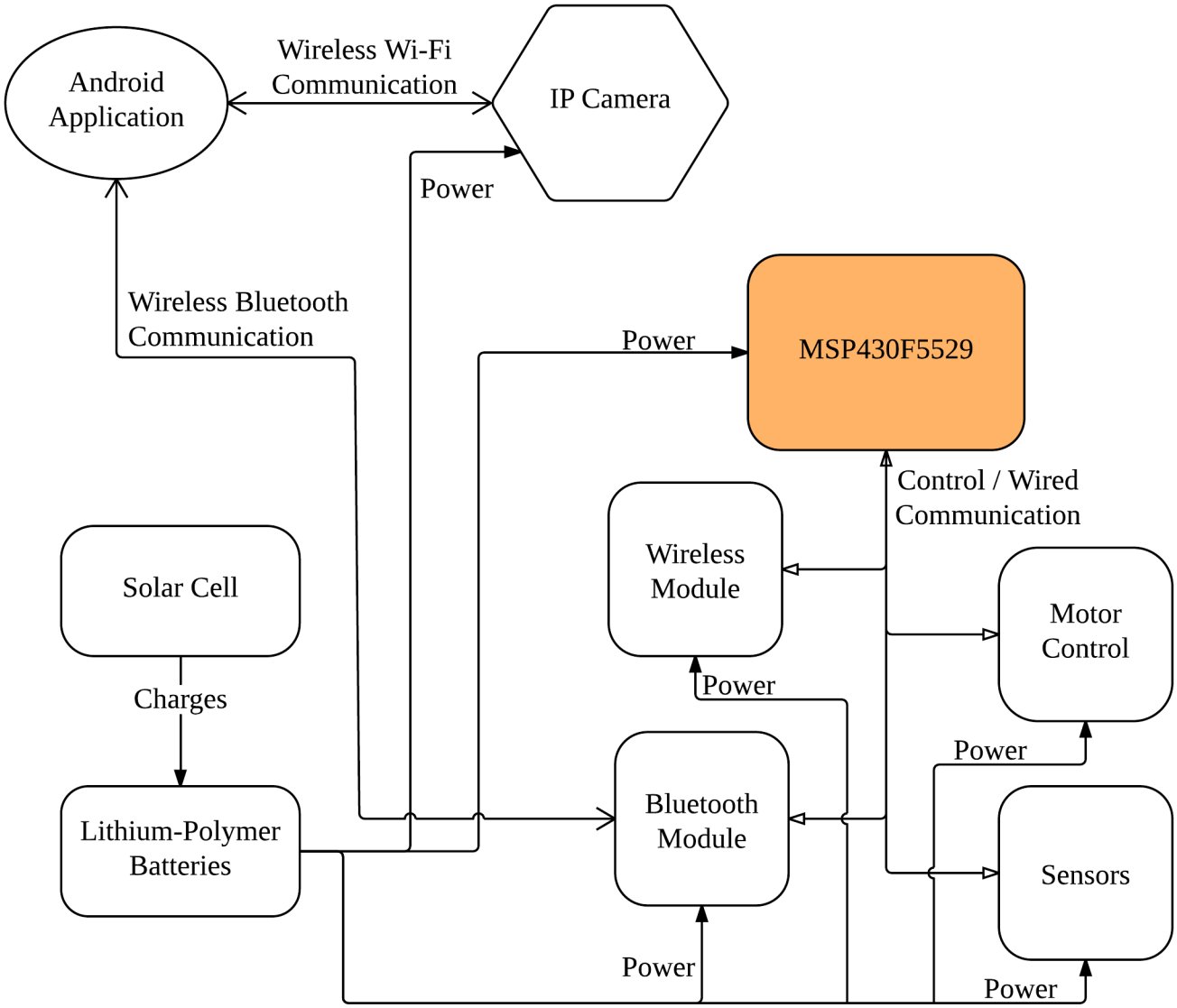
IP CAMERA

- **D-Link DCS-932L ($55, Amazon)**
- **Operates at 5V, 1.2A**
- **Directly connects to a wireless network**
- **Video stream can be accessed from its IP address**

ACCESSING THE VIDEO FEED

- **The IP camera's video feed will be accessible through an IP address.**
- **The Android application will retrieve this video feed using the WebView class.**
- **The camera is equipped with security, requiring a username and password combination in order to access the video feed.**
  - This will prevent other users from accessing the camera even if they know the address .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CHOOSING A MICROCONTROLLER

ATMEGA328

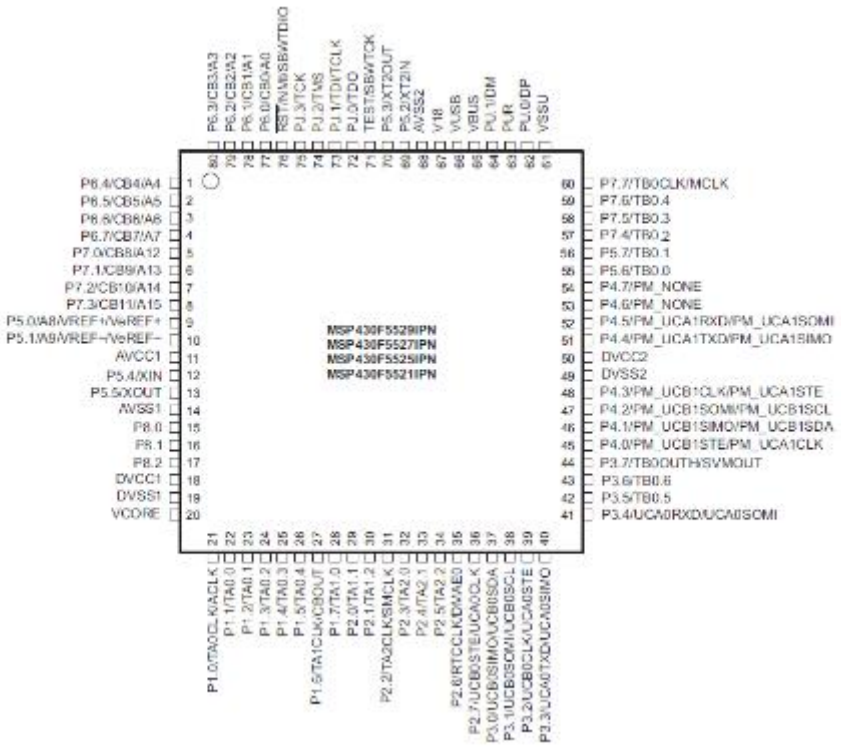
- 1 UART, 1 I2C, 0 SPI
- 14 Digital I/O pins
- 1.8-5.5V
- 2KB RAM
- 32KB Memory
- 20 MHz CPU speed

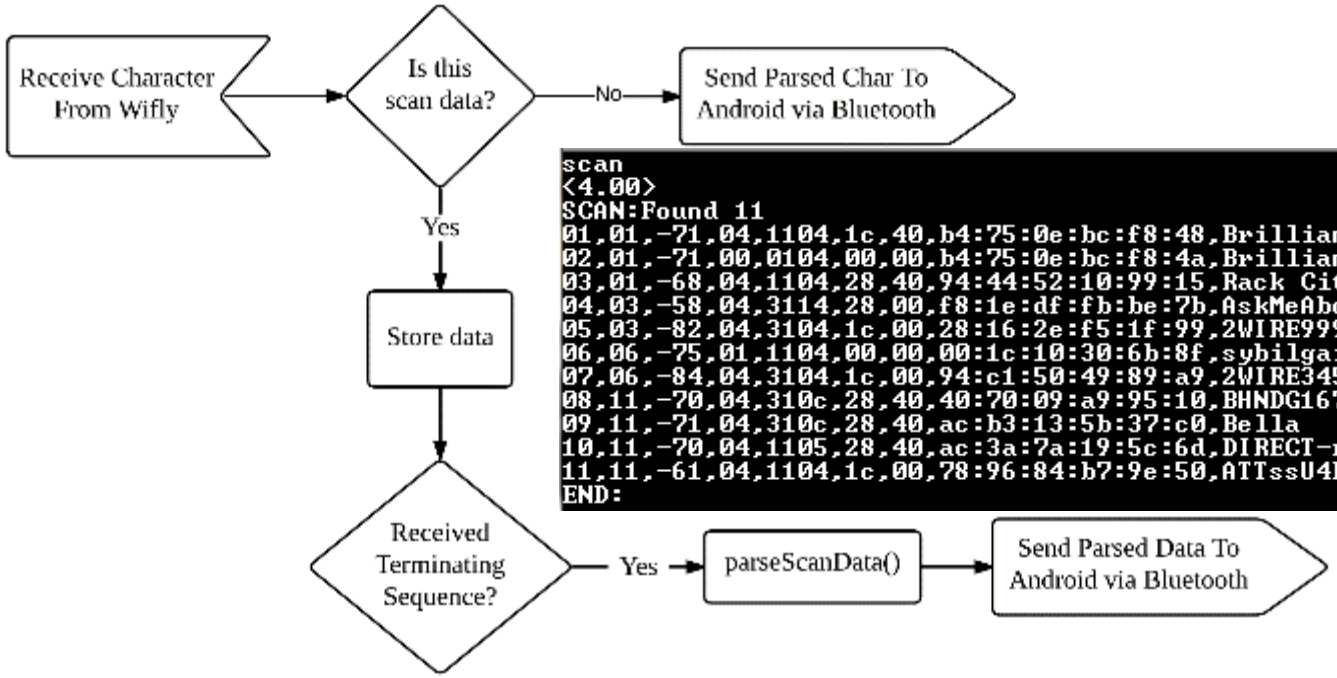
MSP430F5529

- 2 UART, 2 I2C, 4 SPI
- 63 Digital I/O pins
- 1.8-3.6V
- 8KB RAM
- 128KB Memory
- 25 MHz CPU speed

MSP430F5529

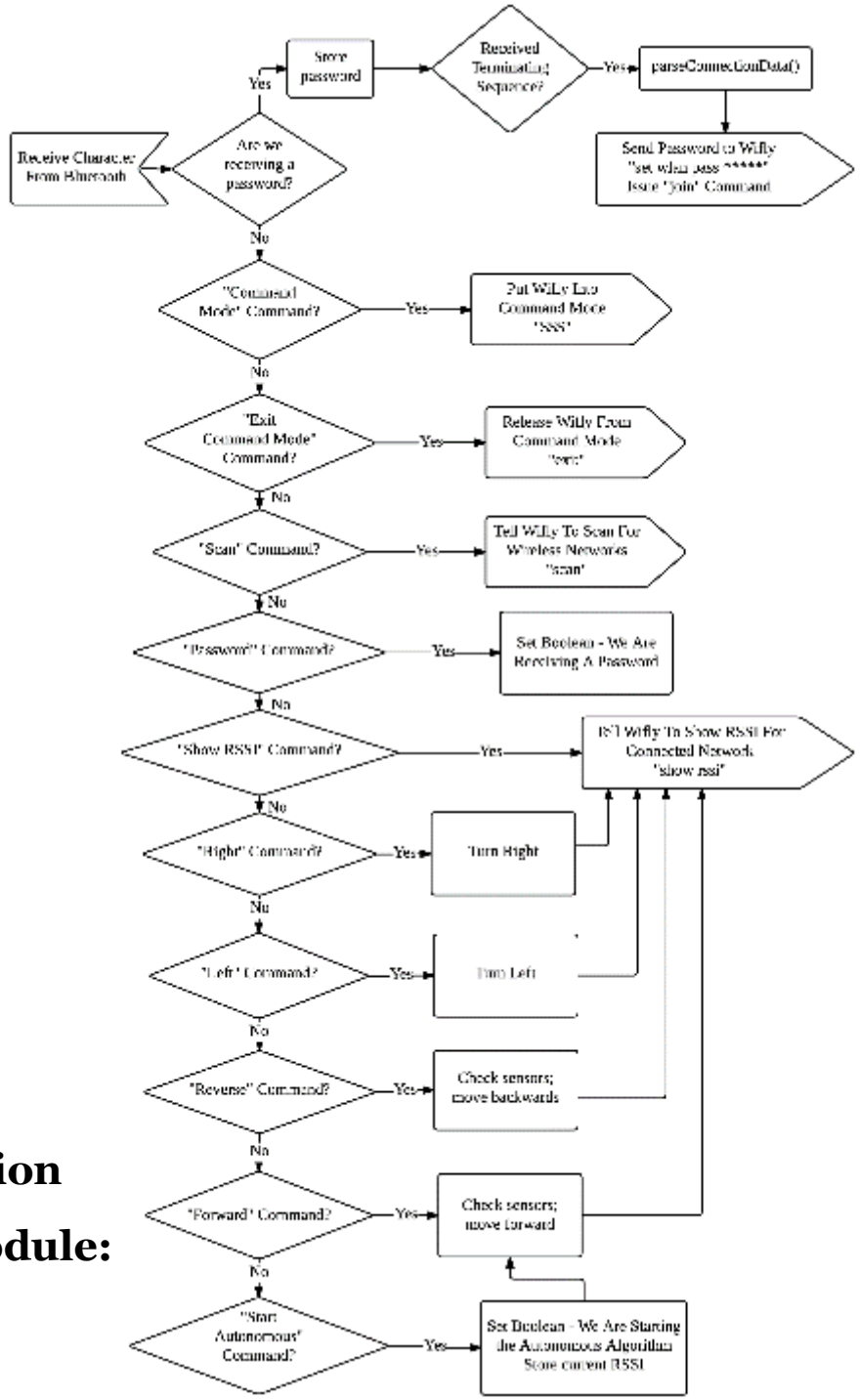
- **TI's MSP430F5529 will be the brain of the Wi-Fi Seeker robot**
- **Communicates with**
  - **Bluetooth module**
  - **Wireless module**
  - **Sensors**
  - **Motor controllers**
- **Will be responsible for the autonomous seeking algorithm**





MSP Communication with Wi-Fi Module: UCAo_Interrupt

MSP Communication with Bluetooth Module: UCA1_Interrupt

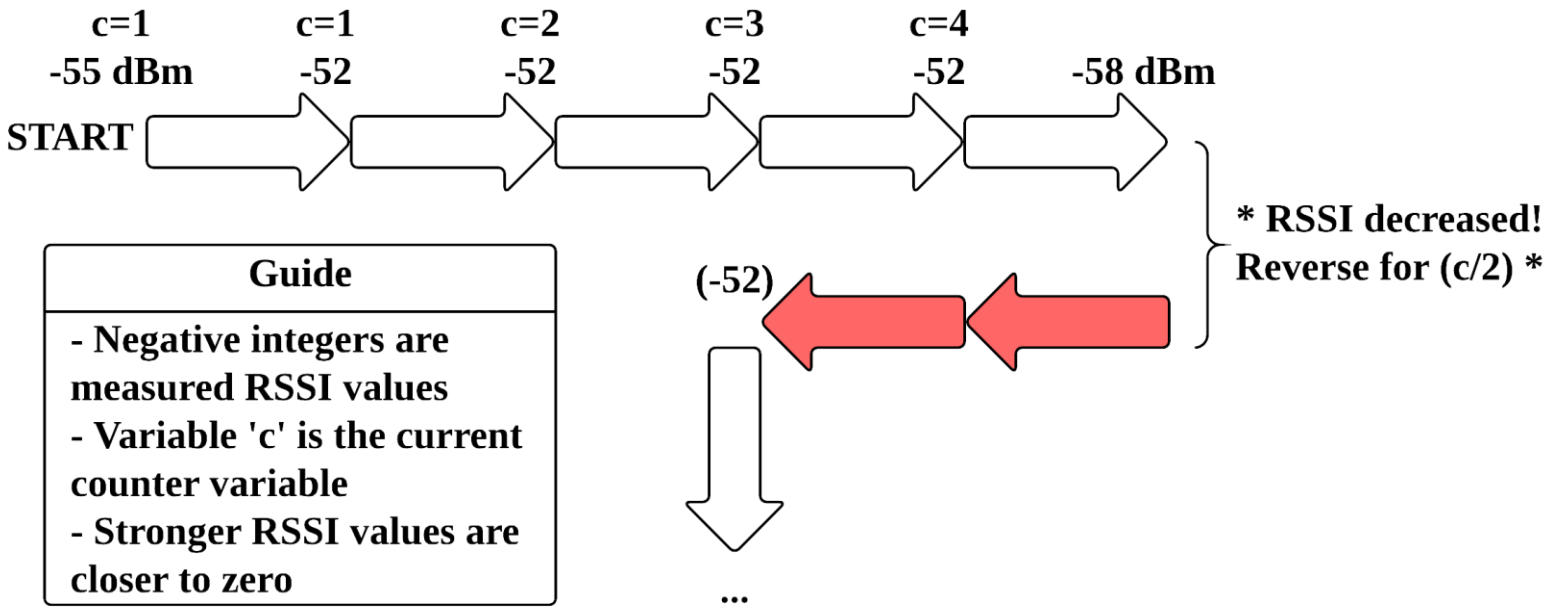


THE AUTONOMOUS ALGORITHM

- **The algorithm is based off of the dynamic reception of the wireless signal strength.**
  - The RSSI value can be retrieved by sending a “show rssi” command to the wireless module.
- **When the user begins the autonomous algorithm, the robot will begin taking RSSI measurements and moving accordingly.**

THE AUTONOMOUS ALGORITHM

- **The robot will move forward, then take an RSSI measurement.**
  - This RSSI value will then be compared to the previously measured RSSI value.
  - A count will be kept for when the same RSSI value is measured consecutively.
- **If the new RSSI measurement is greater than or equal to the previous RSSI measurement, continue to move in the current direction.**
- **Else if the new RSSI measurement is less than the previous RSSI measurement, reverse for half of the measurements taken at the previous RSSI measurement, and then turn 90 degrees.**



Autonomous Algorithm – Visual Example

THE AUTONOMOUS ALGORITHM

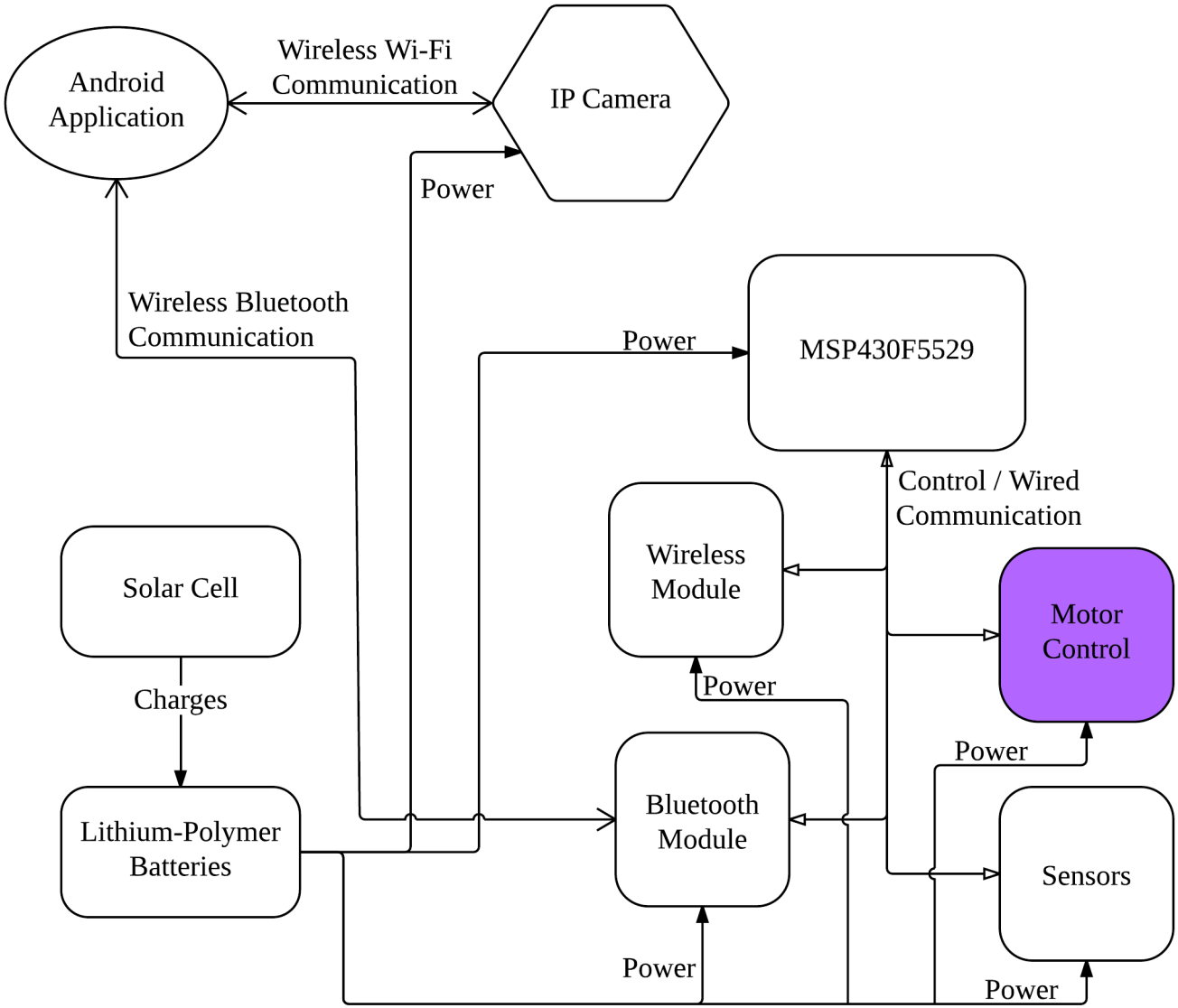
- **Obstacle avoidance is important so the robot can move without colliding with obstacles.**
  - **If an obstacle is detected, the robot will reverse and turn left.**

- **A potential problem is that the target RSSI might not ever be achieved, which would lead to the robot roaming infinitely.**
  - **The number of moves made after a new maximum RSSI will be tallied. After a certain point, the robot will reset it's target RSSI.**

PROGRAMING THE MSP

- **Programming the MSP430F5529 chip is its own problem.**
- **Possible options include designing a JTAG, or buying an expensive programming tool.**
- **Using a G2553 is a third, and is the cheapest and easiest to implement.**

G2553	F5529
3.3V	3.3V
GND	GND
TEST under J3	SBW TEST
RST under J3	SBW RST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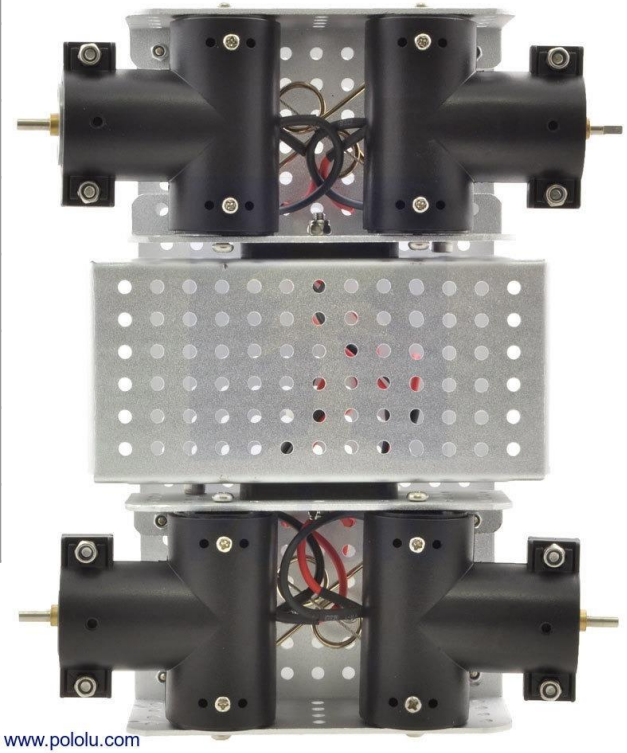
ROBOT PLATFORM

- **4-wheel drive chassis**
- **“Super-twist” suspension**
- **Spiked tires**

Dagu Wild Thumper 4WD	
Dimension	280x300x130mm
Weight	1.9kg
Ground Clearance	60mm
Wheels	120x60mm

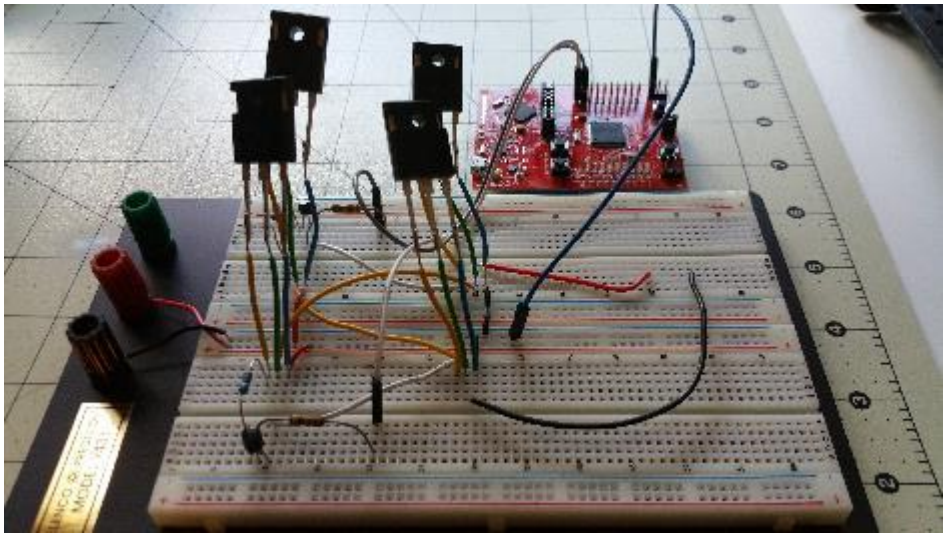
MOTORS

DC Motor	
Description	**Value**
Gear ratio	34:1
Working voltage	2-7.2V
Stall current	6.6A
No-load current	420mA
Top Speed @ 7.2V	4.5 mph
Stall torque	5kg-cm
No-load shaft speed @ 7.2V	350 RPM
Power	47.5 W



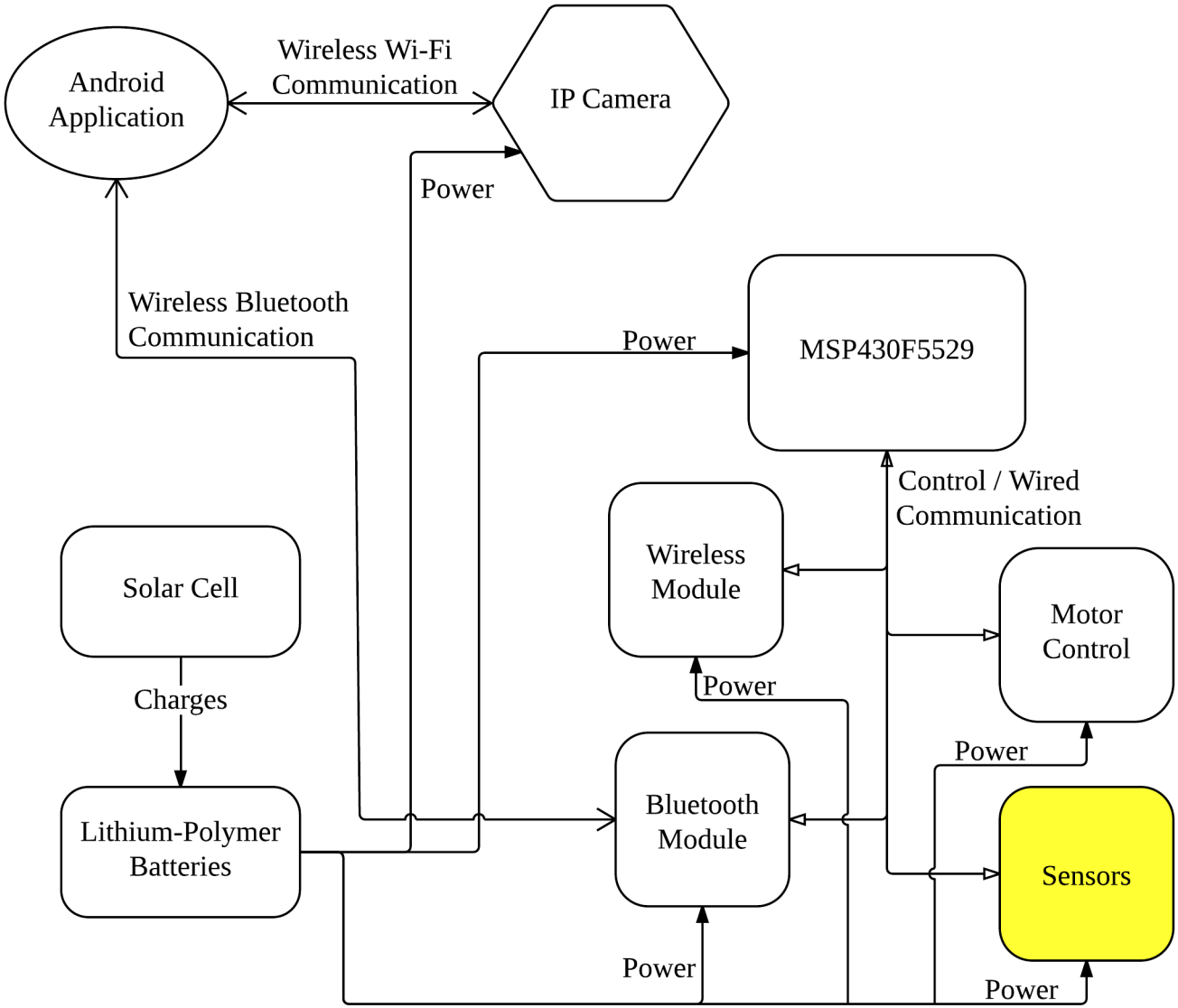
MOTOR CONTROLLER

MJH6284 (NPN) MJH6284 (PNP)	
Description	**Value**
Collector-Emitter Voltage	100V
Collector-Base Voltage	100V
Collector Current	20A Continuous 40A Peak



MOTION CONTROL

- **The 4 motors are setup in a differential-drive configuration.**
- **Motion is controlled by specifying the speed of rotation as well as the length of rotation.**
- **Speed varies from [0,255]**
- **Length is a positive integer**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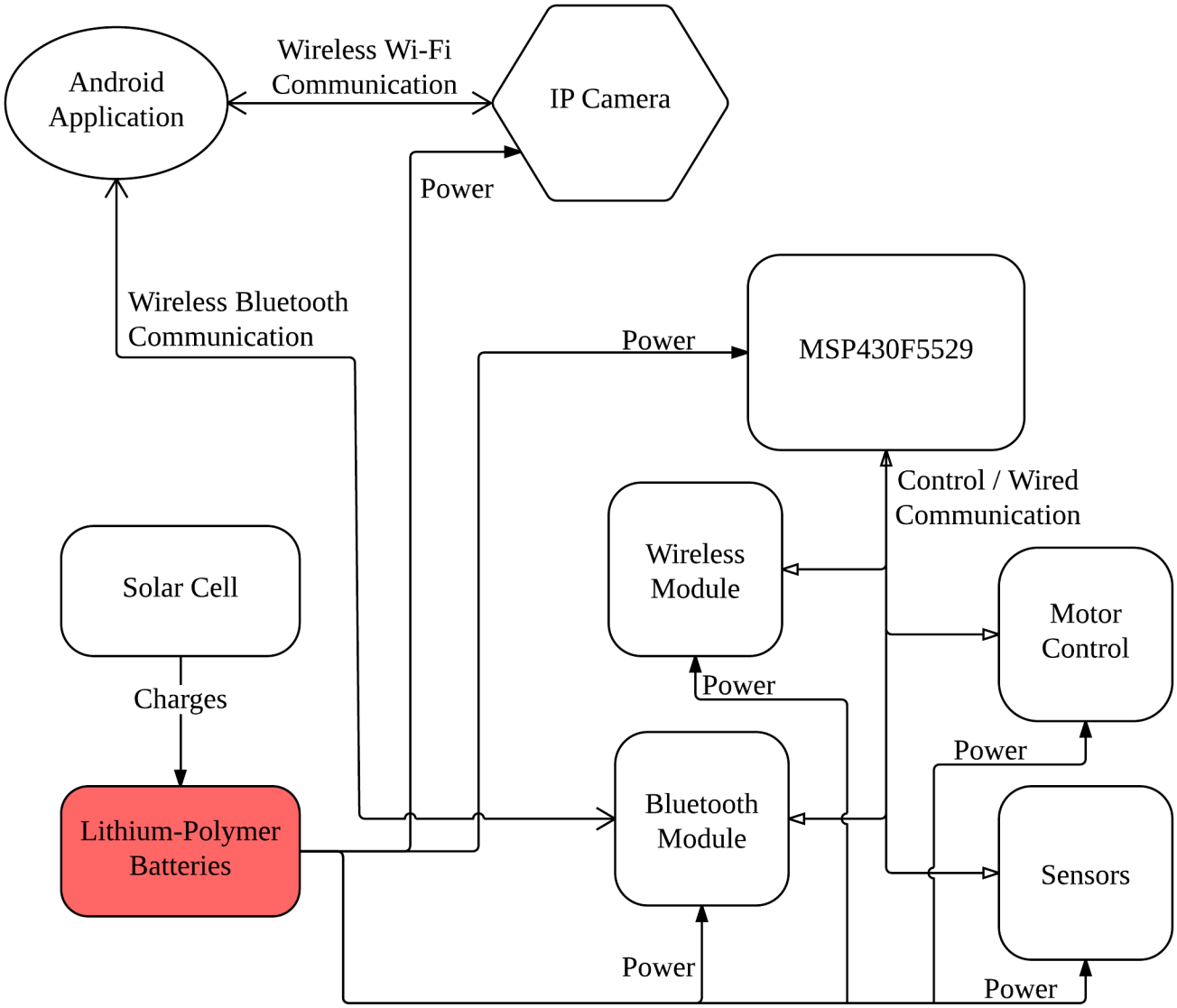
PROXIMITY SENSORS

Sharp GP2Y0A21YK	
Description	**Value**
Operating Voltage	5V
Working Current	30mA
Max Range	80cm
Min Range	10cm
Measure Angle	40 degrees
Dimension	40x13x13.5mm
Power	0.15 W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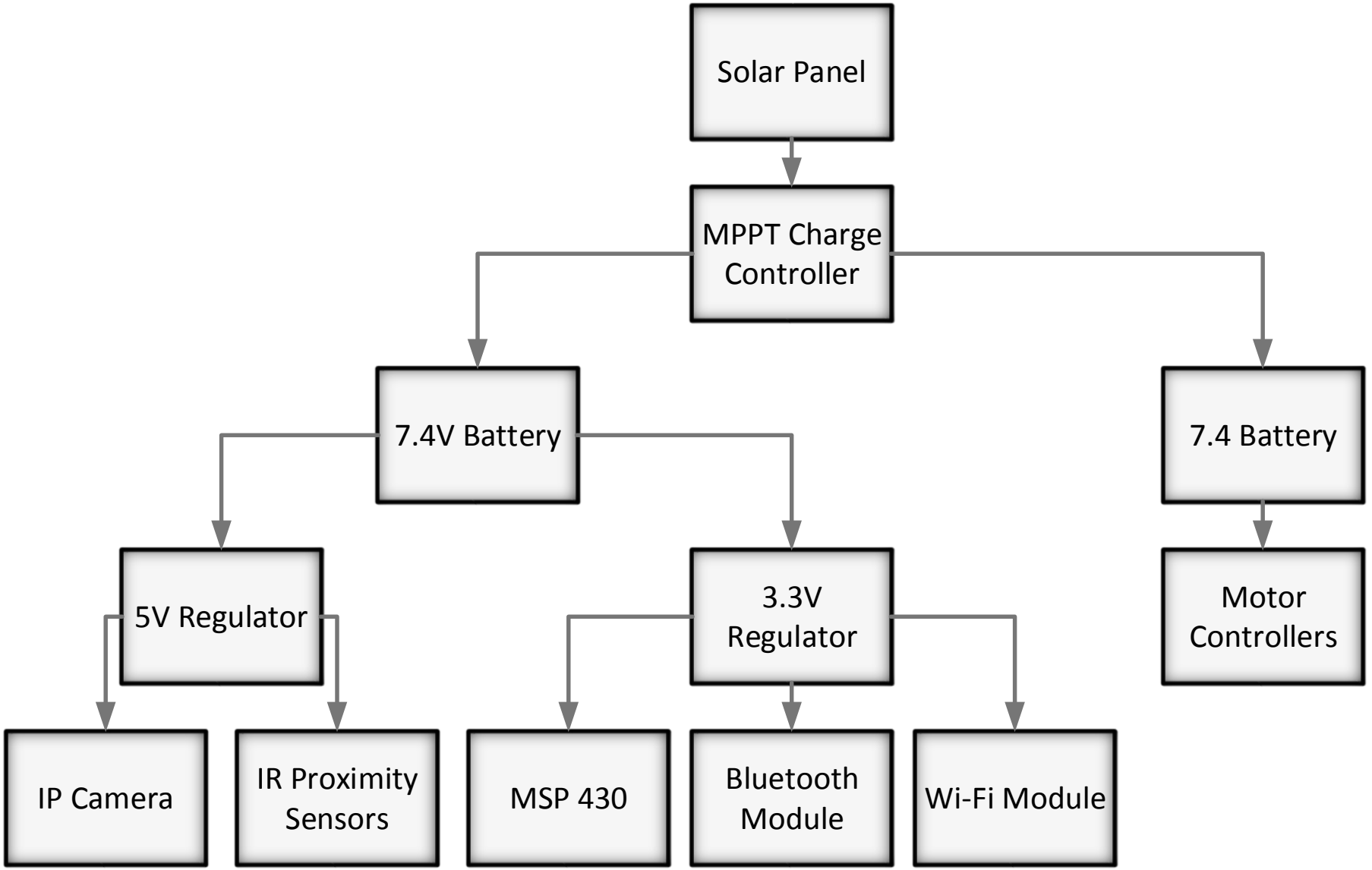
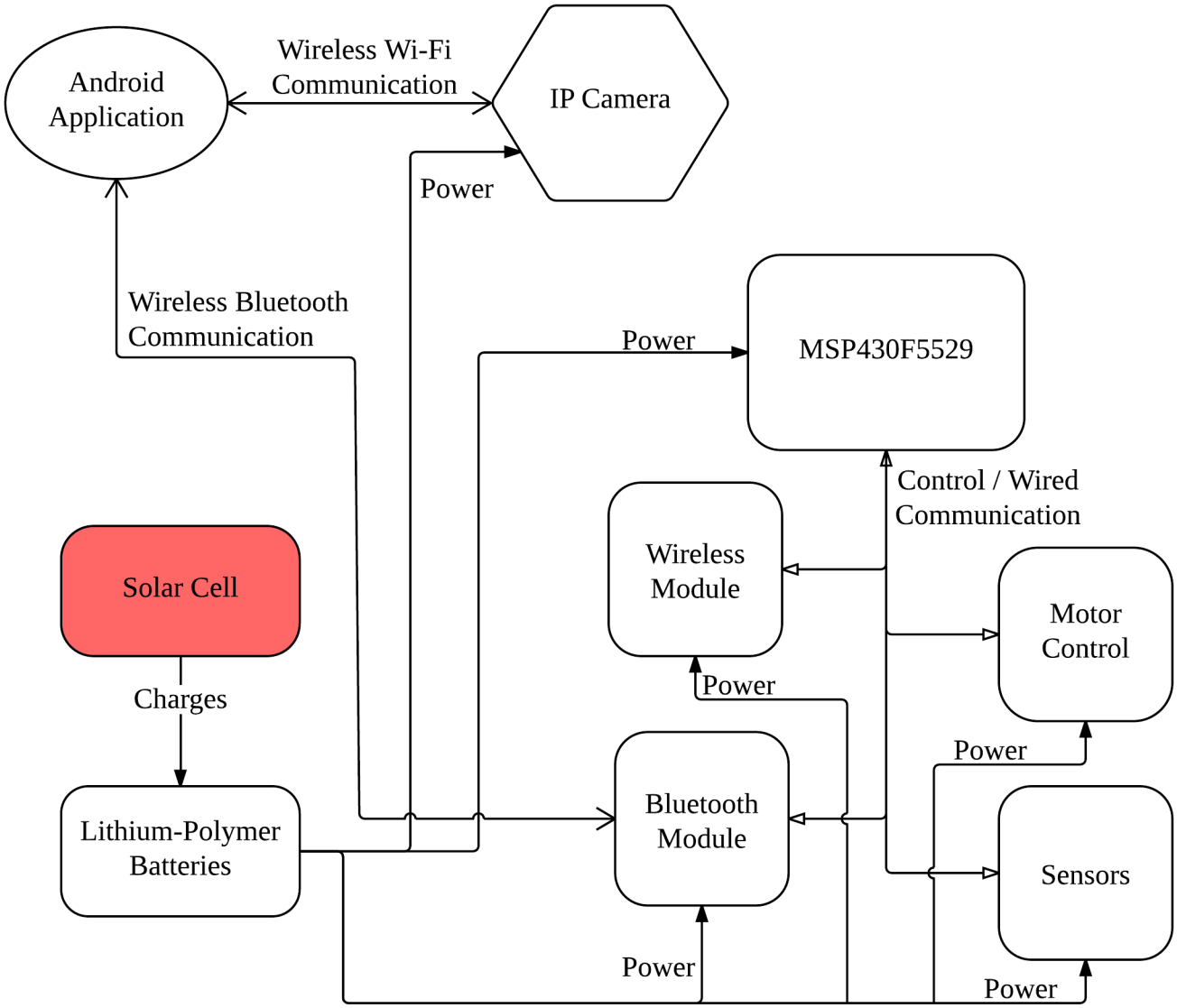
BATTERY

- **Chemistry: Lithium Polymer**
- **Voltage: 7.4V**
- **Capacity: 3200 mAh**
- **Discharge Rate: 20C**
- **Max Output Current: 3200*20 = 64,000 mA or 64 A**
- **Total Current of System (worst case): 28A**

POWER REQUIREMENTS

Component	Voltage	Current	Power
IR Proximity Sensor	4.5-5.5 V	30-40 mA	0.6 W
Webcam	5V	1.2 A	6 W
Motor Controller	7.2 V	26.4 A	190 W
Microcontroller	1.8-3.6 V	15.4-17.2 mA	55 mW
Wi-Fi Module	3-3.7 V	15-180 mA	0.6 W
Bluetooth Module	3-3.6 V	35-160 mA	0.5 W


Solar Panel
MPPT Charge Controller
7.4V Battery
7.4 Battery
5V Regulator
3.3V Regulator
Motor Controllers
IP Camera
IR Proximity Sensors
MSP 430
Bluetooth Module
Wi-Fi Module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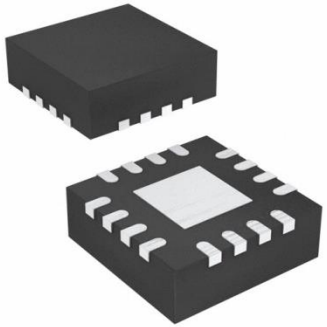
SOLAR PANEL

Specification	Value
Manufacturer	Solartech Power Inc.
Model #	SPM010P
Price ($)	69.95
Maximum Power (Watts)	10
Voltage @ P_{MAX} (V)	17.3
Current @ P_{MAX} (A)	0.59
Efficiency (%)	9.5
Weight (lb)	3.3
Area (in^2)	176.9
Crystal Structure	Polycrystalline

Battery Charge Time: 3200 mAh/ 590 mA = 5.4 hrs

CHARGING CONTROLLER



- **Part #: BQ24650**
- **Package: QFN 16**
- **5-28V Solar Panel Input**
- **Charging Cycle: Preconditioning, CC, CV**
- **Maximum Power Point Tracking**
- **V_{MPPSET} = 17.3V**
- **V_{BAT} = 8.4V**
- **I_{CHARGE} = 3A**

$$V_{MPPSET} = 1.2\ V \times \left[1 + \frac{R3}{R4}\right]$$

$$V_{BAT} = 2.1\ V \times \left[1 + \frac{R2}{R1}\right]$$

$$I_{CHARGE} = \frac{40\ mV}{R_{SR}}$$

SWITCHING VOLTAGE REGULATOR

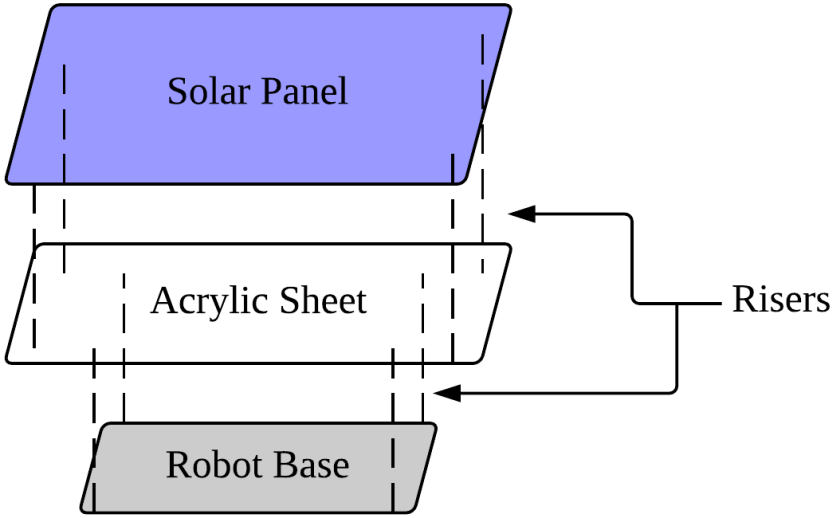
- **Part # LM2592HVSX-3.3/NOPB**
- **Type: Step-Down (Buck)**
- **Package: DDPAK/TO-263**
- **4.5-60V Input**
- **3.3V Output**
- **Internal Feedback Resistors**
- **Max Current: 2A**
- **Efficiency: 74-77%**
- **Switching Frequency: 150 kHz**

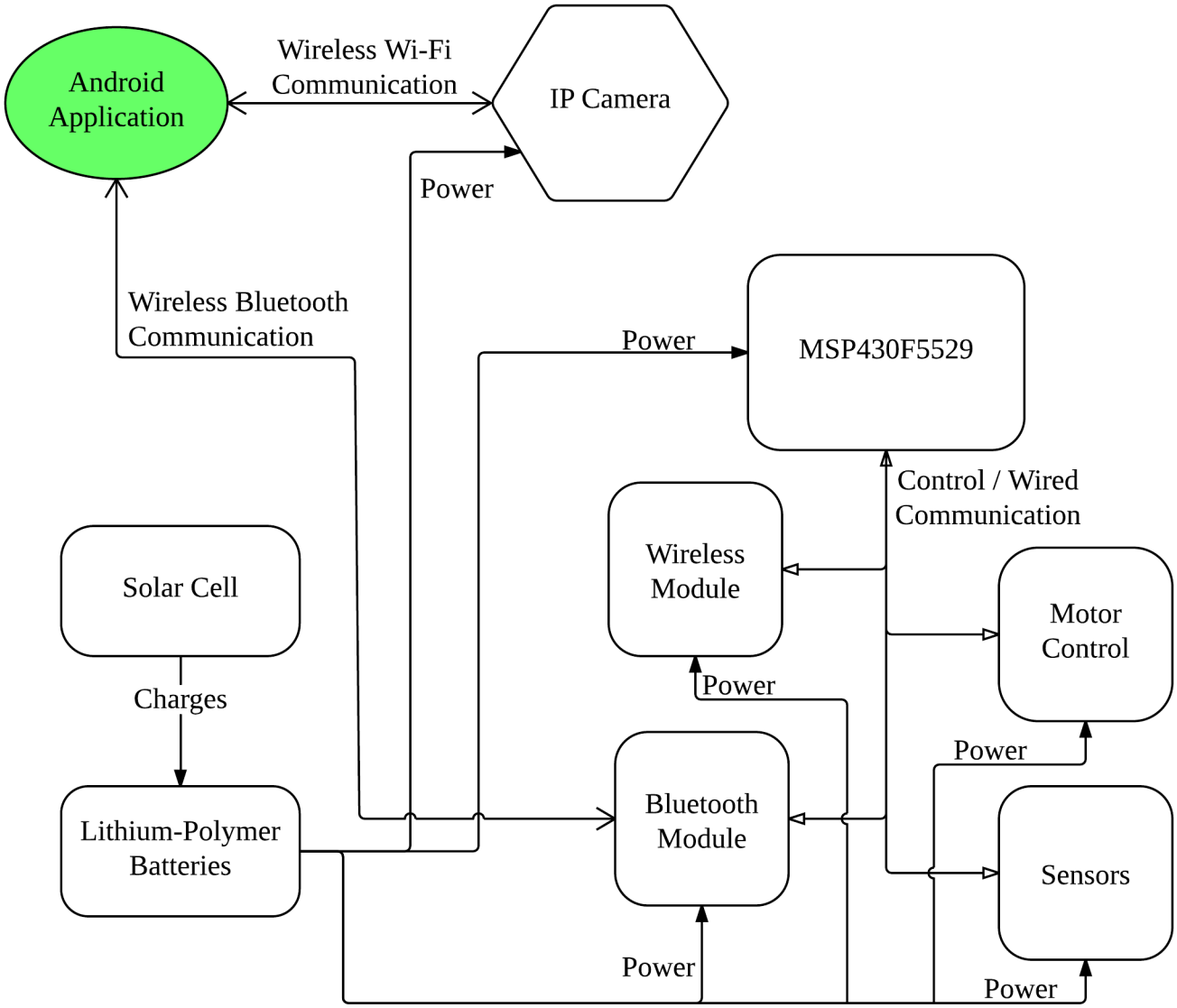
SWITCHING VOLTAGE REGULATOR

- **Part # LM22670MRE-5.0/NOPB**
- **Type: Step-Down (Buck)**
- **Package: SOIC 8**
- **4.5-42V Input**
- **5V Output**
- **Internal Feedback Resistors**
- **Max Current: 3A**
- **Efficiency: 92-95%**
- **Switching Frequency: 250 kHz**

SOLAR PANEL MOUNT

- **Solar panel is mounted via an acrylic sheet that was cut to size using a laser cutter.**

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CHOOSING ANDROID

GOOGLE'S ANDROID

- No developer's fee
- Extensive documentation and example code
- Widely compatible with Bluetooth

APPLE'S IOS

- $100 annual developers fee
- Well-documented, Apple developer forums
- Encrypted, would need special Bluetooth module

ANDROID APPLICATION

- **Developing for Android version 4.4 (KitKat)**
- **IDE: Android Studio**
- **User interface for the user to control the Wi-Fi Seeker robot**
  - Bluetooth connection setup
  - IP camera setup
  - Selecting a wireless network
  - Manual control
  - Autonomous functionality

12:25
The Wi-Fi Seeker Application
Bluetooth Setup
No Connection
Bluetooth Devices:
SEARCH FOR BT DEVICES
STOP SCANNING

12:26
The Wi-Fi Seeker Application
Bluetooth Setup
Scanning for Bluetooth Devices
Bluetooth Devices:
CHRISTY-PC
AC:72:89:DE:73:8E
WFS-G30-BT
00:06:66:61:5F:F9
SEARCH FOR BT DEVICES
STOP SCANNING

12:29

The Wi-Fi Seeker Application

IP Camera Setup
Connection Established with WFS-G30-BT

REFRESH CAMERA

FINISH

12:30

The Wi-Fi Seeker Application

Wireless Network Setup
Connection Established with WFS-G30-BT

Instructions For Selecting a Wireless Network:
1. Turn on command mode.
2. Execute command setup.
3. Scan for your network and select it to connect.
4. Click 'Finish' to complete setup.

TURN ON COMMAND MODE

COMMAND SETUP

SCAN FOR WIRELESS NETWORKS

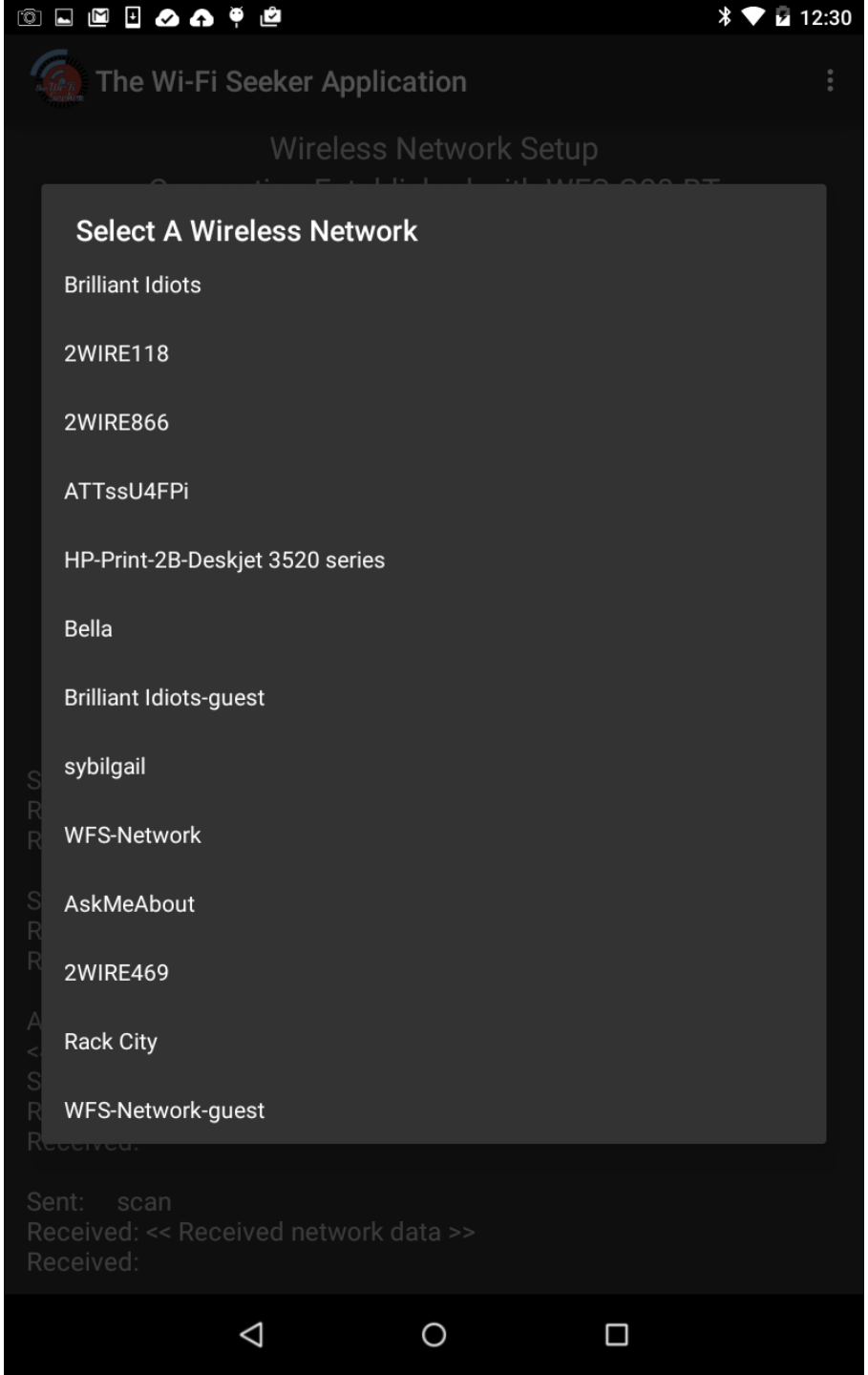
REBOOT WIFLY MODULE

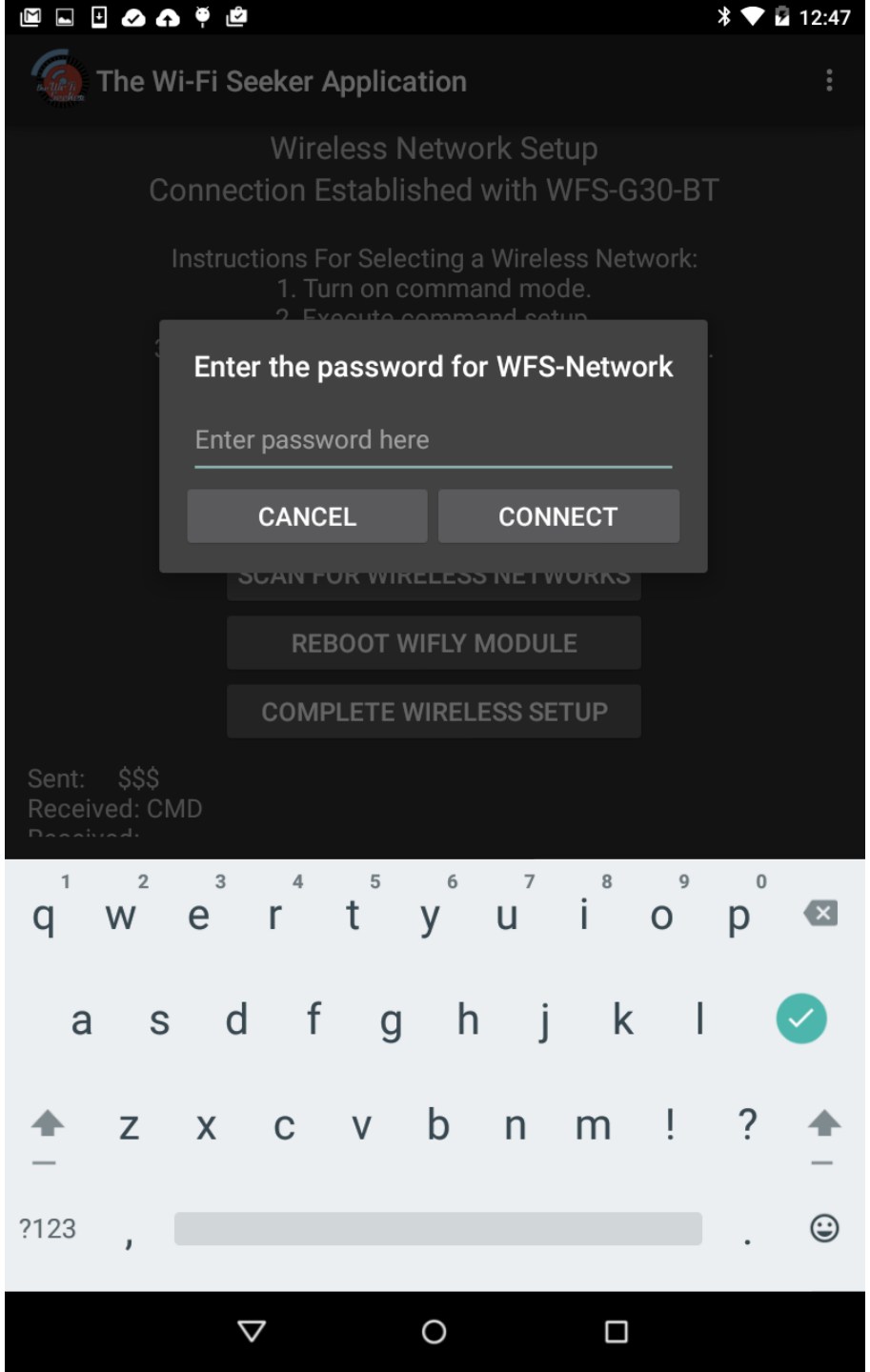
COMPLETE WIRELESS SETUP

Sent: $$$
Received: CMD
Received:

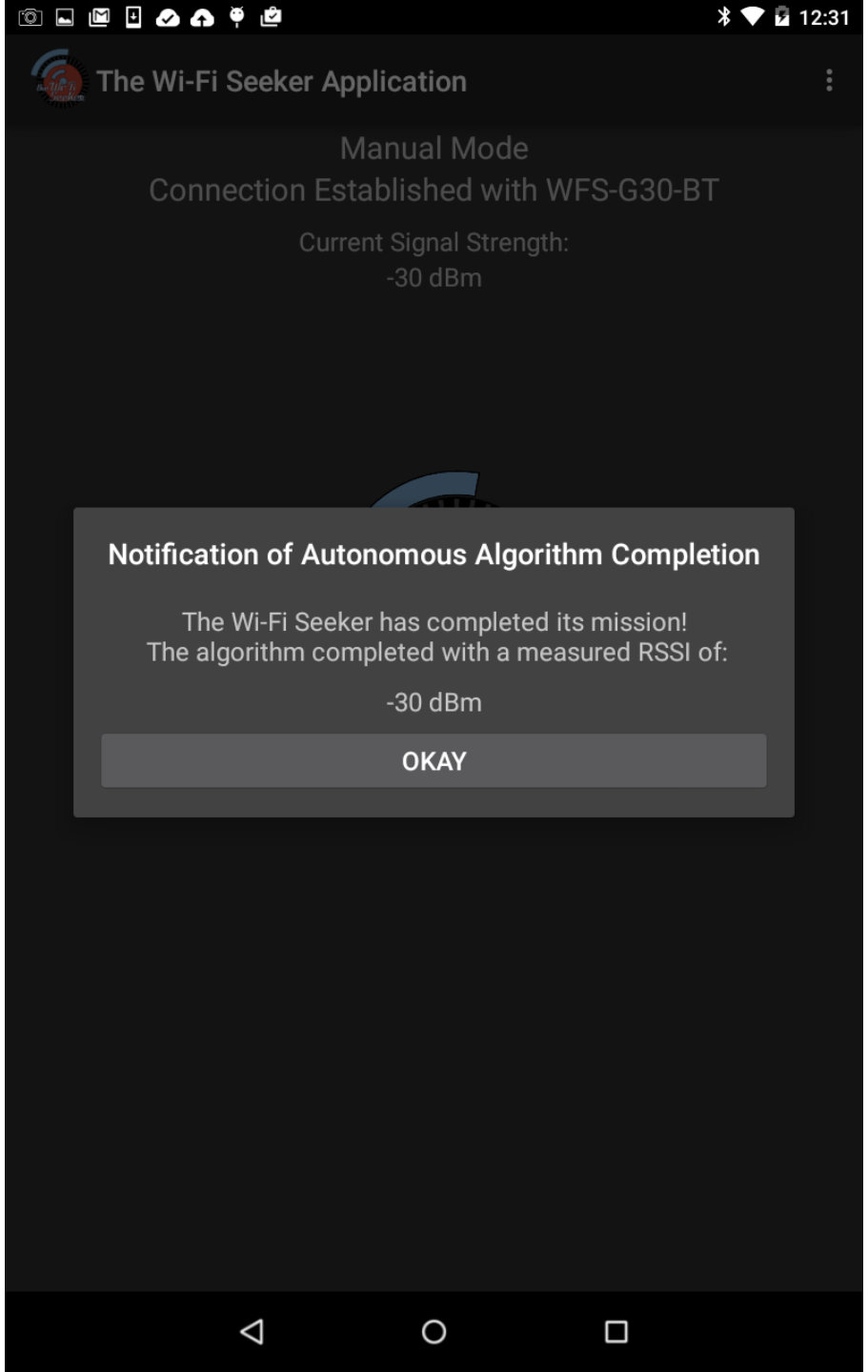
Sent: setup
Received: .00> set w
Received: lan join 0

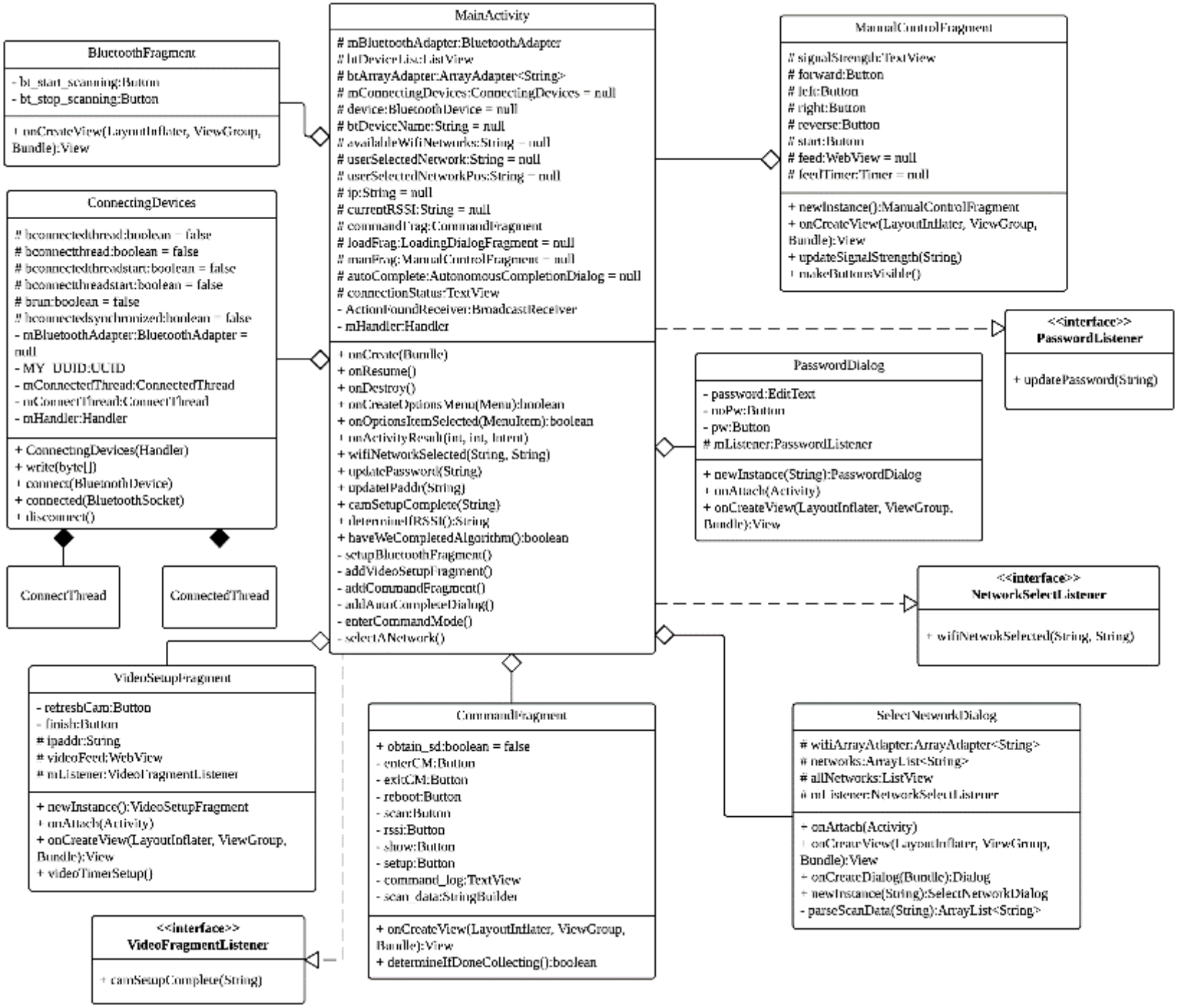
AOK
<4.00>


12:30
The Wi-Fi Seeker Application
Wireless Network Setup
Select A Wireless Network
Brilliant Idiots
2WIRE118
2WIRE866
ATTssU4FPi
HP-Print-2B-Deskjet 3520 series
Bella
Brilliant Idiots-guest
sybilgail
WFS-Network
AskMeAbout
2WIRE469
Rack City
WFS-Network-guest
Sent: scan
Received: << Received network data >>
Received:


12:47
The Wi-Fi Seeker Application
Wireless Network Setup
Connection Established with WFS-G30-BT
Instructions For Selecting a Wireless Network:
1. Turn on command mode.
Enter the password for WFS-Network
Enter password here
CANCEL
CONNECT
REBOOT WIFLY MODULE
COMPLETE WIRELESS SETUP
Sent: $$$
Received: CMD

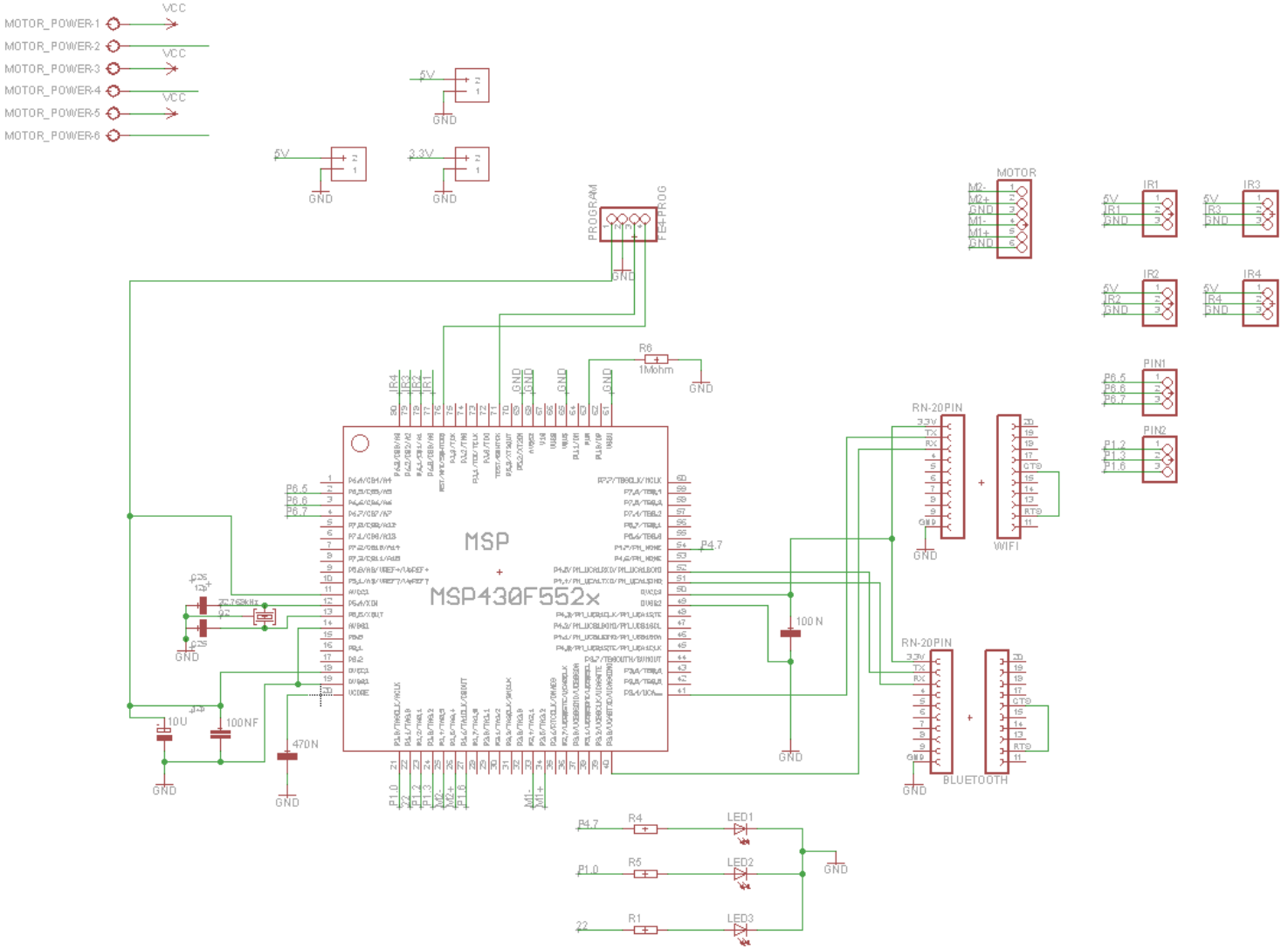
12:31
The Wi-Fi Seeker Application
Manual Mode
Connection Established with WFS-G30-BT
Current Signal Strength:
-31 dBm
START AUTONOMOUS ALGORITHM
the Wi-Fi Seeker
FORWARD
LEFT
RIGHT
REVERSE


12:31
The Wi-Fi Seeker Application
Manual Mode
Connection Established with WFS-G30-BT
Current Signal Strength:
-30 dBm
Notification of Autonomous Algorithm Completion
The Wi-Fi Seeker has completed its mission!
The algorithm completed with a measured RSSI of:
-30 dBm
OKAY

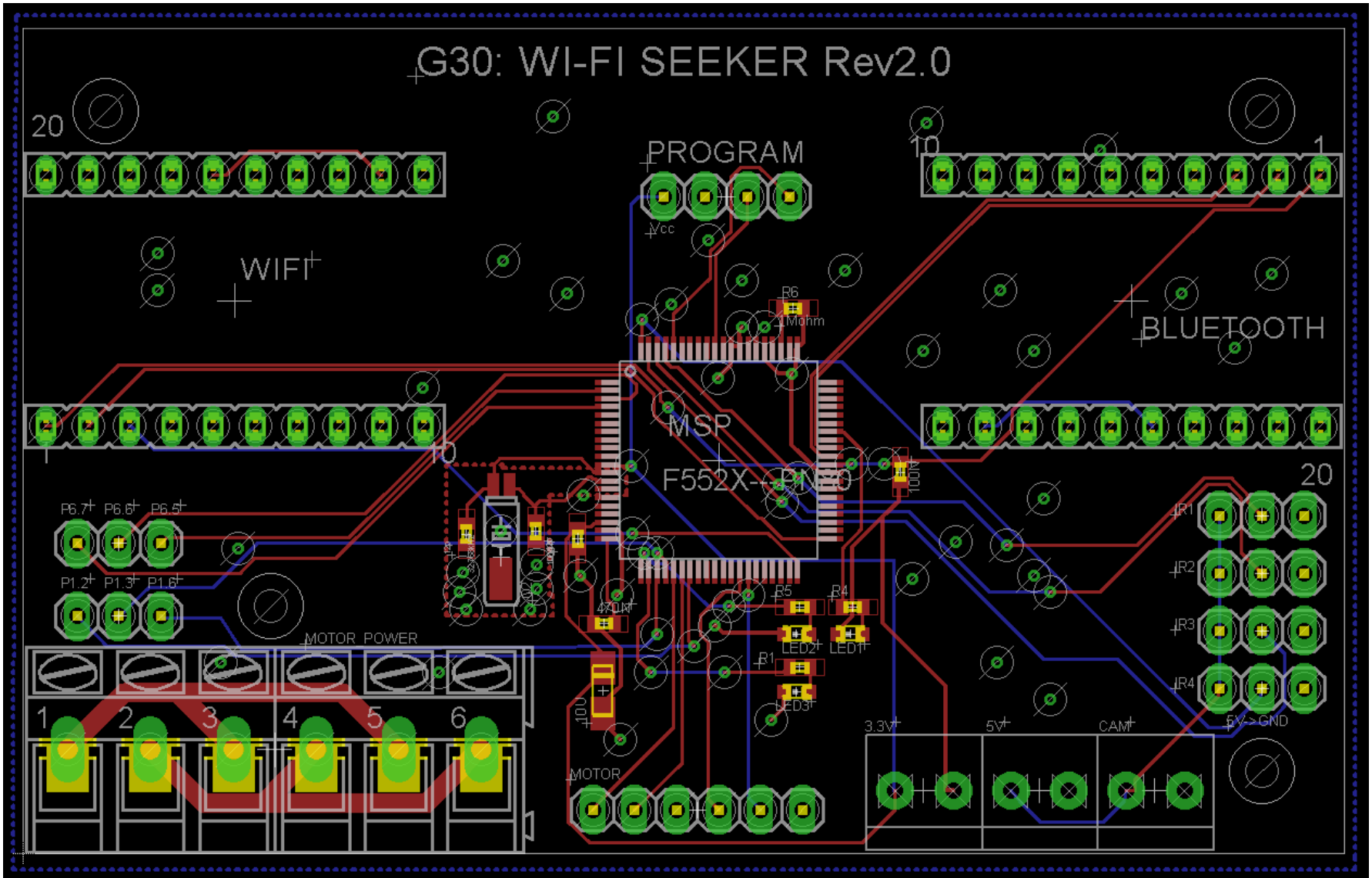

MainActivity
mBluetoothAdapter:BluetoothAdapter
lstDeviceList:ListView
btArrayAdapter:ArrayAdapter<String>
mConnectingDevices:ConnectingDevices = null
device:BluetoothDevice = null
btDeviceName:String = null
availableWifiNetworks:String = null
userSelectedNetwork:String = null
userSelectedNetworkPos:String = null
ip:String = null
currentRSSI:String = null
commandFrag:CommandFragment
loadFrag:LoadingDialogFragment = null
manFrag:ManualControlFragment = null
autoComplete:AutonomousCompletionDialog = null
connectionStatus:TextView
- ActionFoundReceiver:BroadcastReceiver
- mHandler:Handler
+ onCreate(Bundle)
+ onResume()
+ onDestroy()
+ onCreateOptionsMenu(Menu):boolean
+ onOptionsItemSelected(MenuItem):boolean
+ onActivityResult(int, int, Intent)
+ wifiNetworkSelected(String, String)
+ updatePassword(String)
+ updateIPaddr(String)
+ camSetupComplete(String)
+ determineIfRSSI():String
+ haveWeCompletedAlgorithm():boolean
- setupBluetoothFragment()
- addVideoSetupFragment()
- addCommandFragment()
- addAutoCompleteDialog()
- enterCommandMode()
- selectANetwork()
BluetoothFragment
- bt_start_scanning:Button
- bt_stop_scanning:Button
+ onCreateView(LayoutInflater, ViewGroup, Bundle):View
ConnectingDevices
bconnectedthread:boolean = false
bconnectthread:boolean = false
bconnectedthreadstart:boolean = false
bconnectthreadstart:boolean = false
brun:boolean = false
bconnectedsynchronized:boolean = false
- mBluetoothAdapter:BluetoothAdapter = null
- MY_UUID:UUID
- mConnectedThread:ConnectedThread
- mConnectThread:ConnectThread
- mHandler:Handler
+ ConnectingDevices(Handler)
+ write(byte[])
+ connect(BluetoothDevice)
+ connected(BluetoothSocket)
+ disconnect()
ConnectThread
ConnectedThread
ManualControlFragment
signalStrength:TextView
forward:Button
left:Button
right:Button
reverse:Button
start:Button
feed:WebView = null
feedTimer:Timer = null
+ newInstance():ManualControlFragment
+ onCreateView(LayoutInflater, ViewGroup, Bundle):View
+ updateSignalStrength(String)
+ makeButtonsVisible()
<<interface>>
PasswordListener
+ updatePassword(String)
PasswordDialog
- password:EditText
- noPw:Button
- pw:Button
mListener:PasswordListener
+ newInstance(String):PasswordDialog
+ onAttach(Activity)
+ onCreateView(LayoutInflater, ViewGroup, Bundle):View
<<interface>>
NetworkSelectListener
+ wifiNetworkSelected(String, String)
VideoSetupFragment
- refreshCam:Button
- finish:Button
ipaddr:String
videoFeed:WebView
mListener:VideoFragmentListener
+ newInstance():VideoSetupFragment
+ onAttach(Activity)
+ onCreateView(LayoutInflater, ViewGroup, Bundle):View
+ videoTimerSetup()
CommandFragment
+ obtain_sd:boolean = false
- enterCM:Button
- exitCM:Button
- reboot:Button
- scan:Button
- rssi:Button
- show:Button
- setup:Button
- command_log:TextView
- scan_data:StringBuilder
+ onCreateView(LayoutInflater, ViewGroup, Bundle):View
+ determineIfDoneCollecting():boolean
SelectNetworkDialog
wifiArrayAdapter:ArrayAdapter<String>
networks:ArrayList<String>
allNetworks:ListView
mListener:NetworkSelectListener
+ onAttach(Activity)
+ onCreateView(LayoutInflater, ViewGroup, Bundle):View
+ onCreateDialog(Bundle):Dialog
+ newInstance(String):SelectNetworkDialog
- parseScanData(String):ArrayList<String>
<<interface>>
VideoFragmentListener
+ camSetupComplete(String)

SCHEMATICS AND PCB DESIGN

SCHEMATIC 1 - MAIN

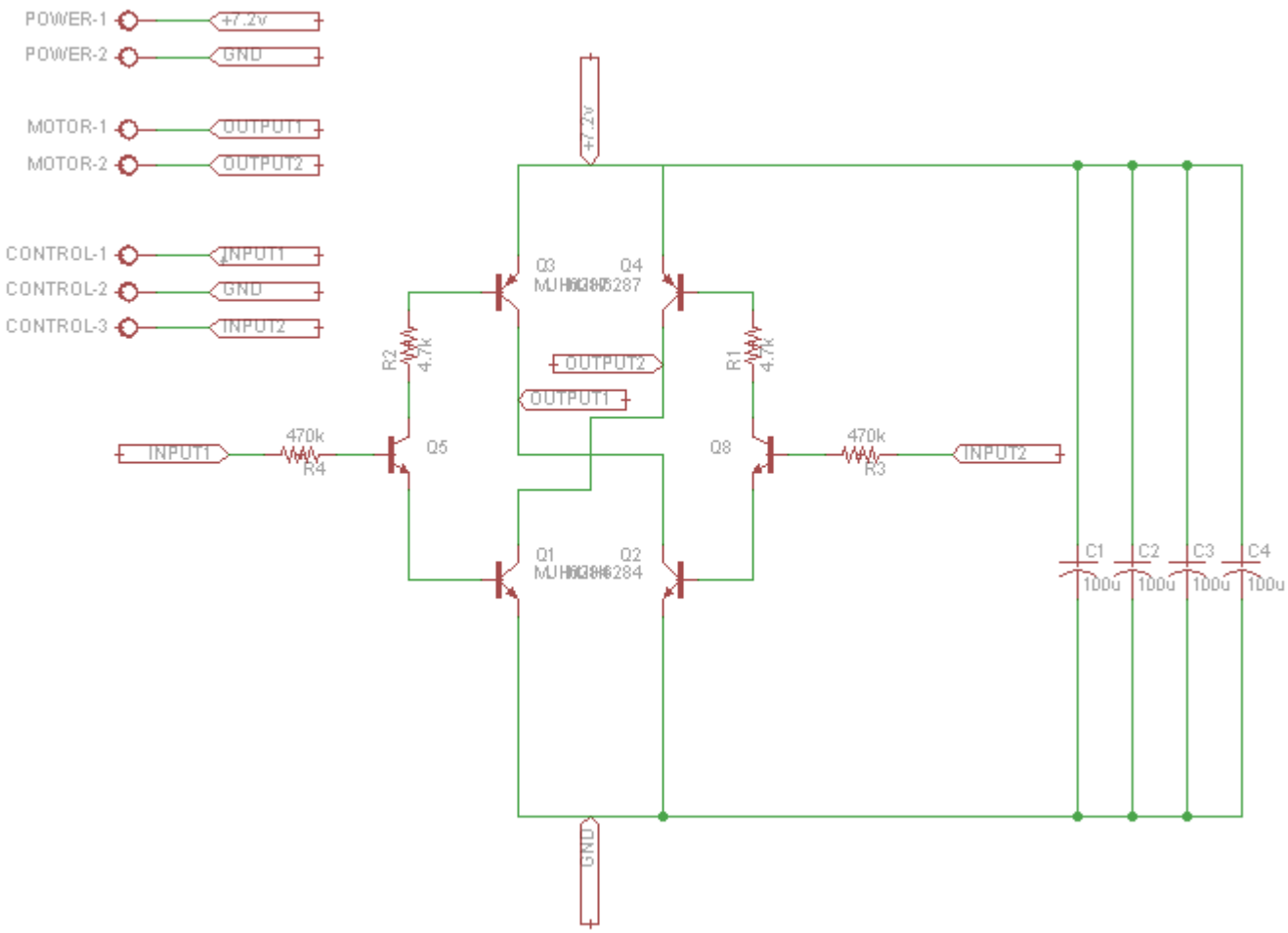


PCB - MAIN

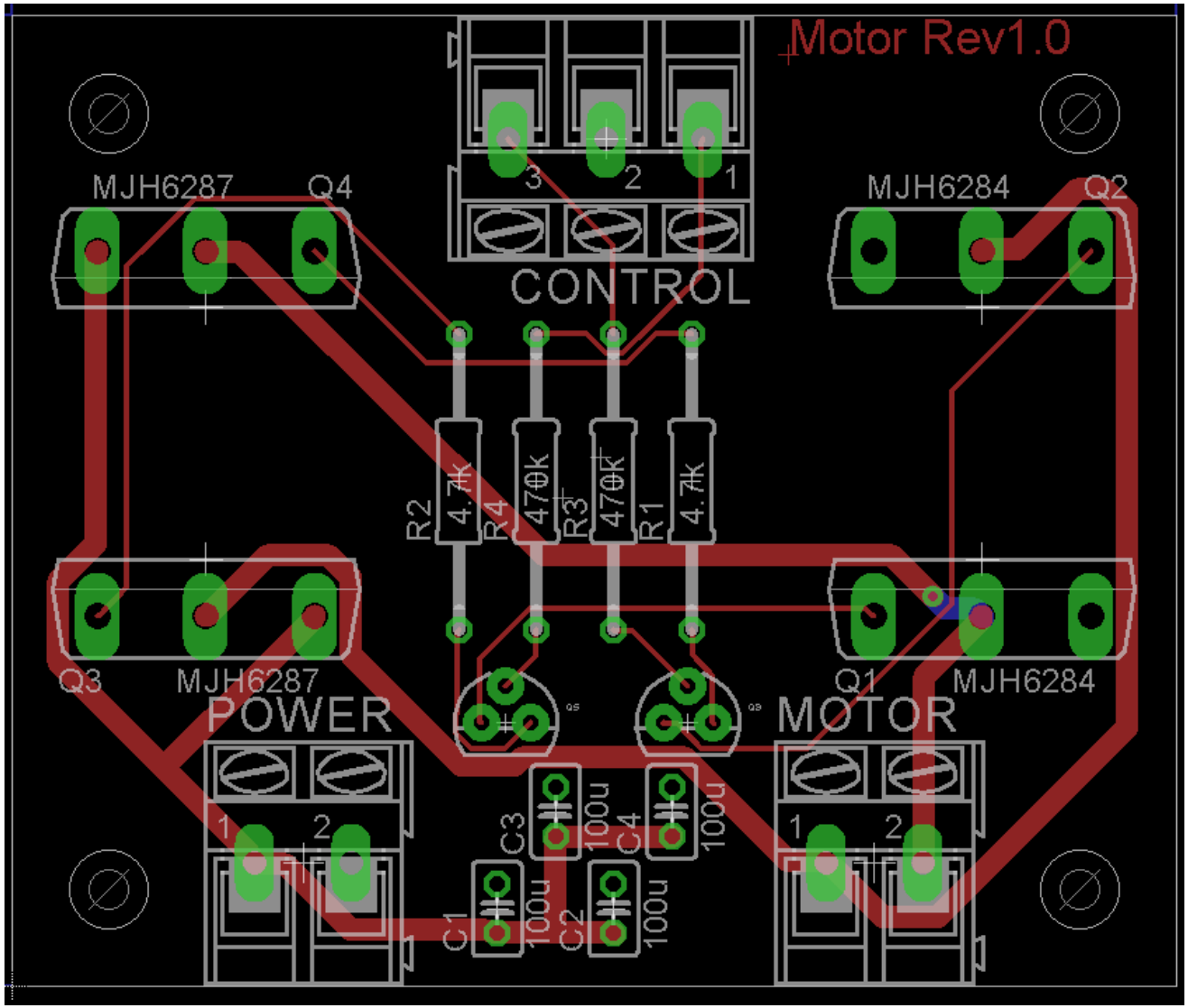


G30: WI-FI SEEKER Rev2.0
20
PROGRAM
10
1
Vcc
WIFI
R6
1Mohm
BLUETOOTH
MSP
F552X-PN=0
10
20
P6.7
P6.6
P6.5
P1.2
P1.3
P1.6
R1
R2
R3
R4
R5
R4
LED2
LED1
R1
LED3
470uH
100uH
MOTOR POWER
1
2
3
4
5
6
MOTOR
3.3V
5V
CAM
5V->GND

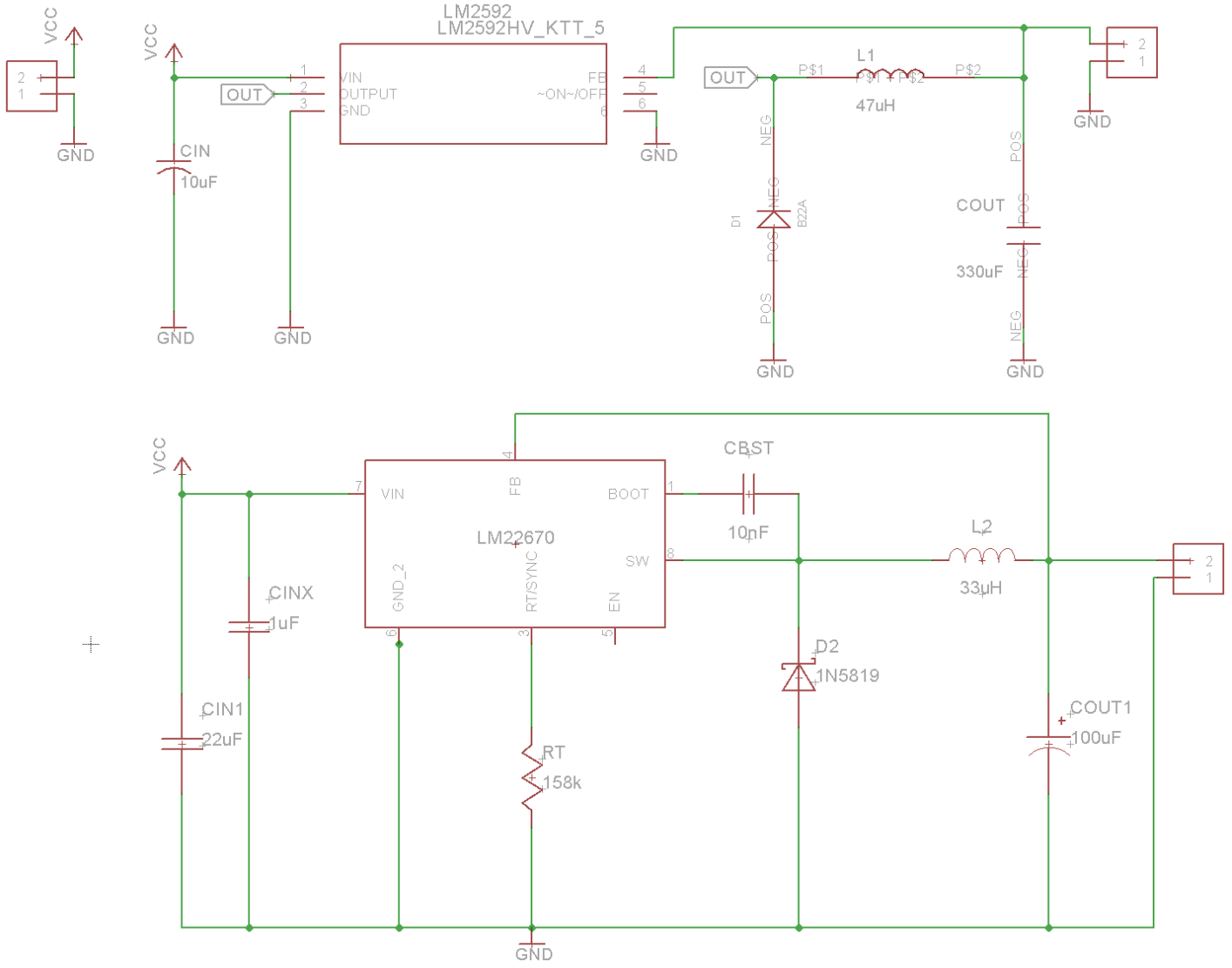
SCHEMATIC 2 - MOTOR CONTROLLER



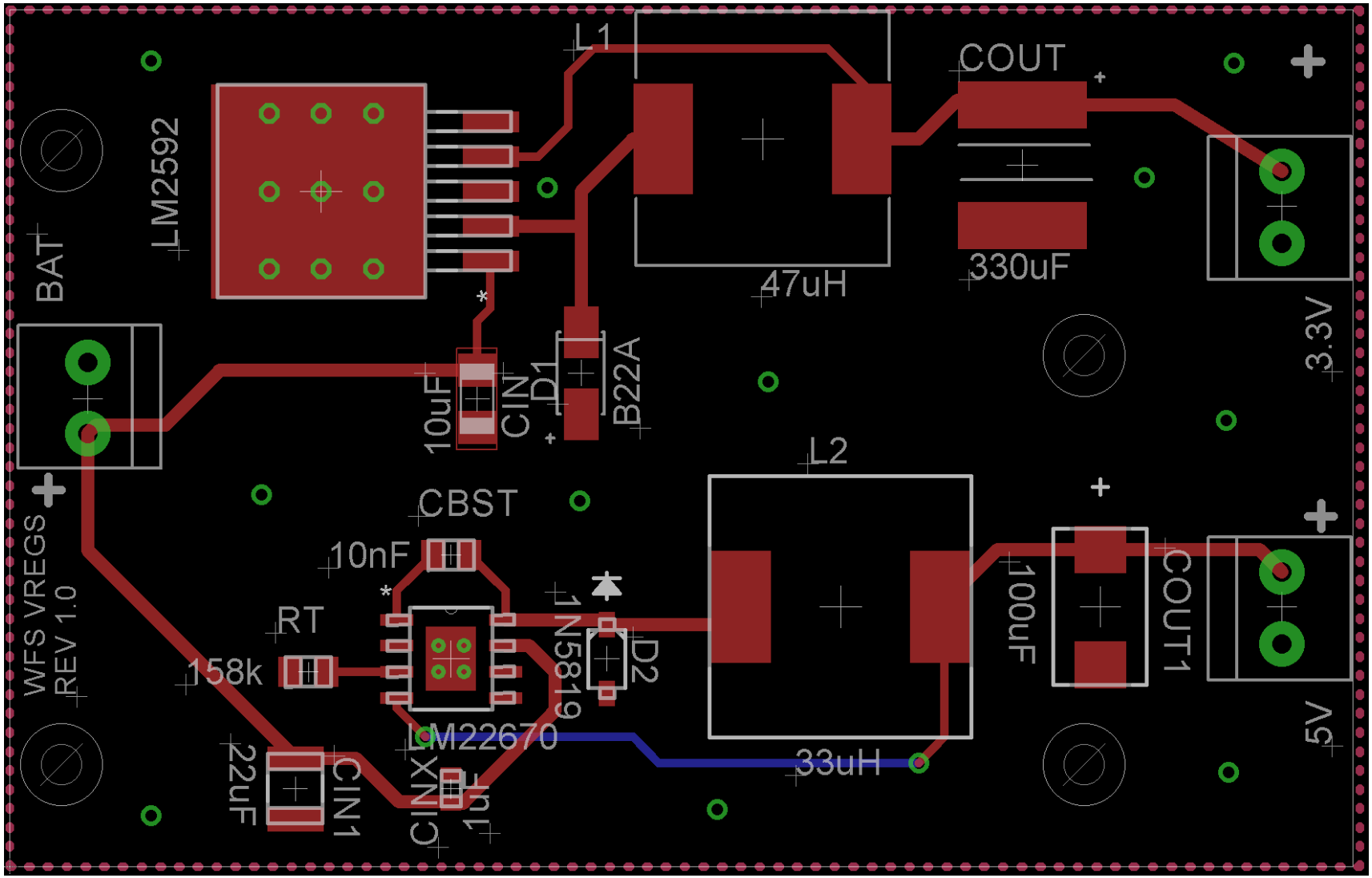
PCB – MOTOR CONTROLLER



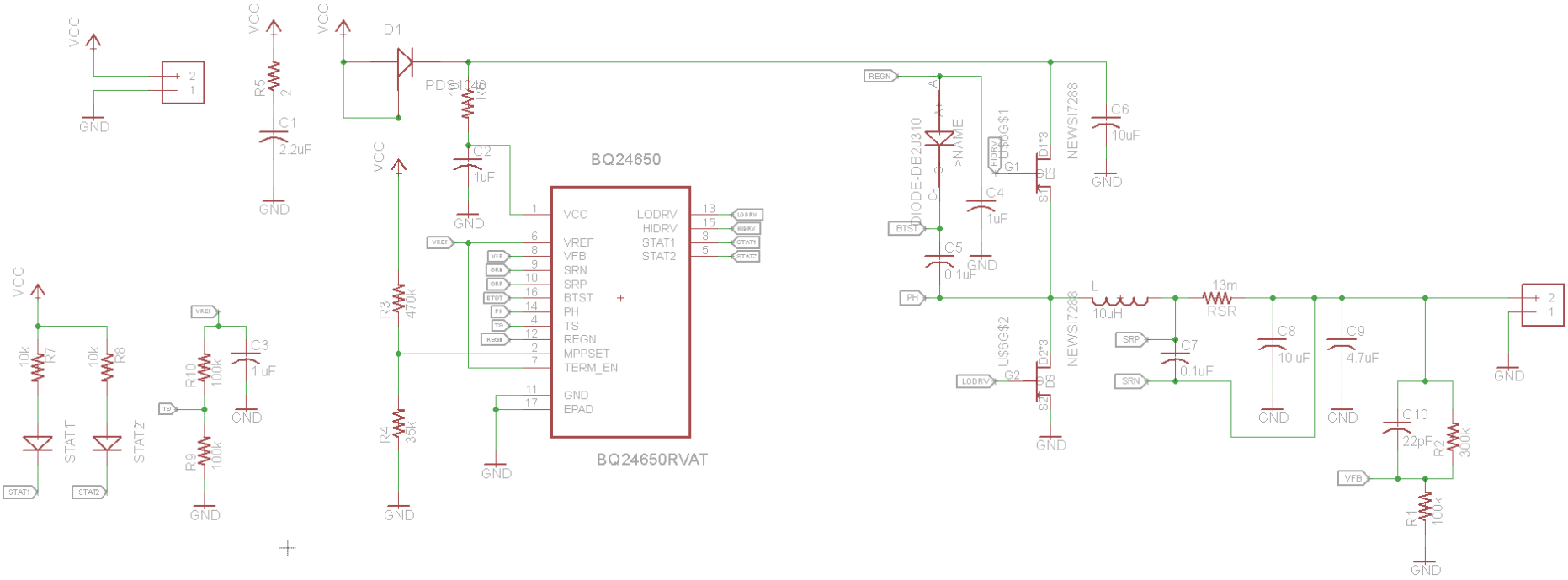
SCHEMATIC 3 - REGULATORS



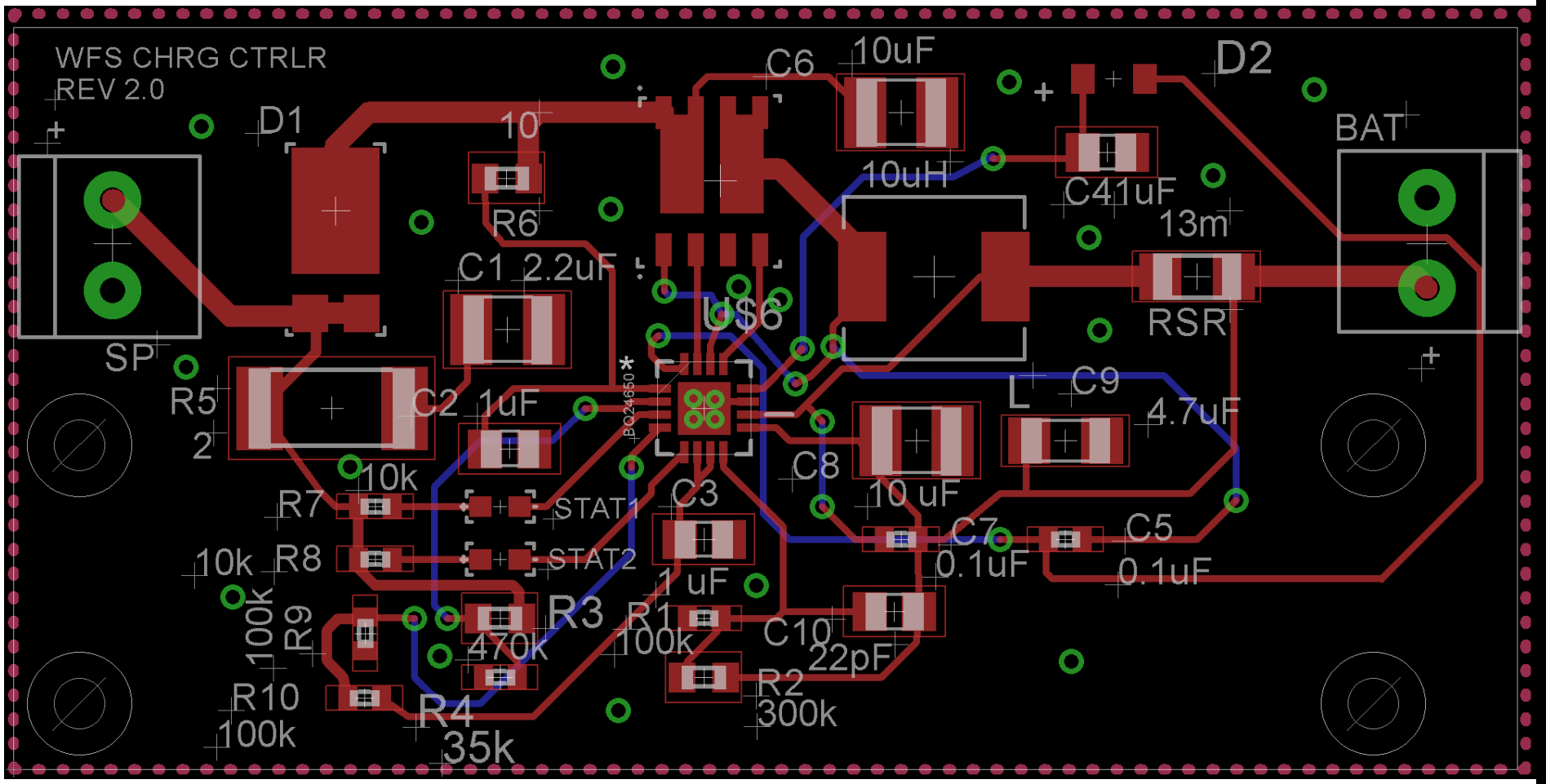
PCB – REGULATORS



SCHEMATIC 4– CHARGE CONTROLLER



PCB – CHARGE CONTROLLER



ADMINISTRATIVE CONTENT

WORK DISTRIBUTION

	Christina	Adrian	Jimmy
Wireless Communication	X		
Android Application	X		
Motor Control			X
Obstacle Avoidance			X
Autonomous Algorithm	X		X
Power		X	
Battery Charging		X	
Video Streaming	X		

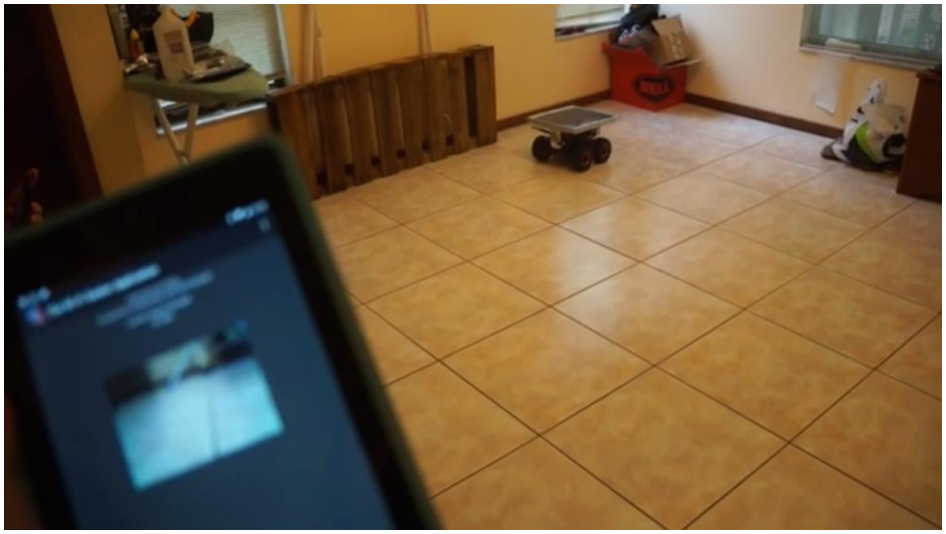
BUDGET – BILL OF MATERIALS

Part	Cost Per Unit	Quantity	Total Cost
MSP430-F5529 Chip	$8.06	1	$8.06
Wi-Fi Module	$34.95	1	$34.95
Bluetooth Module	$29.95	1	$29.95
3.3V Voltage Regulator (LM2592HVSX-3.3/NOPB)	$6.22	1	$6.22
5V Voltage Regulator (LM22670MRE-5.0/NOPB)	$5.52	1	$5.52
Lithium-Polymer Battery Pack	$26.99	1	$26.99
Robot Base and Motors	$174.95	1	$174.95
Infrared Sensors	$13.95	4	$55.80
MPPT Charge Controller (BQ24560)	$5.96	1	$5.96
IP Camera	$53.24	1	$53.24
Various Circuit Components (Passive)	$125.00	1	$125.00
PCB Manufacturing	$108.50	1	$108.50
Solar Panel	$160.00	1	$160.00
Total Cost			$795.14

CHALLENGES

- **Original voltage regulators went out of stock just before we ordered PCBs.**
- **ESD fried first soldered voltage regulator circuit.**
- **Motion on carpet is problematic.**
  - Mainly due to the weight of the solar panel.
- **The Wifly module interrupts IP camera operation.**

VIDEO DEMO



the Wi-Fi
Seeker