Mission Box

A Baccalaureate thesis submitted to the
Department of Electrical Engineering and Computer Science
College of Engineering and Applied Science
University of Cincinnati

in partial fulfillment of the
requirements for the degree of

Bachelor of Science

in Electrical Engineering Technology and Computer Engineering

by

Aswin Balasubramaniam (EET)

and

Jingbin Yang (CMPE)

April 2019

Thesis Advisors:

Dr. Arthur Helmicki
Dr. Victor Hunt
Dr. Mehdi Norouzi

UNIVERSITY OF Cincinnati

MISSION BOX

FINAL PROJECT REPORT

MEMBERS

Jingbin Yang (CMPE)

Aswin Balasubramaniam (EET)

ADVISOR

Dr. Arthur Helmicki
Dr. Victor Hunt
Dr. Mehdi Norouzi

ACKNOWLEDGEMENTS

This project was supported and sponsored by the University of Cincinnati Infrastructure Institute's (UCII) and the funds received for their projects sponsored by the Ohio Department of Transportation (ODOT).

We would like to thank the following for their assistance, guidance, and support to make this project a reality:

- Dr. Mehdi Norouzi for the Mission Box concept, trusting us and giving us the freedom to develop an improved version of the system. His determination and persistence kept us on track to complete the project.
- Dr. Arthur Helmicki and Dr. Victor Hunt for their constant support, motivation, and valuable inputs on the Mission Planner Application design process.
- Parashmani Timilsina for his guidance in designing and manufacturing the front panel for the Mission Box system.
- Friends and family without whose support, motivation and advise this would not have been possible.

Table of Contents

List of Figures

Executive Summary

The popularity of the DJI systems has piqued the interest of many hobbyists and industry experts, to use them in various remote sensing applications. Remote sensing is the process of acquiring information about an object using available sensors without making physical contact with it. Cameras and LiDAR are the most commonly used sensors onboard UAVs.

First responders use UAVs to record videos and images of various emergency situations. Bridge inspectors use UAVs to capture high-resolution images of the structure to analyze them in detail. Farmers use UAVs and multispectral cameras to assess crop damages. City planners use UAVs to map large cities to aid in city planning. The list goes on and on as the applications of a UAV and a camera is bounded by the user's imagination.

The Mission Box is a portable console that aids the Ohio Department of Transportation's (ODOT) UAS center in surveillance and inspection missions. These missions include but are not limited to infrastructure inspections (bridges and buildings), surveillance of a construction project, and natural disaster surveillance (landslides). The system will aid remote pilots to store Unmanned Aerial Vehicles (UAV) /Small Unmanned Aerial Systems (sUAS) data, stream video captured using UAVs and program UAVs to efficiently capture images of structures to build their 3D model.

The project consists of three main parts, the mission box hardware, the mission box user interface, and the mission planner android application.

The mission box hardware consists of mainly three components: 1) Intel NUC PC, 2) Arduino, 3) Sierra MODEM. Ubuntu was used as the operating system for the PC, as it was open source, coder friendly, highly customizable, and the system requirements are less. The mission box UI, built using Python, allows a user to monitor the system's power levels, control the MODEM and analog transmitter (which broadcasts the UAV feed), view and record the video from the UAV camera, and finally open the android emulator to view the mission planner application.

The mission planner android application augments the functionality of the DJI flight planning application that allows users to create plans for UAVs that automates flights to capture images as per requirement. The application was designed to improve the functionality of the DJI GS Pro application by allowing users to specify their image requirements and generate step by step instructions that would allow users to program plans on the DJI GS Pro efficiently. The application allows the user to plan missions to aid in bridge, facility and construction site inspection.

Introduction

This report provides detail and information that led to the completion of the Mission Box senior design project. This project successfully built the 4th version of the Mission Box concept, that would allow its users to process and broadcast Unmanned Aerial Vehicle (UAV) videos and generate instructions that would allow them to program UAVs to map structures to construct its 3D model.

The Mission Box is a portable console that would aid the Ohio Department of Transportation's (ODOT) UAS center in surveillance and inspection missions. These missions include but are not limited to infrastructure inspections (bridges and buildings), surveillance of a construction project, and natural disaster surveillance (landslides).

The senior design team consisted of two members; Aswin Balasubramaniam (Electrical Engineering Technology), and Jingbin Yang (Computer Engineering). The team was advised by Dr. Arthur Helmicki, Dr. Victor Hunt, and Dr. Mehdi Norouzi all who are a part of the University of Cincinnati Infrastructure Institute (UCII). The members of the team have a shared interest in UAV technology and have worked at UCII on similar UAV projects which motivated them to undertake this project.

This project spanned over the course of two semesters, where during the first semester the team focused on budgeting and researching and, during the second semester the team focused on developing and implementing the research work. The project was entirely funded through UCII and the final product was built using the equipment provided by UCII.

The following sections of the report will illustrate the design and implementation process undertaken by the team to complete the project.

Problem/Need

In the current market there is no universal solution that would aid ODOT's remote pilots to do the following:

- Store, stream and process UAV videos
- Efficiently program a UAV to capture the necessary images of a structure that can be used to construct its 3D model.

UCII works with the Ohio Department of Transportation's (ODOT) UAS center conducting research on effectively employing UAVs to improve its core business functions that include but not limited to infrastructure health inspections and traffic monitoring. Conducting inspections involve recording and saving videos and images which will be analyzed and processed later. Therefore, there is a need for a system that would enable users to efficiently plan these missions, record and store data, and stream this data real-time on-site and off-site.

Solution

The proposed solution is a portable on-site solution that stores, streams, and processes live and recorded videos, and plans efficient UAV flights.

The Mission Box system will transmit and store various video feed, is compatible with the majority of commercial UAVs, has the functionalities to share and view videos on multiple devices and an application that will help remote pilots to generate efficient flight plans as per their requirements.

Figure 1: Completed Mission Box

Credibility

The team consists of two members; Aswin Balasubramaniam an Electrical Engineering Technology undergraduate student researching in the field of photogrammetry and the applications of UAVs in the inspection of infrastructure health monitoring. He has worked at UCII under Dr. Arthur Helmicki for more than a year researching in this field and has also had practical experiences in the field of automation and manufacturing.

Jingbin Yang a Computer Engineering undergraduate has also worked at UCII developing solutions to improve the inspection process for a year and has had both technical and practical experience in the field of computer networks and information technology.

The team was advised by Dr. Arthur Helmicki, Dr. Victor Hunt, and Dr. Mehdi Norouzi who are a part of the University of Cincinnati Infrastructure Institute (UCII) collectively have multiple years of experience in the field of research and development.

Goals/Methods

The primary goal of the project was to build a portable, well-designed rugged system that would be an improvement on the previous versions of the Mission Box system. The primary project goals are highlighted below and were used as a guide in the product development process.

- View live video stream from a UAV
- Record and view the live video stream
- Stream the live video stream wirelessly using a local network
- Stream live video to an FPV goggle.
- Stream the live video to a video server using the MODEM
- Monitor internal component status
- Develop a user-friendly application to plan efficient UAV flights
- Package the system in a rigged and portable enclosure
- Develop a user-friendly UI to interact with the system
- Design a professional looking front panel with intuitive controls

To achieve these goals successfully the entire project was divided into three sections which include the mission box hardware, the mission box user interface, and the mission planner android application.

The mission box hardware consists of mainly three components: 1) Intel NUC PC, 2) Arduino, 3) Sierra MODEM. Ubuntu was used as the operating system for the PC, as it was open source, coder friendly, highly customizable, and the system requirements are less. The mission box UI, built using Python, allows a user to monitor the system's power levels, control the MODEM and analog transmitter (which broadcasts the UAV feed), view and record the video from the UAV camera, and finally open the android emulator to view the mission planner application.

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The table in Figure 2 shows the Engineering Design Process created that aided in the progress and defining the goals of the project.

1. Research	2. Plan	3. Develop	4. Prototype	5. Finalize
Communication	Budget	Initial UIs	Troubleshoot	Design
Flight Settings	Timeline	Test Cases	Debug	Poster Presentation
Hardware		Hardware Assembly Schematics	Final Tests	Technical Expo

Figure 2: Engineering Design Process

Discussion

Project Concept

The final product of this project would provide remote pilots (the user) a one-stop solution to stream video/images securely, control their UAV, and plan efficient flight paths to capture images. The user would be able to conveniently carry a Pelican case box around and use their handheld devices (that has Wi-Fi capabilities) to control their drone with ease. The user would not have to worry about carrying multiple devices and will be able to conduct flight missions with ease. The map shown in Figure 3 summarizes the project concepts.

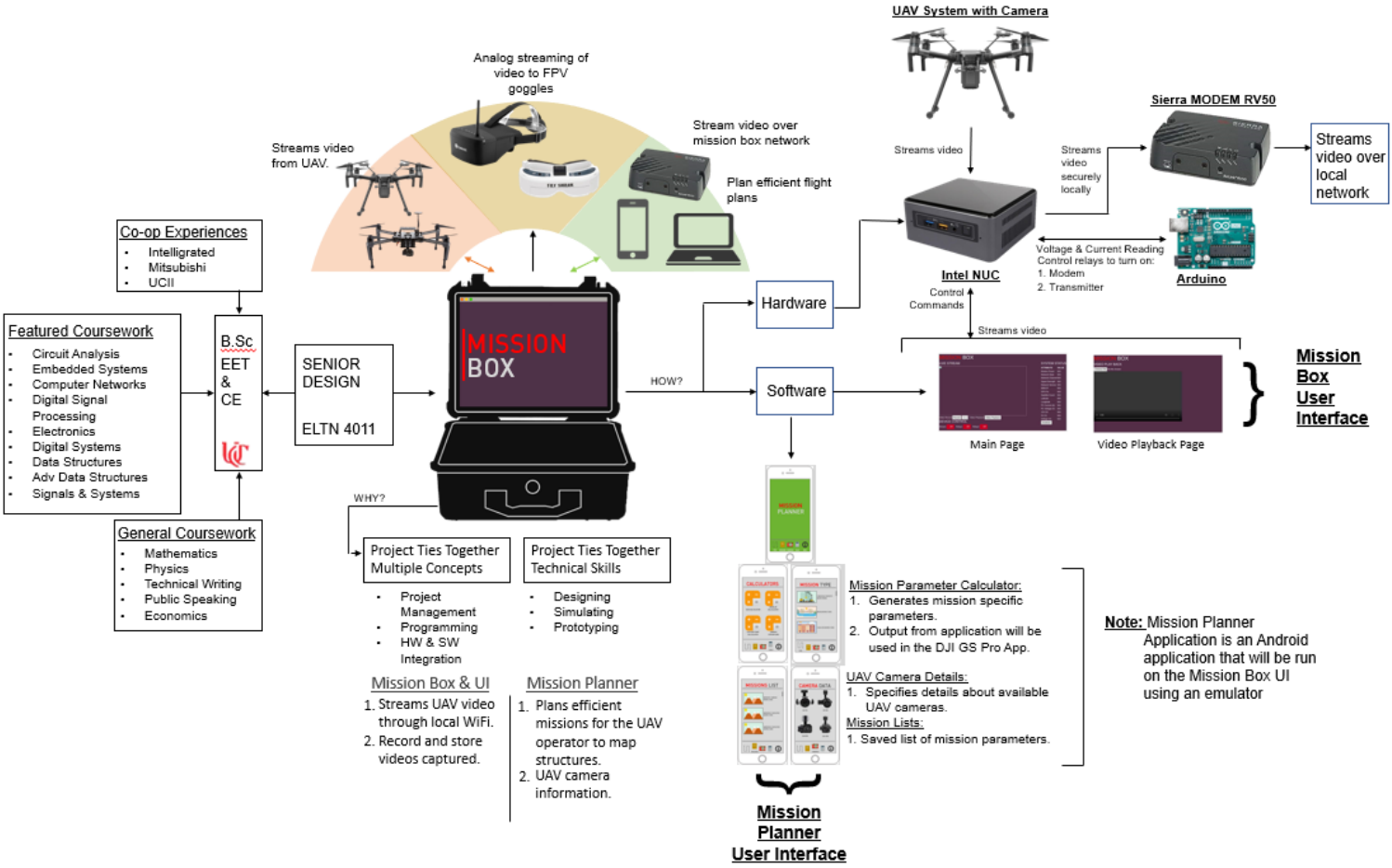


Figure 3: Mission Box Project Concept Map

Design Objectives

The following lists the primary design objectives that fall in line with the project goals:

- View and record the live video feed
    - Allow the user to view live footage from the UAV during its mission. The user can record video when needed and can play back any video file using the UI. This would provide the user with the flexibility to record only the necessary part of the mission and review the clips at any point.

- Stream live video wirelessly
    - Allow user to view live footage on any device that has wireless internet capabilities that include mobile phones, laptops, tablets, and Hololens. Wireless streaming is accomplished through the Mission Box local area network (LAN).
    - Allow the user to view live footage using First Person View (FPV) goggles. Transmit analog live footage over 5.8 GHz signal.

- Post process recorded video
    - Allow the user to save the video in multiple segments and providing them with playback/storage options.

- Monitor modem connection status
    - Allow the user to monitor critical system data from the cellular modem including signal quality, WAN IP address, GPS location, and GPS satellite count.

- Monitor internal system components
    - Allow the user to monitor the power consumption of the entire system as well as specific devices
    - Monitor statuses of internal relays used to turn on and off devices.
    - This will help the user diagnose if one or more components in the mission box are not working.

- User-friendly
    - Provide the user with a touch screen interface to control and monitor the system. This eliminates the need for physical buttons and extra hardware.
    - The mission planner application is designed to help users easily program flight plans as per the requirements.

- Portable and rugged
    - The mission box system is packaged in a Pelican case with wheels, which is rugged and will allow users to easily transport them.

Technical Approach

Hardware

The hardware system of the Mission Box was designed following industry standards. The Mission Box has two control layers, the high and low levels of data processing unit and controller.

The high-level data processing unit and the controller comprises of the Intel NUC PC, which aids in processing videos using OpenCV, processing low-level controller (Arduino UNO) data, and streaming videos locally, and to the cloud servers.

The low-level data processing unit and the controller comprises of the Arduino UNO, which aids in controlling the MODEM and analog transmitter using relays and reads the voltage and current levels of the system.

To ensure system reliability, and smooth operation fuses are used to prevent damages due to overcurrent draw (or shorts), current and voltage levels are monitored, cooling fans are used to prevent overheating of the components, and the system was thoroughly tested in varying temperature conditions.

Figure 4 shows the top-level hardware system design. This gives a general understanding of how all the parts used in the project communicate with each other and how they are connected. This block diagram only aids to give a general understanding of how the system is laid out and not the accurate depiction of the entire system.

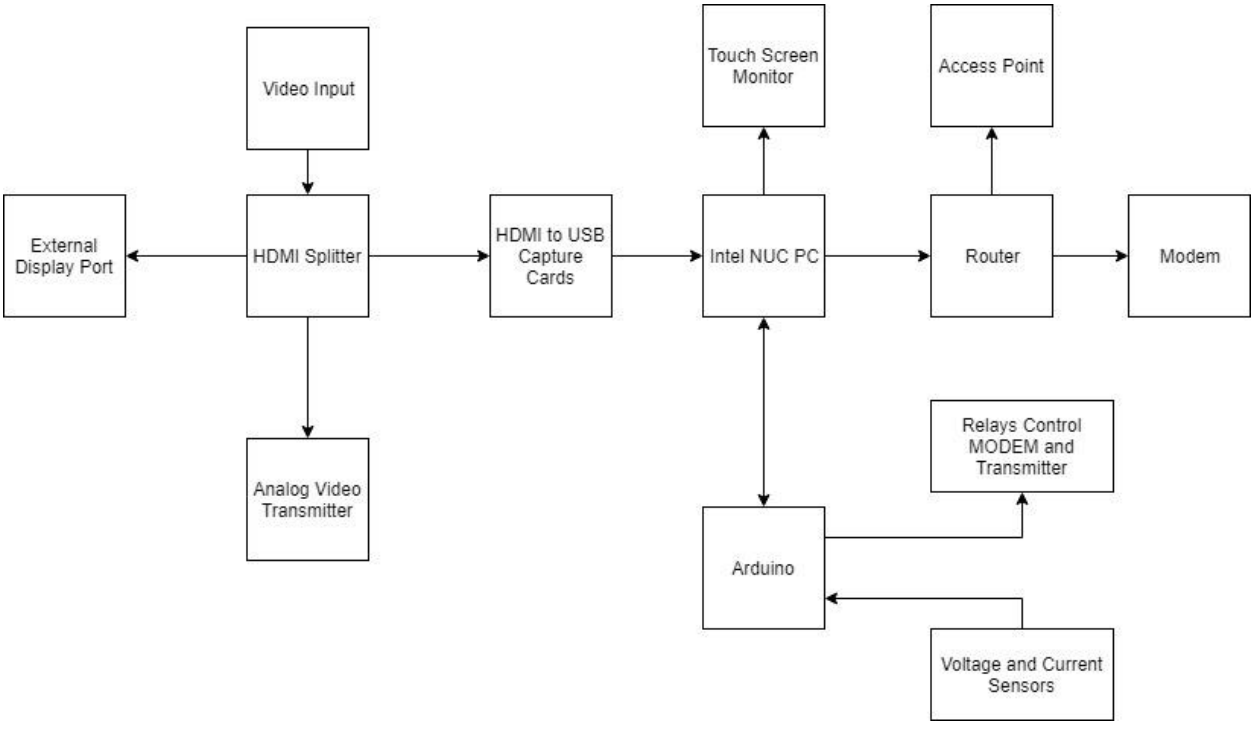


Figure 4: Top-Level Hardware System Design

The following subsections discuss selective important information regarding the hardware system of this project.

1. DJI UAVs (Matrice 100 and Matrice 210)

   Majority of the DJI UAV platforms are fully customizable and have a programmable flight platform. The DJI Onboard SDK allows to build powerful, automated drone applications for the Matrice 100 and Matrice 210 UAVs. Both the DJI Matrice 100 and 210 are capable of carrying a wide variety of sensors. The M100 and M210 were chosen as they are widely used by ODOT's remote pilots. These systems were used to test the functionality of the Mission Box.

Figure 5: DJI Matrice 100 (Left) and Matrice 210 (Right)

2. Intel NUC Kit 7th Generation
   The Intel NUC PC has an i5 processor with integrated graphics. The NUC PC was chosen for its small form factor and its robust performance with impressive processing power. The NUC PC can handle a maximum memory of 32GB and has an M.2 storage slot. The wireless card present in the PC is the Intel Wireless-AC 8265 + Bluetooth 4.2. It has 4 USB 3.0 ports. There are HDMI 2.0a and USB-C ports to connect external displays. The high-level data processing unit and the controller comprises of the Intel NUC PC, which aids in processing videos using OpenCV, processing low-level controller (Arduino UNO) data, and streaming videos locally, and to the cloud servers.

Figure 6: Intel NUC PC 7th Generation

3. Sierra Wireless MODEM RV50
   The RV50 Sierra MODEM provides high-performance LTE at 2G power consumption. The system has an automatic network operator switching. The RV50 offers GPS

information that would allow us to track its position. The RV50 enables the box to stream video to a server and provides users access to the internet.

Figure 7: MG90 Sierra Wireless Modem

4. Arduino UNO
   The Arduino UNO microcontroller is the low-level data processing unit and controller. It aids in controlling the MODEM and analog transmitter using relays and reads the voltage and current levels of the system. The voltage sensor (DIYmall DC 0-25V) is used to measure PC voltage, MODEM voltage, the 12V junction box voltage, and the 5V junction box voltage. The current sensor (ACS712 -10A to 10A) is used to measure the 12V junction box current. These measured values are sent to the PC, which is then displayed on the user interface that would allow the users to monitor the status of internal components and diagnose issues easily.

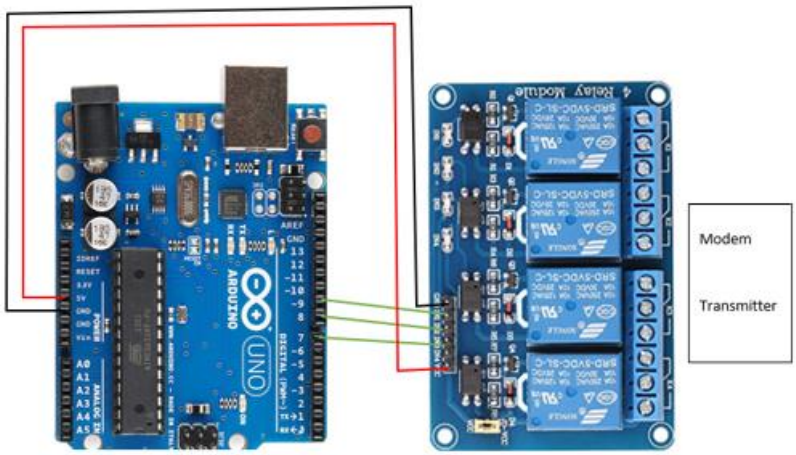


Figure 8: Arduino UNO Circuit Diagram for Control Relays

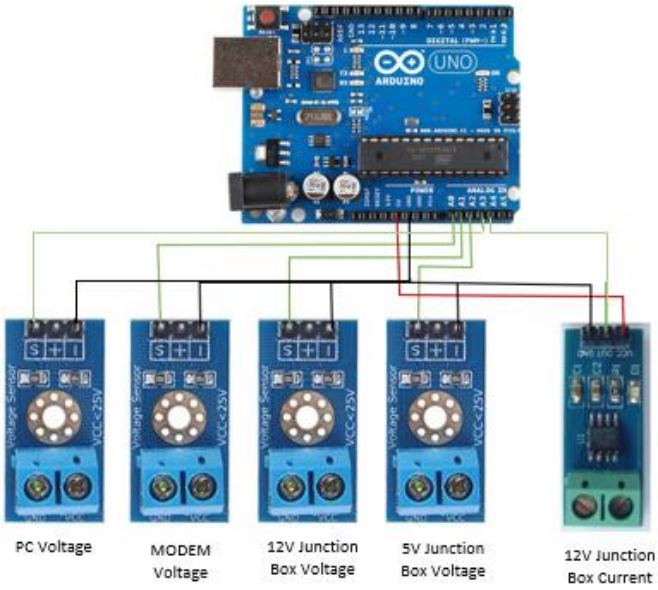


Figure 9: Arduino UNO Circuit Diagram for Voltage and Current Sensors

5. Power Supply Unit
   The power supply supplies required power to all the electrical components in the box. The system requires 12V and 5V to power the different electrical devices. Therefore, a 450W ATX PSU was used since it has a high wattage 12V line and 5V line and has a small form factor. The PSU has a cooling fan that is activated when the temperature of the system increases. The PSU is connected to an ATX breakout board in order to utilize all the features of the PSU. A 12V to 19V boost converter rated at 8A was used to supply the voltage to power the Intel NUC PC. A 12V to 24V boost converter rated at 3.5A was used to supply the voltage to power the Edge Router X.
   The system runs in idle at ~30W and ~130W at full load, and all the electrical components are fused protected.

Figure 10: Corsair SF450 Power Supply Unit

6. Initial Assembly Schematics

Figure 11 shows the schematic of the front panel pate designed to enclose all the internal hardware components. The plate is constructed out of anodized metal and will be laser cut. The vents on the front panel ensure air circulation within the box and make sure the components inside the box remains cool.

The front panel has cutouts for the following ports:

1. Video Input – HDMI Female Port
   The video input port has an HDMI female port that connects to the UAV's remote controller that communicates with the UAV and transmits the video.
2. Video Output – HDMI Female Port
   The video output port has an HDMI female port that would allow users to connect an external monitor to the box.
3. WiFI Antenna/Access Point – RJ45 Female Port
   An external PoE (Power Over Ethernet) access point/antenna can be connected here.
4. SMA Antenna Connectors – SubMiniature Version A Female Connectors
5. Input Power Port – IEC Male Connector
6. Power Button – Non-latching LED Pushbutton
7. Power Receptacle
8. 7" Touchscreen LCD

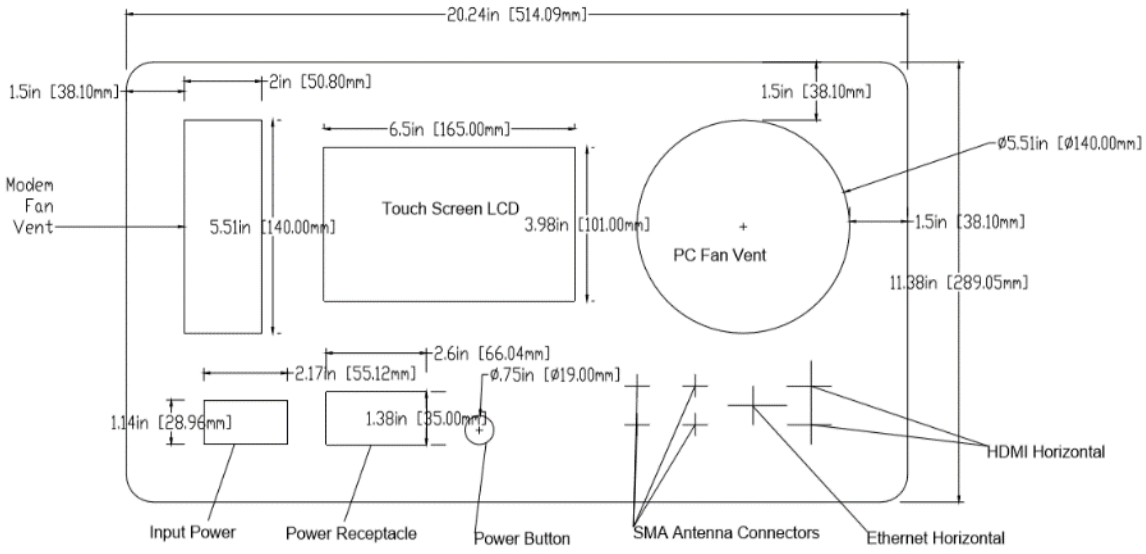


Figure 11: Mission Box Top Panel Schematic Diagram

7. Electric Wiring Diagram and Power Line Diagram

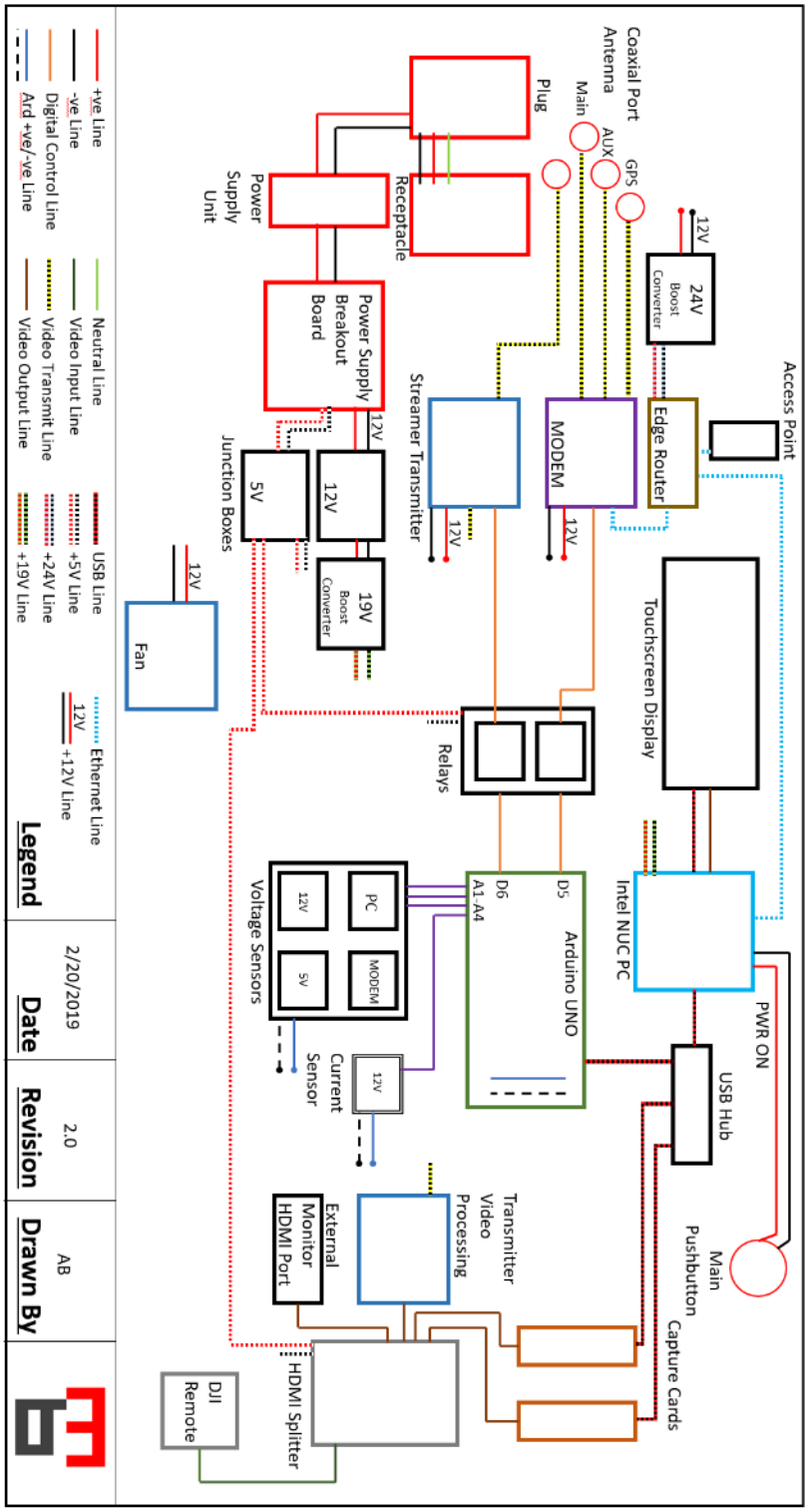


Figure 12: Electrical Wiring Diagram

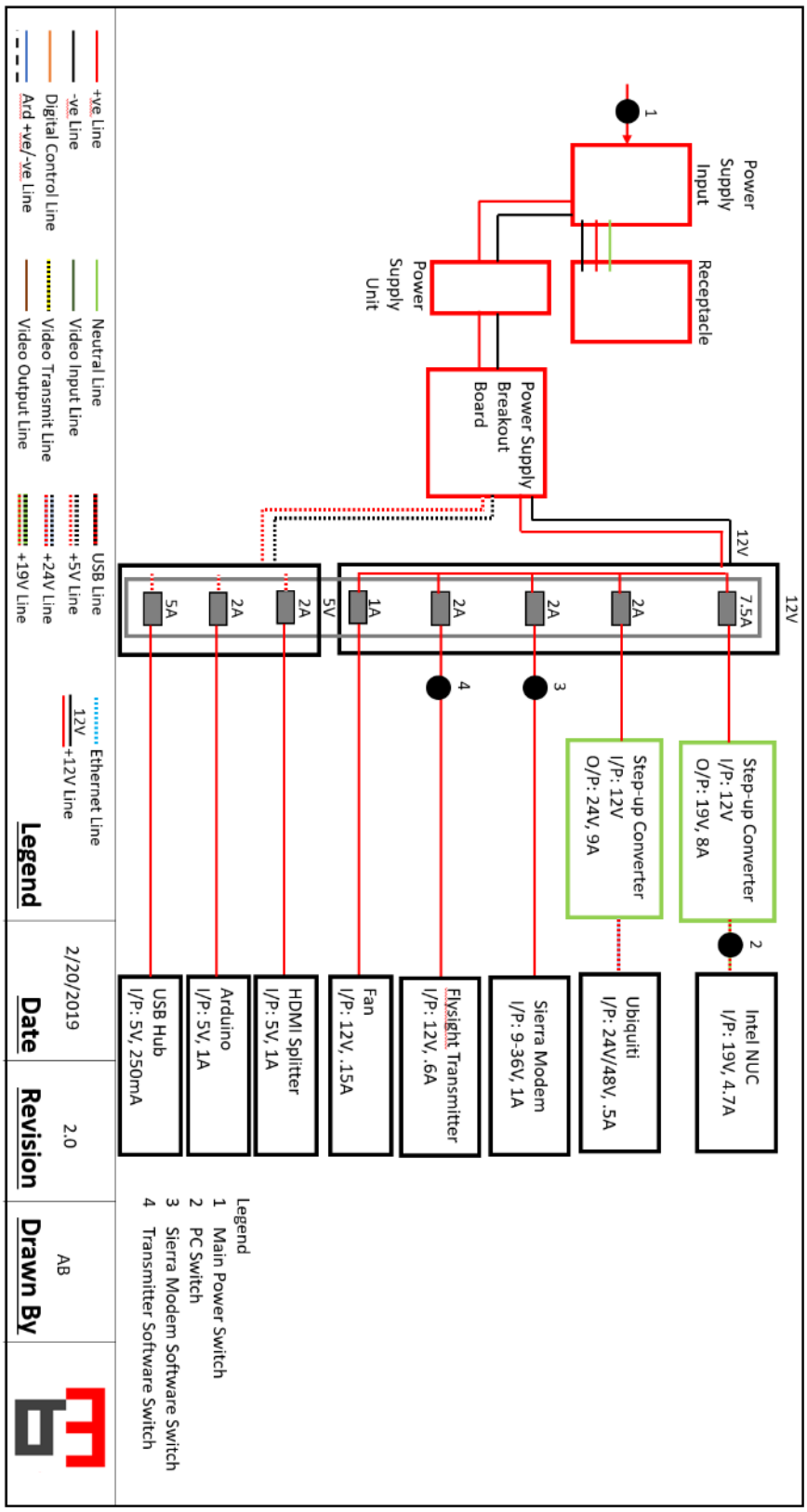


Figure 13: Power Line Diagram

Software

1. Mission Box UI

   This is an improvement of the project version 2 (previous senior design project) and 3(production version). After discussing together and with the advisors, the team Decided a web application would be the best way to create a dynamic interface for the system. It should be noted a console application could be developed to achieve the same results and is being considered for future revisions. HTML was used for the interface layout along with JavaScript, Ajax, and jQuery to provide dynamic data and communication to the web server.

   Live Video & Mission Box Status

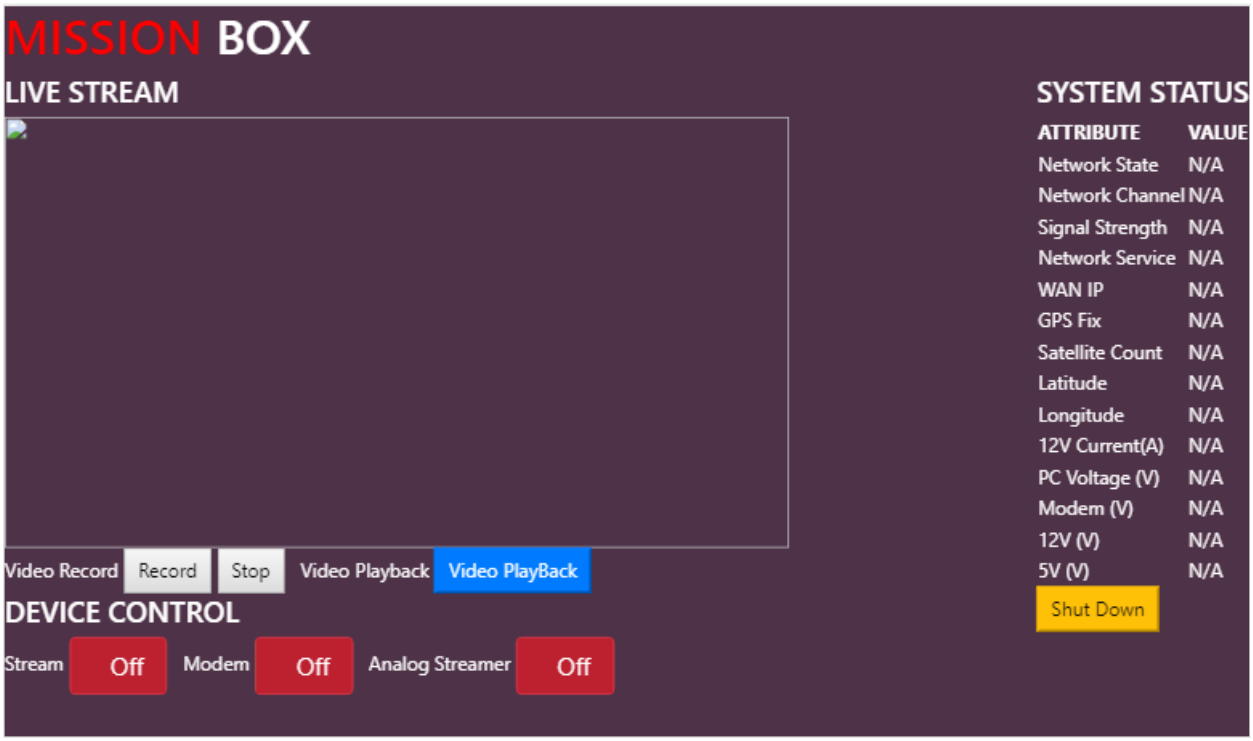


Figure 14: Live Video & Mission Box Status

The panel in the left of the page, under the ‘Live Stream’ label, designates the window for the live video feed. The button next to the label ‘Video Record’ with text ‘Record’ starts a recording of the live video feed which is stored as an mp4 file when the user stops recording. Recording stops when the button with text ‘Stop’ is pressed. The ‘Video Playback’ button is a navigation button. When pressed, the user will be taken to the video playback page. Under the ‘Device Control,’ labels are three labels with its buttons, ‘Stream’, ‘Modem’, and ‘Analog Streamer’. Button with ‘Stream’ label on the right launches the Wi-Fi streamer using FFmpeg and FFserver software. Button with ‘Modem’

label on the right turns of the Sierra RV50 MODEM after the MODEM is turned on will launch the YouTube live stream using FFmpeg software.

The panel in the right of the page labeled “System Status” gets populated with modem data as well as system status of the Mission Box. The button of the “System Status” is a button labeled “Shutdown” safely shuts down the entire system.

Playback Screen

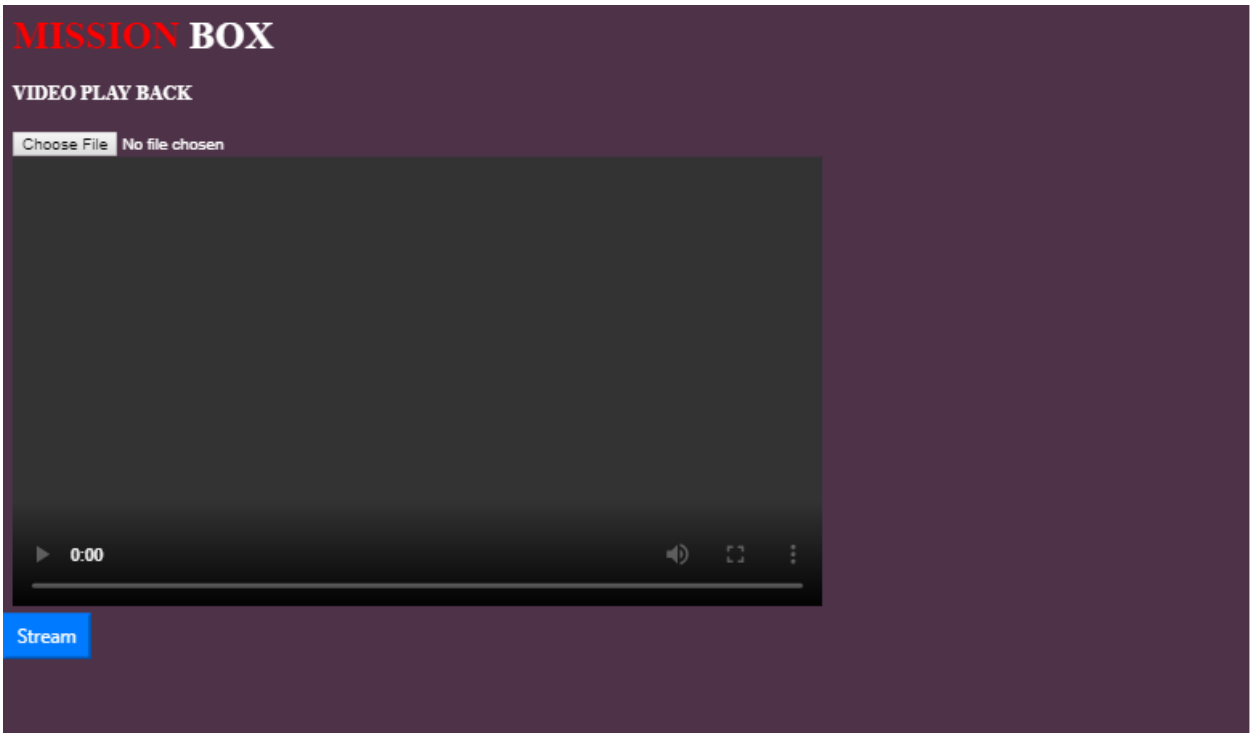


Figure 15: Video Play Back

Located in the top of the page is a button labeled “Choose File” which allows and only allows the user to browse the computer’s storage and select a video for playback. After a file is selected, the gray media displayer will play the video of the selected file. The blue button labeled “Stream” is the navigation button to Live Video & Mission Box Status.

Code Samples

```
class RecordingThread (threading.Thread):
    def __init__(self, name, camera):
        threading.Thread.__init__(self)
        self.name = name
        self.isRunning = True

        self.cap = camera
        size = (int(self.cap.get(cv2.CAP_PROP_FRAME_WIDTH)),int(self.cap.get(cv2.CAP_PROP_FRAME_HEIGHT)))
        fourcc = cv2.VideoWriter_fourcc(*'H264')
        d=datetime.now()
        filename='{}-{}-{}-{}-{}-{}'.format(d.year,d.month,d.day,d.hour,d.minute,d.second)
        url='./static/missionboxVideo_'+filename+'.mp4'
        self.out = cv2.VideoWriter(url, fourcc, 30.0, size)

    def run(self):
        while self.isRunning:
            ret, frame = self.cap.read()
            if ret:
                self.out.write(frame)

        self.out.release()

    def stop(self):
        self.isRunning = False

    def __del__(self):
        self.out.release()
```

Figure 16: video.py code sample handing recording thread

Video.py holds the video functionaries. Figure 16 contains the class for toggling the recording of the live video feed using threading at a mean time save the file in the local directory.

```
class VideoCamera(object):
    def __init__(self):
        # Open a camera
        self.cap = cv2.VideoCapture('/dev/video0')
        self.cap.set(3, 1920)
        self.cap.set(4, 1080)
        # Initialize video recording environment
        self.is_record = False
        self.out = None
        # Thread for recording
        self.recordingThread = None

    def __del__(self):
        self.cap.release()

    def get_frame(self):
        ret, frame = self.cap.read()

        if ret:
            ret, jpeg = cv2.imencode('.jpg', frame)
            return jpeg.tobytes()
        else:
            return None

    def start_record(self):
        self.is_record = True
        self.recordingThread = RecordingThread("Video Recording Thread", self.cap)
        self.recordingThread.start()

    def stop_record(self):
        self.is_record = False

        if self.recordingThread != None:
            self.recordingThread.stop()
```

Figure 17: video.py code sample reading camera data and handing recording thread

Figure 17 contains the class operating the camera and post video processing outputting to 1080p(1920x1080), and also using the previous threading class to record video.

```
@app.route('/record_status', methods=['POST'])
def record_status():
    global video_camera
    if video_camera == None:
        video_camera = VideoCamera()

    json = request.get_json()

    status = json['status']

    if status == "true":
        logFile()
        f.write('capture on\n')
        f.flush()
        video_camera.start_record()
        video_on = True
        return jsonify(result="started")
    else:
        video_camera.stop_record()
        logFile()
        f.write('capture off\n')
        f.flush()
        video_on = False
        return jsonify(result="stopped")


def video_stream():
    global video_camera
    global global_frame

    if video_camera == None:
        video_camera = VideoCamera()

    while True:
        frame = video_camera.get_frame()

        if frame != None:
            global_frame = frame
            yield (b'--frame\r\n'
                   b'Content-Type: image/jpeg\r\n\r\n' + frame + b'\r\n\r\n')
        else:
            yield (b'--frame\r\n'
                           b'Content-Type: image/jpeg\r\n\r\n' + global_frame + b'\r\n\r\n')
```

Figure 18: web.py code sample handing recording

Web.py holds the backend functions. Figure 18 contains the functions for using video.py class to toggle the recording status of the live video feed and outputting the live video.

```
<video width="672" height="378" controls autoplay></video>
<script>
  (function localFileVideoPlayer() {
  var URL = window.URL || window.webkitURL
  var playSelectedFile = function (event) {
    var file = this.files[0]
    var type = file.type
    var videoNode = document.querySelector('video')
    var canPlay = videoNode.canPlayType(type)

    var fileURL = URL.createObjectURL(file)
    videoNode.src = fileURL
  }
  var inputNode = document.querySelector('input')
  inputNode.addEventListener('change', playSelectedFile, false)
})()
</script>
```

Figure 19: load_video.html sample for loading video file to the browser

Figure 19 is a segment of code that is used to construct the video playback page. The “video” tag is the HTML code that hosts the video file. And the code between the “script” is the JavaScript to select a video from storage and load it to the server.

```
HOST = "192.168.13.31"
user = "user"
password = "missionbox"
cmd0="AT*NETIP?"
cmd1="AT*NETSTATE?"
cmd2="AT*LTERSRQ?"
cmd3="AT*NETRSSI?"
cmd4="AT*NETSERV?"
cmd5="AT*GPSDATA?"
def modem():
  try:
    tn = telnetlib.Telnet(HOST,2332)
    tn.read_until(b"login: ")
    tn.write(user + b"\n")
    #time.sleep(2)
    tn.read_until(b"Password: ")
    tn.write(password + b"\n")
    time.sleep(1)

    tn.write(cmd0+b"\n")
    time.sleep(1)
    tn.write(cmd4+b"\n")
    time.sleep(1)
    tn.write(cmd1+b"\n")
    time.sleep(1)
    tn.write(cmd2+b"\n")
    time.sleep(1)
    tn.write(cmd3+b"\n")
    time.sleep(1)
    tn.write(cmd5+b"\n")
    time.sleep(1)
    tl1 = ''
    tl1 = tn.read_very_eager()
          #close telnet connection
    tn.close()
    print tl1
```

Figure 20: modem.py sample for modem communication

Figure 20 is a python code used to communicate with the modem. The code executes AT commands over a Telnet connection to retrieve data from the modem. And then parsed and populated into the table.

```
temp = ''
for i in range(0,len(ttl)):
  if ttl[i] == cmd0:
    temp = temp + ttl[i+1] + ','
  if ttl[i] == cmd1:
      if ttl[i+2] is not 'Ready':
          temp += 'Down,'
  if ttl[i] == cmd2:
    temp = temp + ttl[i+1] + ','
  if ttl[i] == cmd3:
    temp = temp + ttl[i+1] + ','
  if ttl[i] == cmd4:
    temp = temp + ttl[i+1] + ','
  if ttl[i] == cmd5:
    x = ttl[i+2]
    temp += x[4:] + ','
    x = ttl[i+4]
    temp += x[6:] + ','
    x = ttl[i+5]
    temp += x[9:] + ','
    x = ttl[i+6]
    temp += x[10:]
```

Figure 21: modem.py sample for modem data parsing

Figure 21 is the python code used to parse the modem data into CSV format data and then populated in the table.

```
$.ajax({
    type: "get",
    url: "/modem",
    success: function(response) {
        if (response != "False") {
            //console.log("modem on");
            var table=response.split(',');
            if(table[0] == "error");
            else {
                //document.getElementById("pwrState").innerHTML = "ON";
                document.getElementById("netState").innerHTML = table[2];
                document.getElementById("netChan").innerHTML = table[3];
                document.getElementById("sigStrength").innerHTML = table[4];
                document.getElementById("netServ").innerHTML = table[1];
                document.getElementById("wanIP").innerHTML = table[0];
                document.getElementById("gpsFix").innerHTML = table[5];
                document.getElementById("satCount").innerHTML = table[6];
                document.getElementById("latitude").innerHTML = table[7];
                document.getElementById("longitude").innerHTML = table[8];
            }
        } else {
            //console.log("modem false");
            //document.getElementById("pwrState").innerHTML = "ON";
            document.getElementById("netState").innerHTML = "N/A";
            document.getElementById("netChan").innerHTML = "N/A";
            document.getElementById("sigStrength").innerHTML = "N/A";
            document.getElementById("netServ").innerHTML = "N/A";
            document.getElementById("wanIP").innerHTML = "N/A";
            document.getElementById("gpsFix").innerHTML = "N/A";
            document.getElementById("satCount").innerHTML = "N/A";
            document.getElementById("latitude").innerHTML = "N/A";
            document.getElementById("longitude").innerHTML = "N/A";
        }
    }
})
```

Figure 22: Ajax setting modem status table via HTML element id

Figure 22 is the ajax function for setting the HTML elements to the data pulling from the modem function contains the corresponding data in the CSV format.

Communication between Arduino & PC

```
int value1 = analogRead(A1);
int value2 = analogRead(A2);
int value3 = analogRead(A3);
int value4 = analogRead(A4);
//Serial.println(value);
float v1 = value1*((5.0*(R1+R2))/(1023.0*R2));
float v2 = value2*((5.0*(R1+R2))/(1023.0*R2));
float v3 = value3*((5.0*(R1+R2))/(1023.0*R2));
float v4 = value4*((5.0*(R1+R2))/(1023.0*R2));


float average = 0;
for(int i = 0; i < 1000; i++) {
    average = average + (.0264 * analogRead(A0) -13.51);//for the 5A mode,
    //average = average + (.049 * analogRead(A0) -25);// for 20A mode
    // average = average + (.742 * analogRead(A0) -37.8);// for 30A mode
}
```

Figure 23: Arduino reading voltage and current

Arduino Uno analog input is limited to a 5V DC, but 20V DC measurements were needed. A 5:1 voltage divider was implemented using 30k and 8k ohm resistors (Voltage Sensors). The sensor could measure up to 25V DC. The Arduino connected to PC through USB. The code above in Figure 23 shows how voltage and current were read and calculated. Data were sent to the serial port for PC shows below in Figure 24. Read by python code shows below in Figure 25.

```
Serial.print(abs(average/1000),2);
Serial.print(",");
Serial.print(v1,2);
Serial.print(",");
Serial.print(v2,2);
Serial.print(",");
Serial.print(v3,2);
Serial.print(",");
Serial.print(v4,2);
```

Figure 24: Arduino outputting voltage and current

```
def status():
    line = ser.readline()
    #line = line.split(',')
    return line
```

Figure 25: PC reading Arduino voltage and current

Video Streaming Over Network

Video streaming was a main feature which needed to be implemented in the Mission Box. The box supplies an internal router for a local area network (LAN) as well as a modem which can connect to the internet over the cellular connection. Different software packages were considered when selecting a method to handle video streaming to different connected devices. There were lots applications available, however, they either need admin permission or not flexible enough to be controlled through the web server with a single click, Ultimately, Ffmpeg and ffserver were chosen as the multimedia framework and server. Down below in Figure 26 shows how the visualization of how FFmpeg and ffserver works.

Once streaming is initialized, the web application provides the confirmation to the user that the stream is in fact started and online via the “Live Stream & Box Status” page. To view the stream, a user must connect to the Mission Box Wi-Fi network, and type in the URL provided in the UI into any giving web browser. This allows the user to view the stream in multidevice (smartphones, laptops, and Microsoft HoloLens), and cross-platform, no additional application needed, just native web browser.

Additionally, using the modem, the streaming server’s port can be forwarded allowing the stream to be accessed remotely. This could allow a remote user to share the live video and save the video feed. Mission Box provided two ways of streaming, either private server or public server.

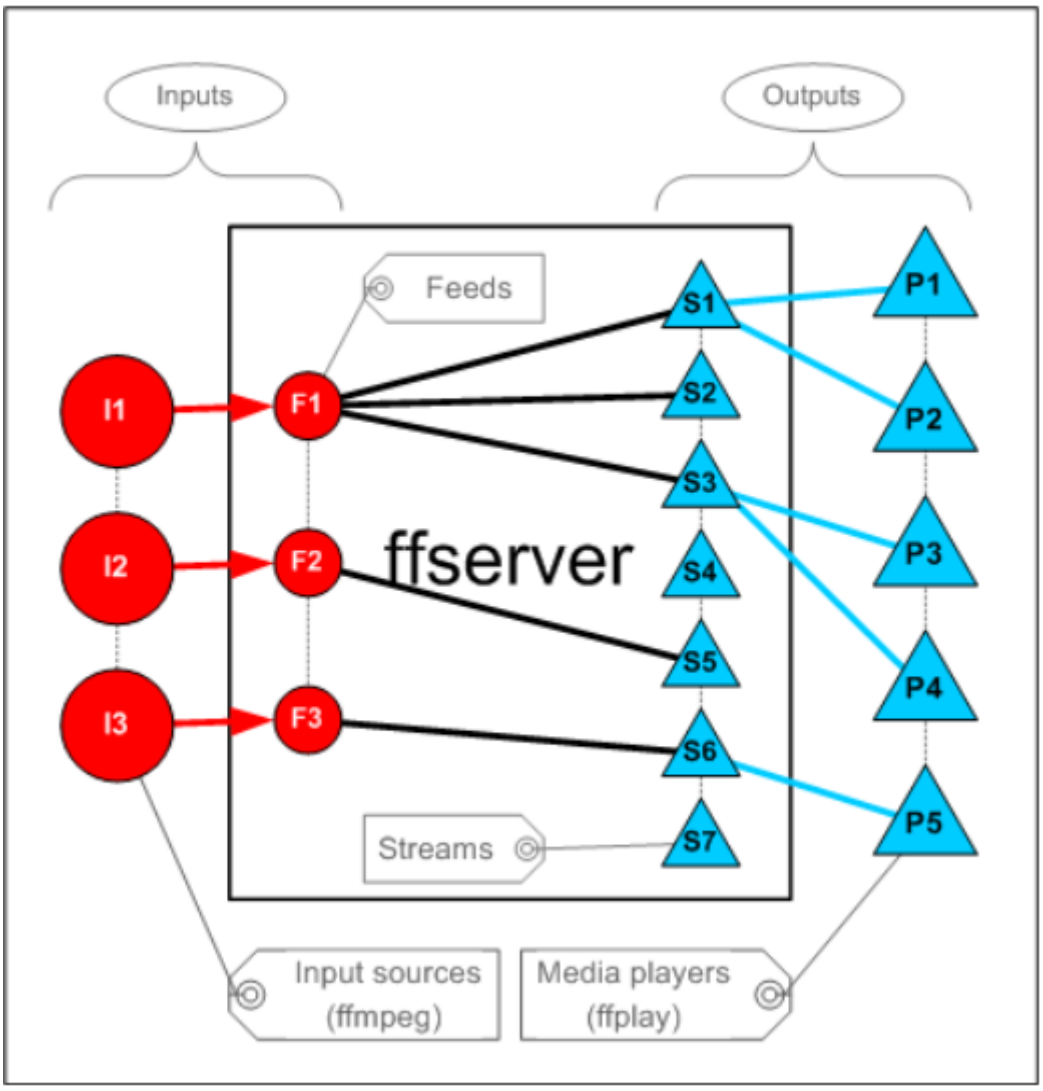


Figure 26: Visualization how FFmpeg and ffserver interact to create a stream. "I" – video input, "S" – streams created from the input, and "P" – peers connected to the stream to the desired video

2. Mission Planner Application

   The Mission Planner application is an Android-based application that would allow users to plan UAV missions to capture images for inspections, as per the user's requirements. Users can then process these images on Pix4D to augment the inspection process.

   Commonly used flight planning applications (DJI GS Pro) do not take into consideration the user's requirements when planning a mission. This application does not intend to replace the existing functionalities of flight planning applications, like DJI GS Pro, but rather complements their functions, by providing instructions that would guide users to generate efficient flight plans based on their inspection needs.

   The flight planning application has five main pages:

1. Mission Type
2. Missions List
3. Camera Data
4. Calculators
5. Information and FAQ

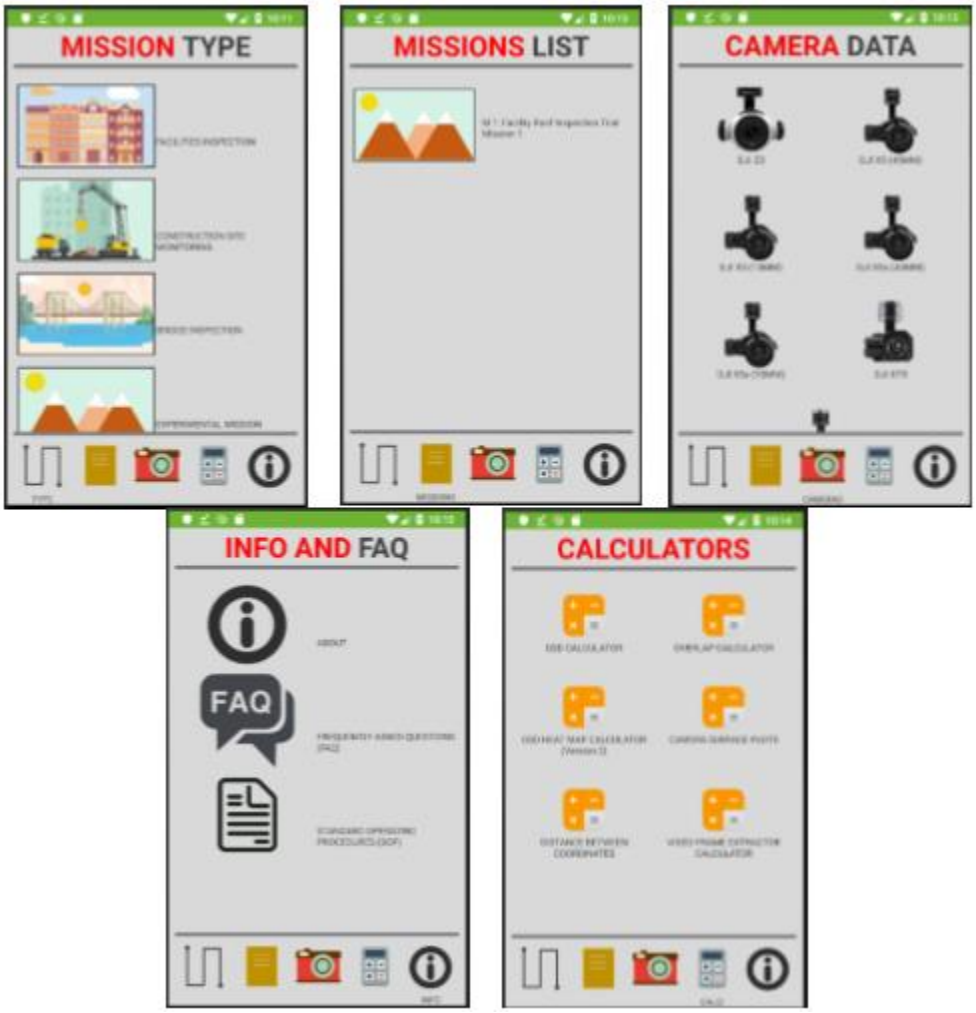


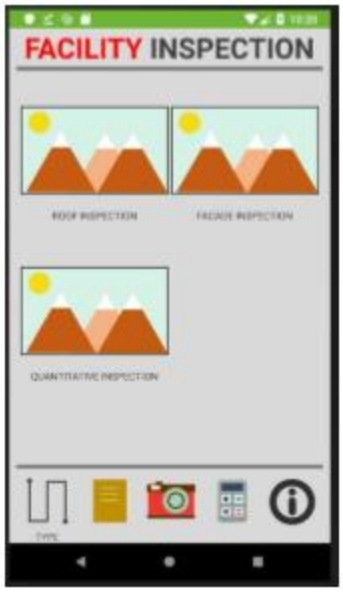
Figure 27: Mission Planner Main Pages

The application is created using the Android Studio. The front end of the application is coded using XML (Extensible Markup Language). The back end of the application is coded using Java. The algorithms for the various calculators present in the application was derived by Aswin as part of his research for the Master of Science degree.

Mission Type

The "Mission Type" page lists all the available UAV inspection missions a user can plan for using the Android application. There are mainly three categories of inspections available in the application:

1. Facility Inspection
2. Bridge Inspection
3. Construction Site Inspection



Facility Inspection

Under the facility inspection page, the user is provided with three more options:

1. Roof Inspection: Instructions and calculations to generate flight plans to aid in the facility roof inspection.
2. Façade Inspection: Instructions and calculations to generate flight plans to aid in facility facade inspection.
3. Quantitative Inspection: Instructions and calculations to generate flight plans to aid in facility quantitative inspection (i.e. capturing images to generate 3D models using Pix4D to make measurements of the structure)

Each of the options given above opens a new page with a set of instructions that would aid users to create efficient flight plans for their respective inspections.

After following the instructions given in the page the user has the option to save the generated information in a PDF file, which they can later view under the "Missions List" page.

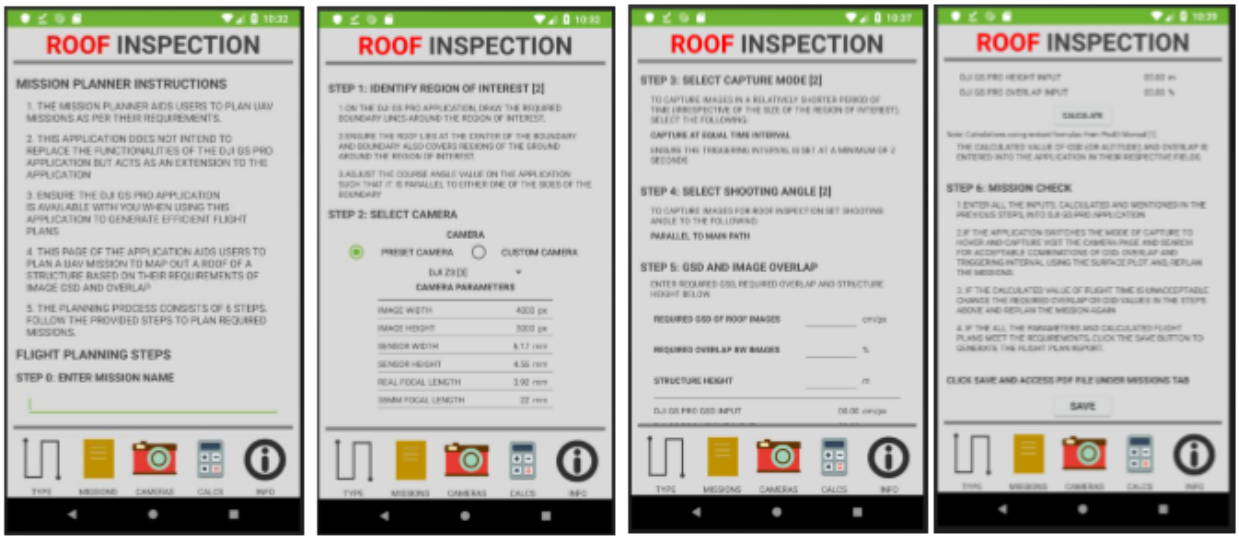


Figure 28: Roof Inspection Page

Missions List

The "Missions List" page lists all the mission plans created using this application and saved in the phone's storage. Clicking on the image icon will open the pdf file below the button and users can view the generated mission plans by swiping horizontally. The user can close the pdf file by clicking on the button again.

Figure 29: Saved Missions Page

Camera Data

The “Camera Data” page lists all the commonly used UAV cameras for this ODOT project. Clicking on each camera lists all the information about the camera, provides the user an idea of obtainable GSDs using the camera at different heights, a surface plot for varying triggering intervals that shows all the possible sets of GSDs, image overlap, and flight speed for that triggering interval, and finally user notes.

Calculators

The “Calculators” page lists all the calculators that are useful to plan UAV missions and allows the user to see all the separate calculators that were used to build the flight planner pages (e.g. the facility roof inspection page).

The following are the calculators present in version 1 of the application:

1. GSD Calculator: Calculates the GSD on top of a structure and ground for a flight height entered.

2. Image Overlap Calculator: Calculates the overlap between images on the ground and on top a structure for a flight height entered.

3. Camera Surface Plot Calculator: Generates characteristic surface plots for a camera and a triggering interval entered. The plot allows users to visualize the sets of all GSDs, image overlaps, and flight speeds when missions are flown under the equal timed mode of capture. This gives users an idea when DJI GS Pro would switch a user's preference of image capture from Equal Timed to Hover and Capture. For sets of GSDs, overlap, and flight speed that does not lie in the plot generated would force DJI GS Pro to switch a mission's mode of capture to "Hover and Capture".

4. Distance between Coordinates Calculator: Calculates the distance between two points (Latitude and Longitude) using the GRS80 Earth's model.

5. Video Frame Extractor Calculator: Calculates every Nth frame to be extracted from a video recording of a structure, based on the required overlap between frames, which can then be used in Pix4D Mapper to construct a 3D model.

Information and FAQ

The "Information and FAQ" page has the following options:

1. About: Displays information about the application.

2. FAQ: Displays a list of FAQs about the application.

3. Standard Operating Procedures: Displays the list of available standard operating procedures being developed for ODOT to aid in their UAV based structural inspections.

Budget

Majority of the equipment required to complete the project was provided by the UCII lab. The total cost of the project, that includes hardware, software, and labor was $50,833. The labor cost per hour was estimated using the average pay scale for an electrical engineer. Figure 30 shows the breakdown of the project's budget.

Item	Qty	Item Price	Total	Website	Notes (Procured/Downloaded)
Software/Application					
Arduino Studio IDE	1	$ -	$ -	Link	Downloaded: Free
Microsoft Visual Studio	1	$ -	$ -	Link	Downloaded: Free
MATLAB	1	$ 100.00	$ 100.00	Link	Downloaded: Student version
DJI SDK Application	1	$ -	$ -	Link	Downloaded: Free
JetBrains PyCharm	1	$ -	$ -	Link	Downloaded: Free for students
Adobe Photoshop CS6	1	$ 60.00	$ 60.00	Link	Downloaded: Reduced price for students
DJI GS Pro	1	$ -	$ -	Link	Downloaded: Free
GeoSetter	1	$ -	$ -	Link	Downloaded: Free
Pix4D Mapper Desktop	1	$ 3,500.00	$ 3,500.00	Link	Downloaded: Purchased by UCII
Microsoft Project	1	$ -	$ -	Link	Downloaded: Free for students
Microsoft Office Products	1	$ -	$ -	Link	Downloaded: Free for students
Hardware					
Mission Box System	1	$ 2,500.00	$ 2,500.00	N/A	Procured through UCII
DJI Matrice 100	1	$ 3,300.00	$ 3,300.00	Link	Procured through UCII
DJI Matrice 210 RTK	1	$18,797.00	$ 18,797.00	Link	Procured through UCII
DJI Z3 Camera	1	$ 900.00	$ 900.00	Link	Procured through UCII
DJI X5 Camera	1	$ 1,659.00	$ 1,659.00	Link	Procured through UCII
DJI X5s Camera	1	$ 1,899.00	$ 1,899.00	Link	Procured through UCII
DJI XTR Camera	1	$ 5,900.00	$ 5,900.00	Link	Procured through UCII
DJI Z30 Camera	1	$ 4,999.00	$ 4,999.00	Link	Procured through UCII
Apple iPad	1	$ 350.00	$ 350.00	Link	Procured through UCII
Micro SD Card 64GB	4	$ 16.00	$ 64.00	Link	Procured through UCII
SD Card Reader	1	$ 11.00	$ 11.00	Link	Procured through UCII
Custom Personal Computer	1	$ 1,500.00	$ 1,500.00	N/A	Procured through UCII
Intel Aero Drone Kit	1	$ 1,099.00	$ 1,099.00	Link	Will be purchased using personal funds
OpenMV M7 Camera	1	$ 65.00	$ 65.00	Link	Will be purchased using personal funds
		TOTAL	**$ 46,703.00**		

Work Performed	Time (hrs)
Aswin Balasubramaniam	
Course Tasks	7
Project Tasks	
Literature Review	6
Preliminary Algorithm	5
Design UI	5
Preliminary Coding	15
Troubleshooting	5
Testing	8
Revision of Design	5
Jingbin Yang	
Course Tasks	6
Project Tasks	
Literature Review	6
Preliminary Algorithm	4
Design UI	2
Preliminary Coding	20
Troubleshooting	10
Testing	8
Revision of Design	6
TOTAL	**118**

Item	Cost ($)
Software & Hardware	$ 46,703.00
Labor @ 35/hour	$ 4,130.00
TOTAL	**$ 50,833.00**

Figure 30: Project Budget Breakdown

Timeline

The Gantt chart shown in Figure 31 shows the timeline of the entire project. The summary of the entire timeline is shown in Figure 32.

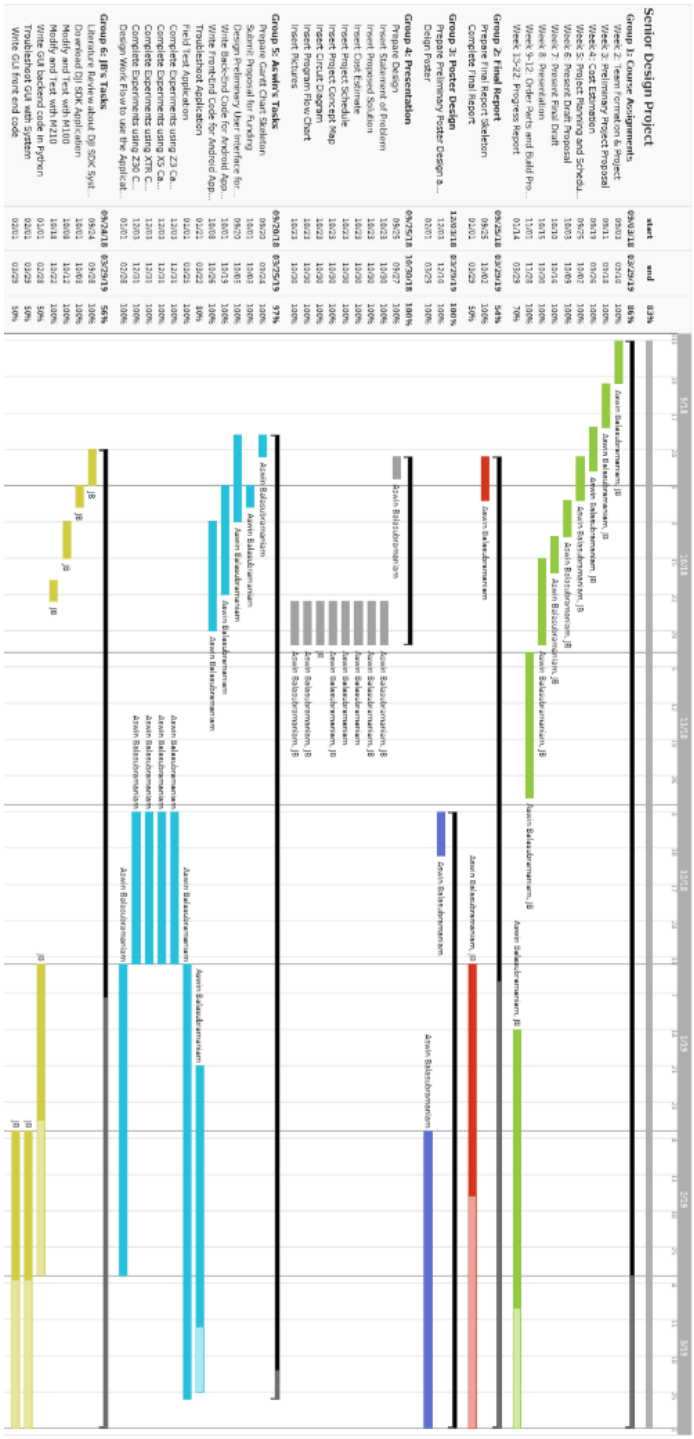


Figure 31: Project Timeline Gantt Chart

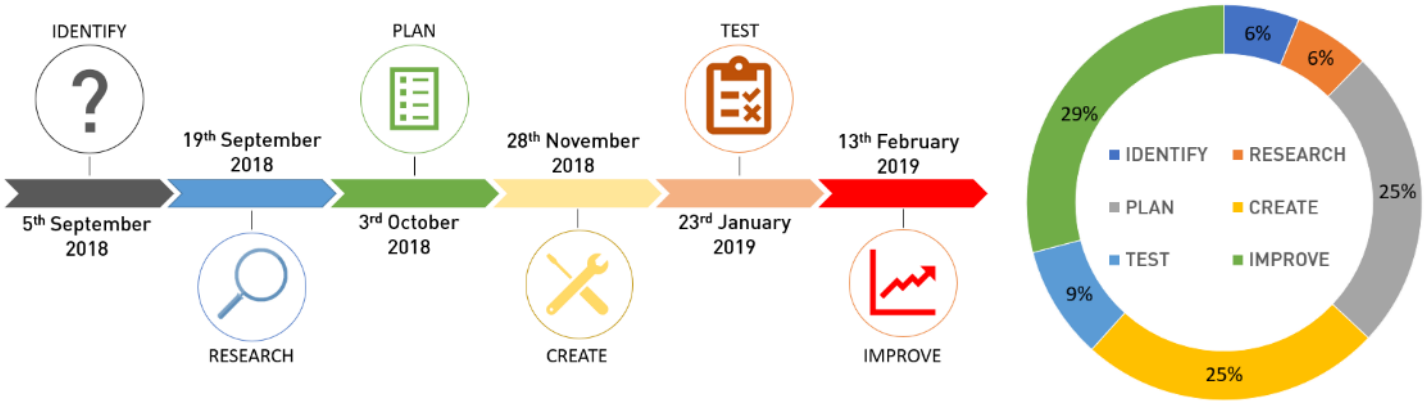


Figure 32: Project Timeline Summary

Issue Discussion

Hardware Issues

There were some initial assembly issues due to the number and size of electrical components present inside the box. After multiple trials, all the electrical components were made to fit inside the Pelican case and was assembled in a way that would prevent any malfunction due to heating.

Software Issues

There were some issues on the software level, the main issues are communication between PC and Arduino and display live video and record using the same HDML Capture card on high quality(1080p).

The first issue, communication between PC and Arduino via a serial connection, on this way latency should be lesser than 1us. When backend was first writing, the latency was less than 1us, and when time moves, the latency increases. After multiple trials and debug, the issue was serial port at dormant by the Linux policy. So, there is a bash script keeping serial port alive to achieve real time data retrieval between PC and Arduino.

The second issue, display live video, and record using the same HDML Capture card on high quality. After many discussion and research, OpenCV was decided to be used as video processing package. OpenCV can output a video in FHD resolution (1920x1080) in maximum. But many parameters where adjusted, the outputs always come to 480p. Many adjustments were at the output rate, but OpenCV defaulted input at 480p, after changing the input rate that has been solved. So, the video is displaying on the screen, but the recording is not yet implemented, the first way come across were using bash or another python function for running the recording, which fails. Then, threading comes across mind, threading can allow the processor to fork a sub processor to do work and still under control of the program itself, in another work still can end the process whenever stop record is performed which solved the problem.

Future Recommendations

The mission box system in its current state can be efficiently used by the remote pilots of ODOT's UAS center to aid infrastructure inspections. A remote pilot can connect their UAV controllers, to the box and broadcast the video feed locally to inspectors on the field over the local network. If given an ODOT issued SIM card the MODEM can be configured to send the video to ODOT's Milestone server, where inspectors can view live UAV feeds at one's leisure /view them during a live or virtual team meeting. Moreover, the mission planner application would also allow remote pilots to plan efficient flights to capture the necessary images of structure to build its 3D model.

The mission box is a black box that has a plethora of capabilities limited by the designer's imagination. Given the availability of the Intel NUC PC inside the box, the UI can be re-designed to run computational heavy processes. This includes but not limited to processing 3D models using images captured by the UAV, image and video processing to estimate traffic data using the videos captured by the UAV, and control the UAV using available Software Development Kits (SDKs).

References

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[11] DJI. Zenmuse Z30 User Manual. DJI. Retrieved from http://www.sekidorc.com/pdf/ZZ30_UserManual_en_v1.0_161228.pdf

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Appendix

Component List

1. Plug Socket

Figure 33: Power Plug Socket with Fuse and Switch

2. Electrical Outlet/Receptacle

Figure 34: Electrical Outlet with USB Charging Ports

3. Corsair SF450 Power Supply Unit

Figure 35: Power Supply Unit

4. Power Supply Breakout Board

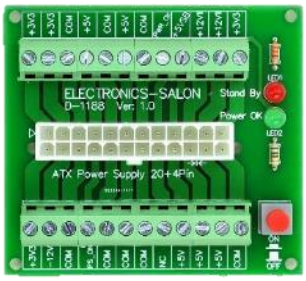


Figure 36: Power Supply Breakout Board

5. Fuse Box

Figure 37: Fuse Box

6. Boost Converters (12V-19V & 12V-24V)

Figure 38: Boost Converter

7. Noctua Cooling Fan

Figure 39: Noctua Cooling Fan

8. Sierra MODEM RV50

Figure 40: Sierra MODEM RV50

9. Ubiquiti Edge Router X

Figure 41: Ubiquiti Edge Router X

10. Ubiquiti Access Point

Figure 42: Ubiquiti Access Point

11. Relays

Figure 43: Arduino 4-Relay Module

12. Touchscreen Display

Figure 44: 7” Touchscreen Display

13. Intel NUC PC

Figure 45: Intel NUC PC

14. Arduino Uno

Figure 46: Arduino UNO Rev 3

15. Voltage Sensor

Figure 47: Arduino Voltage Sensor

16. Current Sensor

Figure 48: Arduino Current Sensor

17. HDMI Splitter

Figure 49: OREI 4 Port HDMI Splitter

18. Capture Cards (Magewell)

Figure 50: Magewell USB 3.0 Capture Card

19. Capture Card (HopCentury)

Figure 51: HopCentury USB 3.0 Capture Card

20. USB Hub

Figure 52: 4 Port Sabrnet USB Hub

21. Non-Latching Pushbutton

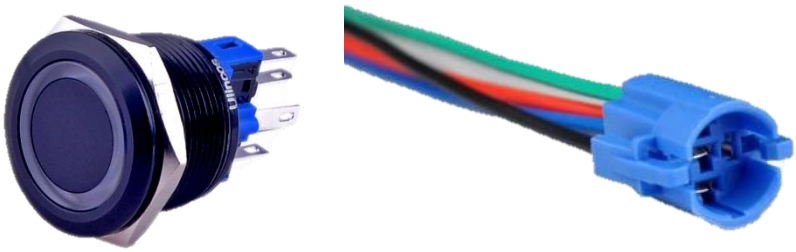
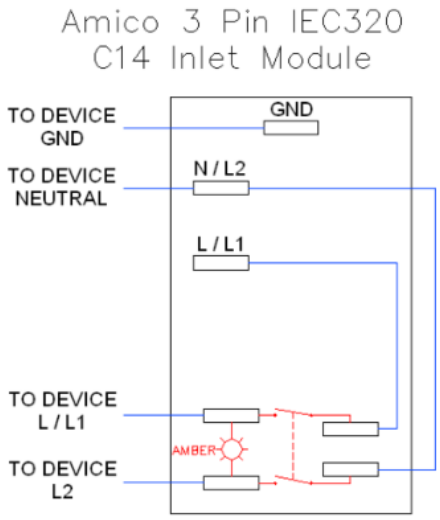
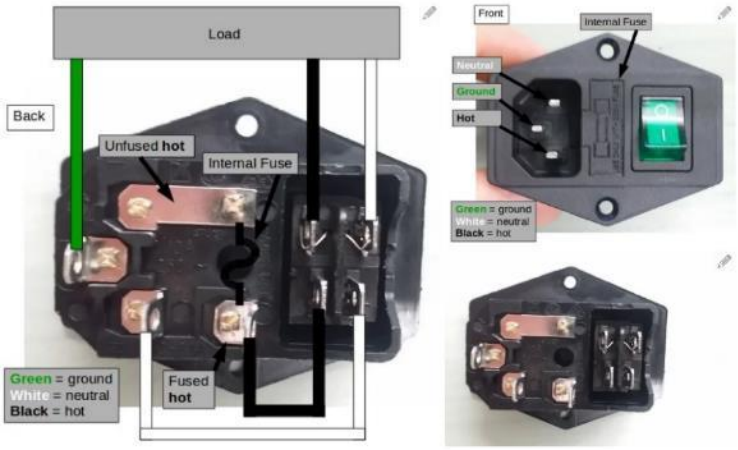


Figure 53: Non-Latching Pushbutton

Component Datasheets

1. Plug Socket Wiring Diagram





2. Power Supply Datasheet

SF SERIES™

Congratulations on the purchase of your new Corsair SF Series High Performance SFX power supply.

SF Series power supplies give you 80 PLUS Gold efficiency, excellent electrical performance, and virtually silent operation in a SFX form factor. With 105°C Japanese capacitors and ZERO-RPM fan mode, they're a great choice for high performance small form factor PC's where reliability and low noise are essential.

Safety and protection

- **Over-voltage protection (OVP)**
  Over-voltage protection for the 12V, 5V and 3.3V DC outputs is required to comply with the SFX specification. OVP shuts down the PSU in the event that the DC outputs exceed a set level, determined by the PSU manufacturer. The minimum voltage levels required for compliance are 13.4V for the +12V rail(s), 5.74V for the +5V rail and 3.76V for the 3.3V rail.

- **Over-current protection (OCP)**
  The SF Series features OCP on the 3.3V, 5V and 12V rails. OCP ensures that the output of the DC voltage rails remains within safe operating limits.

- **Over-temperature protection (OTP)**
  OTP ensures that the PSU will shut down when the internal temperature reaches a set point. This is usually as a result of internal current overloading or a fan failure.

- **Short-circuit protection (SCP)**
  A short-circuit is defined as any output impedance of less than 0.1 ohms. Amongst other things, SCP ensures that the PSU shuts down should the 3.3V, 5V and 12V rails short to any other rail, or to ground. It also ensures that no damage should occur to the unit, or your PC's components in the event of a short.

SF SERIES™

SF450

Dimensions: 125mm (W) x 63.5 mm (H) x 100mm (L)

Package contents

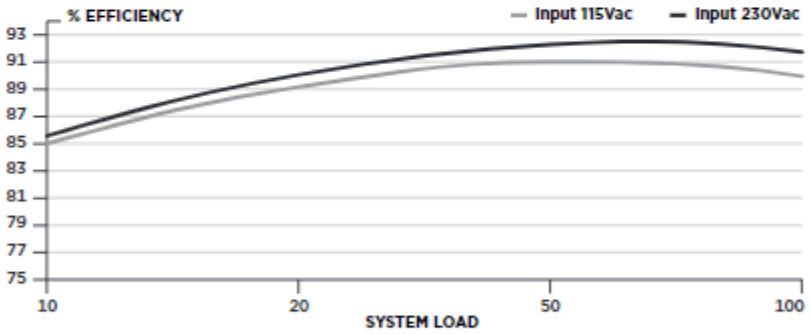
- Corsair SF Series power supply unit
- AC power cord
- DC Modular cable set
- DC Modular cable storage bag
- Cable ties
- Corsair case badge
- User manual

Corsair SF450 power table

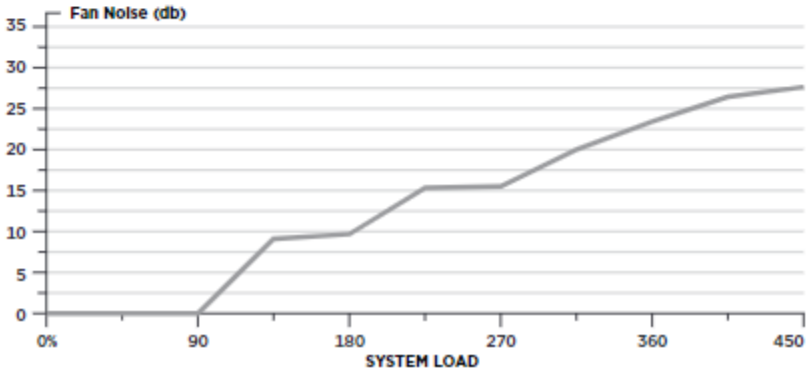
			Max Load	Max Output
Model	RPS0025	**+3.3V**	15A	100W
Part No.	CP-9020104 /75-011263	**+5V**	20A	
AC Input Rating	100-240V	**+12V**	37.5A	450W
Input Current	10A-5A	**-12V**	0.3A	3.6W
Frequency	47~63Hz	**+5Vsb**	2.5A	12.5W

Total Power: 450W

Corsair SF450 power supply efficiency



Corsair SF450 power supply fan noise curve



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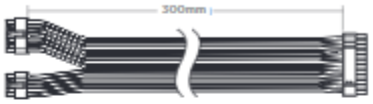
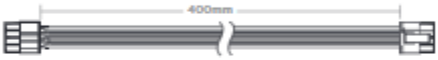
Corsair SF450 DC cable listing

Qty	Description		Total Length
1	SFX Cable 24 pin (20+4) 	Connectors Per Cable 1 Total Connectors 1	300mm (± 10mm)
1	EPS/SFX12V 8 pin (4+4) cable 	Connectors Per Cable 1 Total Connectors 1	400mm (± 10mm)
2	PCIe 8 pin (6+2) cable 	Connectors Per Cable 1 Total Connectors 2	400mm (± 10mm)
1	SATA cable (4 SATA) 	Connectors Per Cable 4 Total Connectors 4	445mm (± 10mm)
1	Peripheral cable (4-pin) 	Connectors Per Cable 4 Total Connectors 4	445mm (± 10mm)

SF SERIES™

Important safety information

CAUTION ELECTRIC SHOCK HAZARD!

1. Install in accordance with all manufacturer instructions and safety warnings. Failure to do so may result in damage to your power supply or system, and may cause serious injury or death.
2. High voltages are present in the power supply. Do not open the power supply case or attempt to repair the power supply; there are no user-serviceable components.
3. This product is designed for indoor use only.
4. Do not use the power supply near water, or in high temperature or high humidity environments.
5. Do not install near any heat sources such as radiators, heat registers, stoves, or other apparatus that produce heat.
6. Do not insert any objects into the open ventilation or fan grill area of the power supply.
7. Do not modify the cables and/or connectors included with this power supply.
8. If this power supply uses modular cables, use only manufacturer supplied cables. Other cables might not be compatible and could cause serious damage to your system and power supply.
9. The 24-pin main power connector has a detachable 4-pin connector. This 4-pin connector is not a P4 or SFX 12V connector. Do not force this cable in the P4 or SFX +12V socket on the motherboard.
10. Failure to comply with any manufacturer instructions and/or any of these safety instructions will immediately void all warranties and guarantees.

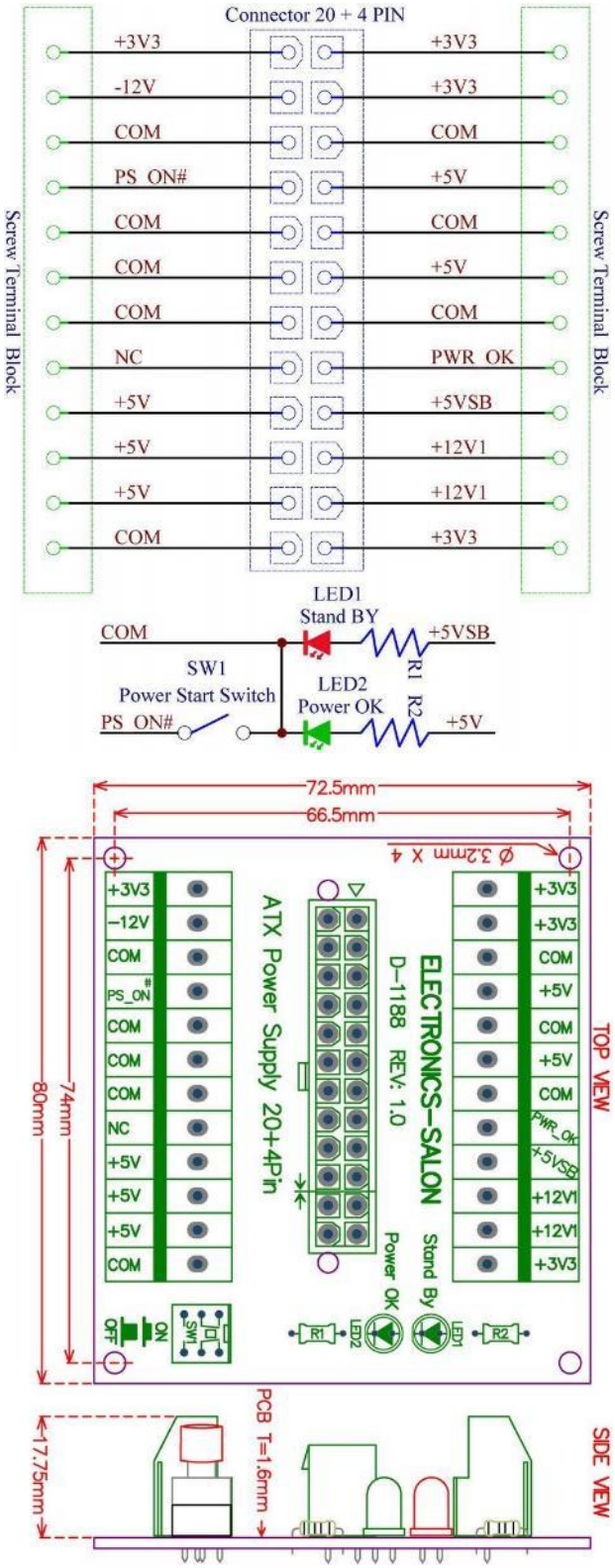
SF SERIES™

Safety and agency approvals

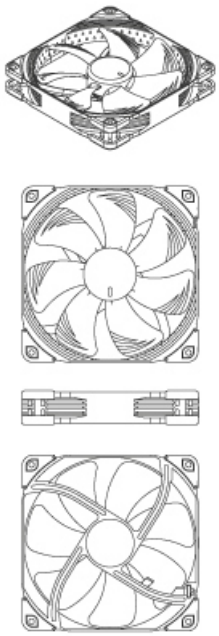
Agency	Standard
FCC	FCC Rules Part 15, Class B
ICES	ICES-003
CE	EN 55022:2010, Class B CISPR 22:2008,Class B AS/NZS CISPR 22:2009,Class B EN 61000-3-2:2014,Class D EN 61000-3-3:2013 EN55024:2010 IEC61000-4-2: 2008 ED.2.0 IEC61000-4-3: 2010 ED.3.2 IEC61000-4-4: 2012 ED.3.0 IEC61000-4-5: 2005 ED.2.0 IEC61000-4-6:2008 ED.3.0 IEC61000-4-8: 2009 ED.2.0 IEC61000-4-11: 2004 ED.2.0
UL+cUL(American)	UL 60950-1, 2nd Edition,CAN/CSA C22.2 No. 60950-1-07, 2nd Edition
RCM	EN 55022:2010, AS/NZS60950-1:2011
TUV	EN60950-1 A2/2013
CB	IEC 60950-1/A2:2013
CCC	GB4943.1-2011 GB9254-2008 GB17625.1-2012
BSMI	CNS14336 CNS13438
EAC	R IEC 60950-1-2011 R 61000-3-2-2006 R 61000-3-3-2011
ROHS	2011/65/EC, Restriction of Hazardous Substances Directive
WEEE	2002/96/EC, Waste Electrical and Electronic Equipment Directive
ROHS (China)	China Order No.39, Administration on the Control of Pollution Caused By Electronic Information Products
KC	K60950-1,K00022,K00024

Mission Box Version History

3. Power supply Breakout Board Schematic



4. Cooling Fan



FAN Specification	
Size	140x140x25 mm
Mounting hole spacing	124,5x124,5 mm
Connector & pin-configuration	4-pin PWM
Cable length	20cm + 30cm NA-EC1 extension cable
Bearing	SSO2
Blade geometry	A-Series with Flow Acceleration Channels
Frame technology	AAO (Advanced Acoustic Optimisation)
Rotational speed (+/- 10%)	1500 RPM
Rotational speed with L.N.A. (+/- 10%)	1200 RPM
Min. rotational speed (PWM, +/-20%)	300 RPM
Airflow	140,2 m³/h
Airflow with L.N.A.	115,5 m³/h
Acoustical noise	24,6 dB(A)
Acoustical noise with L.N.A.	19,2 dB(A)
Static pressure	2,08 mm H_2O
Static pressure with L.N.A.	1,51 mm H_2O
Max. input power	1,56 W
Max. input current	0,13 A
Operating voltage	12 V
MTTF	> 150.000 h
Scope of delivery	• Low-Noise Adaptor (L.N.A.) • 4-Pin Y-Cable • 30cm Extension Cable • 4 Vibration-Compensators • 4 Fan Screws
Warranty	6 years

5. Sierra MODEM

SIERRA WIRELESS

AirLink RV50 Datasheet

AirLink® RV50 Industrial LTE Gateway

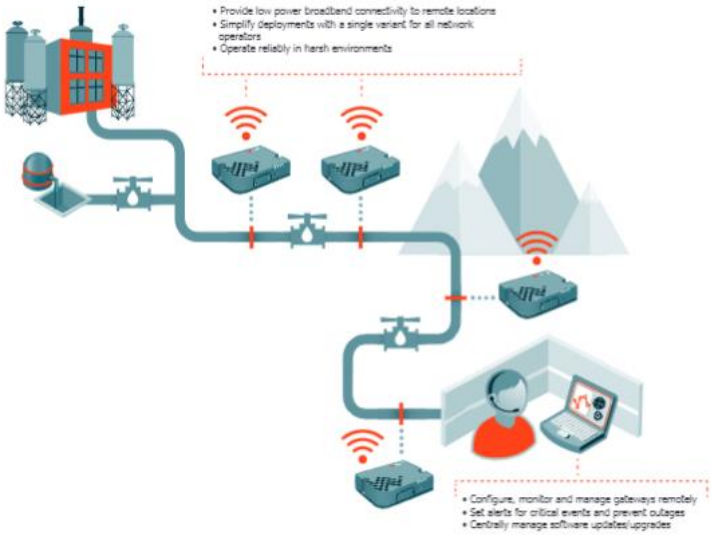
FEATURES

- LTE performance at 2G power consumption (less than 1W in idle mode)
- State-of-the-art LTE coverage spanning 21 LTE frequency bands worldwide
- Two product variants cover the globe
- Fully automatic network operator switching: just insert the SIM
- Provides network connectivity via Ethernet, Serial and USB
- Remote configuration, software update, and monitoring with cloud-based AirLink Management Service (ALMS) or on-premises with AirLink Mobility Manager (AMM)
- Dual-SIM functionality to enable automatic failover between SIMs (CANADA/EMEA/APAC)
- Meets industrial-grade certifications including Class 1 Div 2, MIL-STD-810G, IP64 ingress protection
- Supports up to 5 VPN tunnels for secure cellular communications
- Events Engine for alert reporting to third party server platforms
- Application Framework (AAF) offers real-time onboard data processing; RV50X's dual-core processor provides added performance for advanced edge computing applications.
- GPS for tracking equipment

Industrial Grade, LTE-Advanced Performance, Low Power

The AirLink RV50 is the industry's lowest power and most rugged LTE gateway. Simple to install and easy to manage, this industrial-grade gateway is designed to connect critical assets and infrastructure. Ideal for energy, utilities and smart-city applications, the RV50 provides real-time remote connectivity for SCADA, distribution management systems and metering.

With the lowest power consumption available on the market, the RV50 dramatically reduces infrastructure costs when running on battery or solar power. The RV50X variant supports an extensive range of LTE bands worldwide, and its LTE-Advanced capabilities deliver up to 300 Mbps downlink speeds. For deployments in areas with limited LTE coverage, the RV50 provides fallback to 2G and 3G networks. Furthermore, the RV50 provides programmability to enable edge computing applications, using the ALEOS Application Framework (AAF).



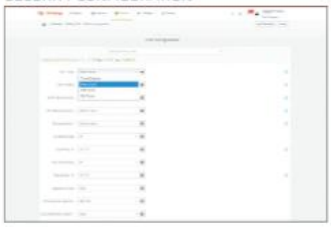
sierrawireless.com/routers-gateways

AirLink Raven RV50 Industrial LTE Gateway Datasheet

DASHBOARD

MONITOR CONNECTIVITY

SECURITY CONFIGURATION



SOFTWARE UPGRADES/UPDATES

RUGGED DESIGN FOR DEMANDING ENVIRONMENTS

The RV50 is designed to withstand harsh industrial conditions, and is capable of surviving 5 V brownouts and spikes from -600 VDC to 200 VDC.

Certified as Class I Div 2, it is ideal for hazardous environments. The die cast aluminum housing is sealed to meet IP64 for resistance to dust and water ingress.

The RV50 is tested to meet and exceed the MIL-STD-810G specification for shock, vibration, temperature and humidity. The built-in power supply protection make it suitable for harsh electrical environments such as compressors, generators, and excavators.

ULTRA-LOW POWER CONSUMPTION

The RV50 offers best-in-class power consumption combined with LTE performance, and is optimized for battery and solar applications. It is the industry's only LTE gateway with 2G power consumption, operating at 900 mW in idle mode. For 2G and 3G deployments migrating to LTE, the RV50 will work with existing power infrastructure, eliminating the need to invest in replacement solar panels or batteries. Standby Mode provides additional protection for batteries by dropping power consumption to 53 mW, and can be triggered by timers, low voltage detection or I/O.

SIMPLIFIED DEPLOYMENT

The RV50 automatically configures the radio based on the SIM, which provides versatility and simplicity when changing operator networks.

Ideal for global deployments, the RV50X provides worldwide LTE coverage with just two product variants; one for North America and EMEA, and one for Asia-Pacific.

BEST-IN-CLASS REMOTE MANAGEMENT

Network Management solutions for the RV50 allow over-the-air registration, configuration and software updates, and can be deployed either as a cloud-based service, or as a licensed software platform in the enterprise data center. Both options provide a centralized and remote view of an entire fleet and enable simplified management, control and monitoring of connected RV50s and critical infrastructure.

AirLink Management Service (ALMS) is a secure, centralized cloud-based service that remotely monitors and manages signal strength, network technology and location. ALMS provides dashboards with up-to-date views of an entire deployment, and custom alerts to monitor and report critical events, to increase efficiency and prevent downtime.

AirLink Mobility Manager (AMM) is a licensed, unified software platform which can

SIERRA WIRELESS

AirLink RV50 Industrial LTE Gateway Datasheet

BENEFITS

- Provides LTE broadband connectivity to remote locations and in harsh environments
- Ultra-low power consumption, ideal for solar or battery powered installations
- Maximizes longevity of deployed equipment and protects investments with LTE
- Improves ROI by supporting multiple network operators without additional hardware costs
- Powerful remote management solutions
- Built-in, class-leading voltage transient protection provides superior reliability and continuous operation
- Proven reliability and over 2 million AirLink routers and gateways deployed
- Industry leading warranty includes support, software updates and advance replacement

be deployed in the enterprise data center, and provides a consolidated network view of an entire fleet, using a virtual dashboard to monitor, report, manage, and troubleshoot all mobile resources as required.

INSTANT INTEGRATION

The RV50 is designed to install directly into existing infrastructure. Offering both serial and Ethernet connectivity, it can be used to connect devices like PLCs and RTUs, and transmit a wide variety of protocols like Modbus/DNP3 with ease. RV50 can also be integrated directly into existing management systems via SNMP.

INTELLIGENCE AT THE EDGE

The RV50 provides an application framework which allows customers to apply intelligence at the edge of the network. The RV50X offers a dual core processor which enhances the performance of edge applications.

SECURE INDUSTRIAL COMMUNICATIONS

The RV50 supports secure communications to multiple back-end systems by providing up to five concurrent VPN sessions. Remote authentication management allows enterprise-grade systems to manage access to devices in the field. Port filtering and trusted IP protect the devices connected to RV50s from unwanted access. Secure signing and authentication of software images offers end-to-end protection of the software upgrade process, protecting the RV50 against unwanted malware.

	RV50		RV50X	
	North America	International	North America & EMEA	Asia Pacific
LTE CATEGORY	Cat 3		Cat 6	
Peak D/L	(Up to 100 Mbps DL)		(Up to 300 Mbps DL)	
Peak U/L	(Up to 50 Mbps UL)		(Up to 50 Mbps UL)	
4G LTE Frequency Bands*	1900(B2), AWS(B4), 850(B5), 700(B13), 700(B17), 1900(B25)	2100(B1), 1800(B3), 2600(B7), 900(B8), 800(B20)	2100(B1), 1900(B2), 1800(B3), AWS(B4), 850(B5), 2600(B7), 900(B8), 700(B12), 700(B13), 800(B20), 1900(B25), 850(B26), 700(B29), TDD B41	2100(B1), 1800(B3), 850(B5), 2600(B7), 900(B8), 850(B18), 850(B19), 1500(B21), 700(B28), TDD 38, TDD 39, TDD 40, TDD 41
3G HSPA/HSPA+ Frequency Bands*	2100(B1), 1900(B2), AWS(B4), 850(B5), 900(B8)	2100(B1), 1900(B2), 850(B5), 900(B8)	2100(B1), 1900(B2), 1800(B3), AWS(B4), 850(B5), 900(B8)	2100(B1), 850(B5), 800(B6), 900(B8), 1700(B9), 850(B19),
3G TD-SCDMA Frequency Bands*				B39
2G CDMA 1XRTT/EV-DO REV 1 Frequency Bands*	2100(B1), 1900(B2), AWS(B4), 850(B5), 900(B8)			
2G EDGE/GSM/GPRS Frequency Bands*	Quad-band	Quad-band		
APPROVALS Regulary	FCC, IC, PTCRB	CE, RCM, GCF, R&TTE	FCC, IC, PTCRB, R&TTE, GCF, CE	RCM, JRF/JPA
Carrier	Verizon, AT&T, Sprint, T-Mobile USA, US Cellular, Rogers, Bell, Telus		Verizon, AT&T, T-Mobile USA Other Major carriers pending	Telstra

*For carrier specific band support please refer to the hardware user guide.

SIERRA WIRELESS

Sierra Wireless
AIRLINK RV50

	Specification
HOST INTERFACES	10/100/1000 Ethernet (RJ45)
	RS-232 serial port (DB-9)
	USB 2.0 Micro-B Connector
	3 SMA antenna connectors (primary, diversity, GPS)
	Active GPS antenna support
INPUT/OUTPUT	Configurable I/O pin on power connector • Digital Input ON Voltage: 2.7 to 36 VDC • Configurable Pull-up for dry contact input • Digital Open Collector Output > sinking 500 mA • Analog Input: 0.5-36 VDC
LAN (ETHERNET/USB)	DNS, DNS Proxy
	DHCP Server
	IP Passthrough
	VLAN
	Host Interface Watchdog
	PPPoE
SERIAL	TCP/UDP PAD Mode
	Modbus (ASCII, RTU, Variable)
	PPP
	DNP3 Interoperability
NETWORK AND ROUTING	Network Address Translation (NAT)
	Port Forwarding
	Host Port Routing
	NEMO/DMNR
	VRRP
	Reliable Static Route
	Dynamic DNS
VPN	IPsec, GRE, and OpenVPN Client
	Up to 5 concurrent tunnels
	Split Tunnel
	Dead Peer Detection (DPD)
	Multiple Subnets
EVENTS ENGINE	Custom event triggers and reports
	Configurable interface, no programming
	Event Types: Digital Input, Network Parameters, Data Usage, Timer, Power, Device Temperature and Voltage
	Report Types: RAP, SMS, Email, SNMP Trap, TCP (Binary, XML, CSV)
	Event Actions: Drive Relay Output
DIMENSIONS	119 mm x 34 mm x 85 mm (94 mm including connectors)
	4.69 in x 1.34 in x 3.35 in (3.70 in including connectors)
SECURITY	Remote Authentication (LDAP, RADIUS, TACACS+)
	DMZ
	Inbound and Outbound Port filtering
	Inbound and Outbound Trusted IP
	MAC Address Filtering
	PCI compatible
APPLICATION FRAMEWORK	ALEOS Application Framework (AAF)
	LUA Scripting Language
	Eclipse-based IDE
	Integrated with AirVantage®
	Dual-Core Processing (RV50X)

	Specification
SATELLITE NAVIGATION (GNSS)	12 Channel GPS and GLONASS Receiver
	Acquisition Time: 1 s Hot Start
	Accuracy: <2 m (50%), <5 m (90%)
	Tracking Sensitivity: -145 dBm
	Reports: NMEA 0183 V3.0, TAIP, RAP, XORA
	Multiple Redundant Servers
	Reliable Store and Forward
NETWORK MANAGEMENT	Secure network management applications available in the cloud or licensed platform in the enterprise data center
	Fleet wide firmware upgrade delivery
	Router configuration and template management
	Router staging over the air and local Ethernet connection
	Over-the-air software and radio module firmware updates
	Device Configuration Templates
	Configurable monitoring and alerting
	Remote provisioning and airtime activation (where applicable)
GATEWAY MANAGEMENT INTERFACES	ALMS
	Local web user interface
	AT Command Line Interface (Telnet/SSH/Serial)
	SMS Commands
	SNMP
MANAGEMENT SYSTEM ACCESS/SECURITY	Remote authentication (LDAP, RADIUS and TACACS+)
POWER	Input Voltage: 7 to 36 VDC
	LTE Idle Power: 900mW (75 mA @ 12VDC)
	Standby Mode Power: 53 mW (4.4 mA @ 12 VDC) triggered on low voltage, I/O or periodic timer
	Low voltage disconnect to prevent battery drain
	Built-in protection against voltage transients including 5 VDC engine cranking and +200 VDC load dump
	Ignition Sense with time delay shutdown
	Configurable features and ports to optimize power consumption
ENVIRONMENTAL	Operating Temperature: -40°C to +70°C / -40°F to +158°F
	Storage Temperature: -40°C to +85°C / -40°F to +185°F
	Humidity: 90% RH @ 60°C
	Military Spec MIL-STD-810G conformance to shock, vibration, thermal shock, and humidity
	IP64 rated ingress protection
INDUSTRY CERTIFICATIONS	Safety: IECEE Certification Bodies Scheme (CB Scheme), UL 60950
	Vehicle Usage: E-Mark (UN ECE Regulation 10.04), ISO7637-2, SAE J1455 (Shock & Vibration)
	Hazardous Environments: Class 1 Div 2
	Environmental: RoHS, REACH, WEEE
SUPPORT AND WARRANTY	Includes 1st Year AirLink Complete: • AirLink Management Service (ALMS) • Direct 24/7 Technical Support • 3-year standard warranty; optional 2-year warranty extension 1-day Accelerated Hardware Replacement available through participating resellers

About Sierra Wireless

Sierra Wireless (NASDAQ: SWIR) (TSX: SW) is an IoT pioneer, empowering businesses and industries to transform and thrive in the connected economy. Customers Start with Sierra because we offer a device-to-cloud solution, comprised of embedded and networking solutions seamlessly integrated with our IoT services. OEMs and enterprises worldwide rely on our expertise in delivering fully integrated solutions to reduce complexity, turn data into intelligence and get their connected products and services to market faster. Sierra Wireless has more than 1,400 employees globally and operates R&D centers in North America, Europe and Asia.

For more information, visit www.sierrawireless.com.

SIERRA WIRELESS

6. Edge Router X

EdgeRouter™ X | DATASHEET

EdgeMAX®

Overview

Ubiquiti Networks introduces the EdgeRouter™ X, part of the EdgeMAX® platform. The EdgeRouter X combines carrier-class reliability with excellent price-to-performance value in an ultra-compact form factor.

PoE Versatility

Two models of the EdgeRouter X are available. The standard model, the ER-X, can be powered by an external power adapter or 24V passive PoE input. A passive PoE passthrough option[1] is available to support a single airMAX® device[2].

The SFP model, the ER-X-SFP, is powered by an external power adapter. The five Gigabit RJ45 ports support 24V passive PoE output for airMAX or UniFi® devices, while its SFP port provides fiber connectivity to support backhaul applications.

Configuration Methods

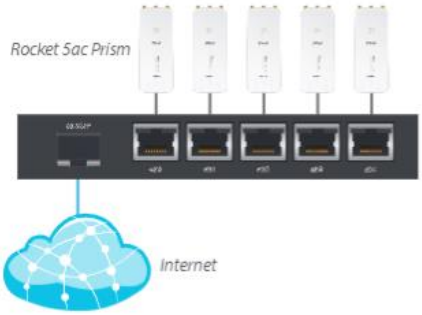
Powered by a proprietary and intuitive graphical interface, EdgeOS®, every EdgeRouter X can easily be configured for the routing, security, and management features required to efficiently run your network. For advanced network professionals, an integrated CLI is available for quick and direct access using familiar commands.

[1] Requires 24V passive PoE or a 12W minimum power adapter (not included).

[2] Check your airMAX device's specifications for voltage and wattage requirements.

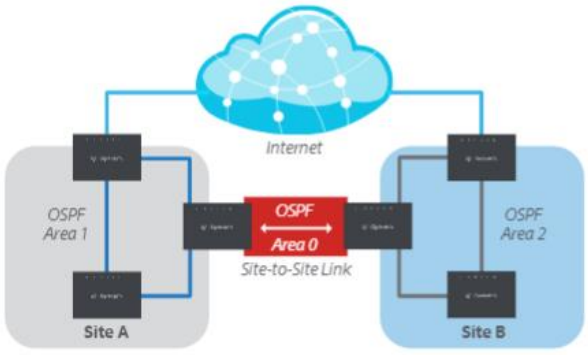
Example of a CPE Deployment for the ER-X

Powered by 24V passive PoE, the ER-X provides data with 24V passive PoE to the NanoBeam® ac and data to the UniFi Video Camera G3 Dome, UniFi AP AC LR, and computer.



Example of a Backhaul Deployment for the ER-X-SFP

Powered by the included 24V power adapter, the ER-X-SFP has a fiber connection to the Internet and provides data with 24V passive PoE to the five Rocket® 5ac Prism radios.



Example of a Service Provider Deployment for the ER-X

Multiple ER-X devices connect the Internet and three OSPF areas of the service provider's network.

2

Intuitive User Interface

The EdgeRouter X provides a graphical user interface designed for convenient setup and control.

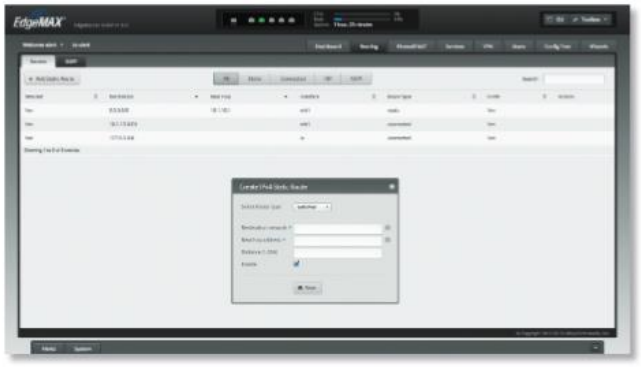
Accessed via a network port and web browser, the user-friendly interface provides intuitive management with a virtual view of the ports, displaying physical connectivity, speed, and status.

The Dashboard displays detailed statistics: IP information, MTU, transmit and receive speeds, and status for each physical and virtual interface.

Powerful Features

EdgeOS is a sophisticated operating system with robust features, including:

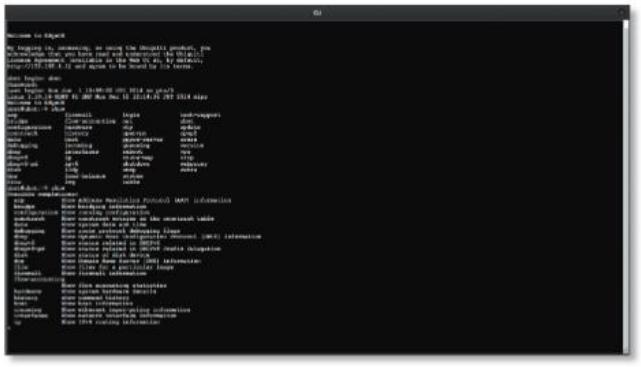
- VLAN interfaces for network segmentation
- Static routes and support of routing protocols: OSPF, RIP, and BGP
- Firewall policies and NAT rules
- DHCP services
- Quality of Service (QoS)
- Network administration and monitoring tools
- Administrator and operator accounts
- Comprehensive IPv6 support



Configuration by CLI

The CLI provides quick and flexible configuration by command line and features the following:

- For power users, configuration and monitoring of all advanced features
- Direct access to standard Linux tools and shell commands
- CLI access through SSH, Telnet, and the graphical user interface



EdgeRouter X | DATASHEET

3

EdgeRouter X | DATASHEET

Models

EdgeRouter X

Model: ER-X

- (5) Gigabit RJ45 ports
- Passive PoE passthrough option*
- Power via 24V passive PoE or power adapter
- Ports configurable for line-rate, Layer-2 switching
- 260 kpps for 64-byte packets
- 1 Gbps for 1518-byte packets

Front Panel

Back Panel

EdgeRouter X SFP

Model: ER-X-SFP

- (5) Gigabit RJ45 ports with passive PoE support
- (1) Gigabit SFP port for backhaul applications
- Ports configurable for line-rate, Layer-2 switching
- 260 kpps for 64-byte packets
- 1 Gbps for 1518-byte packets

Front Panel

Back Panel

* Requires 24V passive PoE or a 12W minimum power adapter (not included).

4

EdgeRouter X

Hardware Specifications

ER-X	
Dimensions	110 x 75 x 22 mm (4.33 x 2.95 x 0.87")
Weight	175 g (6.17 oz)
Max. Power Consumption	5W
Power Input	12VDC, 0.5A Power Adapter (Included) or 24V Passive PoE
Power Supply	External AC/DC Adapter
Supported Voltage Range	9 to 26VDC
Button	Reset
LED	Power, Ethernet 0-4
Processor	Dual-Core 880 MHz, MIPS1004Kc
System Memory	256 MB DDR3 RAM
Code Storage	256 MB NAND
Certifications	CE, FCC, IC
Wall-Mount	Yes
ESD/EMP Protection	Air: ± 24 kV, Contact: ± 24 kV
Operating Temperature	-10 to 45° C (14 to 113° F)
Operating Humidity	10 to 90% Noncondensing

Networking Interfaces	
Data/PoE Input Port	(1) 10/100/1000 RJ45 Port
Data Ports	(3) 10/100/1000 RJ45 Ports
Data/PoE Passthrough Port	(1) 10/100/1000 RJ45 Port

DATASHEET | EdgeRouter X

5

EdgeOS

Software Specifications

EdgeOS	
Interface/Encapsulation	Ethernet 802.1q VLAN PPPoE GRE IP in IP Bridging Bonding (802.3ad)
Addressing	Static IPv4/IPv6 Addressing DHCP/DHCPv6
Routing	Static Routes OSPF/OSPFv3 RIP/RIPng BGP (with IPv6 Support) IGMP Proxy
Security	ACL-Based Firewall Zone-Based Firewall NAT
VPN	IPSec Site-to-Site and Remote Access OpenVPN Site-to-Site and Remote Access PPTP Remote Access L2TP Remote Access PPTP Client
Services	DHCP/DHCPv6 Server DHCP/DHCPv6 Relay Dynamic DNS DNS Forwarding VRRP RADIUS Client Web Caching PPPoE Server
QoS	FIFO Stochastic Fairness Queueing Random Early Detection Token Bucket Filter Deficit Round Robin Hierarchical Token Bucket Ingress Policing
Management	Web UI CLI (SSH, Telnet) SNMP NetFlow LLDP NTP UBNT Discovery Protocol Logging

www.ubnt.com

EdgeRouter X | DATASHEET

NBULOT2817

7

7. Ubiquiti Access Point

DATASHEET

UniFi AC MESH

UniFi®

Scalable Enterprise Wi-Fi Management

UniFi® is the revolutionary Wi-Fi system that combines enterprise performance, unlimited scalability, and a central management controller. The UniFi AC Mesh APs have a refined industrial design and can be easily installed using the included mounting hardware.

Easily accessible through any standard web browser and the UniFi mobile app (iOS or Android), the UniFi Controller software is a powerful software engine ideal for high-density client deployments requiring low latency and high uptime performance.

Use the UniFi Controller software to quickly configure and administer an enterprise Wi-Fi network – no special training required. RF map and performance features, real-time status, automatic UAP device detection, and advanced security options are all seamlessly integrated.

Features

Save Money and Save Time UniFi comes bundled with a non-dedicated software controller that can be deployed on an on-site PC, Mac, or Linux machine; in a private cloud; or using a public cloud service. You also have the option of using the UniFi Cloud Key with built-in software.

Powerful Hardware The UniFi AC Mesh APs feature Wi-Fi 802.11AC with Plug & Play Mesh technology.

Intuitive UniFi Controller Software Configure and manage your APs with the easy-to-learn user interface.

Expandable Unlimited scalability: build wireless networks as big or small as needed. Start with one and expand to thousands while maintaining a single unified management system.

Extend Your Coverage

With the UniFi Controller software running in a NOC or in the cloud, administrators can manage multiple sites: multiple distributed deployments and multi-tenancy for managed service providers. Below are some deployment examples.

2

UniFi Controller

Packed with Features

Use the UniFi Controller to provision thousands of UniFi APs, map out networks, quickly manage system traffic, and provision additional UniFi APs.

Breakthrough RF Map

Use the RF map to monitor and analyze radio frequencies for optimal AP placement, configuration, and troubleshooting.

Powerful RF Performance Features

Advanced RF performance and configuration features include spectral analysis, airtime fairness, and band steering.

Detailed Analytics

Use the configurable reporting and analytics to manage large user populations and expedite troubleshooting.

Wireless Uplink

Wireless Uplink functionality enables wireless connectivity between APs for extended range. One wired UniFi AP uplink supports up to four wireless downlinks on a single operating band, allowing wireless adoption of devices in their default state and real-time changes to network topology.

For devices that support Plug & Play Mesh, this functionality is extended to allow multi-hop wireless uplink – so wirelessly uplinked APs can support uplink to other wirelessly uplinked APs.

Guest Portal/Hotspot Support

Easy customization options for Guest Portals include authentication, Hotspot setup, and the ability to use your own external portal server. Use UniFi's rate limiting for your Guest Portal/Hotspot package offerings. Apply different bandwidth rates (download/upload), limit total data usage, and limit duration of use.

All UniFi APs include Hotspot functionality:

- Built-in support for billing integration using major credit cards.
- Built-in support for voucher-based authentication.
- Built-in Hotspot Manager for voucher creation, guest management, and payment refunds.
- Full customization and branding of Hotspot portal pages.

Multi-Site Management

A single cloud-based UniFi Controller can manage multiple sites: multiple, distributed deployments and multi-tenancy for managed service providers. Each site is logically separated and has its own configuration, maps, statistics, guest portal, and admin read/write and read-only accounts.

WLAN Groups

Manage flexible configurations of large deployments. Create multiple WLAN groups and assign them to an AP's radio.

Dashboard

UniFi provides a visual representation of your network's status and delivers basic information about each network segment.

RF Map

Monitor UniFi APs and analyze the surrounding RF environment.

Statistics

UniFi visualizes network traffic in clear and easy-to-read graphs.

UniFi Mobile App

Manage your UniFi devices from your smartphone or tablet.

DATASHEET

UniFi AC MESH

3

DATASHEET

UniFi AC MESH

Model Comparison

	UAP-AC-M	UAP-AC-M-PRO
Environment	Indoor/Outdoor	Outdoor
Simultaneous Dual-Band	✓	✓
2.4 GHz Radio Rate	300 Mbps	450 Mbps
2.4 GHz MIMO	2x2	3 x 3
5 GHz Radio Rate	867 Mbps	1300 Mbps
5 GHz MIMO	2x2	3 x 3
Secondary Ethernet Port		✓
PoE Mode	24V Passive PoE 802.3af PoE: Alternative A	802.3af PoE
Wall Mount	✓	✓
Pole Mount	✓	✓
Fast Mount	✓	

Use Cases

Mesh Multi-Hop A large outdoor area, such as a park with minimal infrastructure, can take advantage of a mesh network comprised of the UniFi AC Mesh models.

Omnidirectional Coverage, Indoors or Outdoors The UAP-AC-M includes adjustable dual-band omni antennas.

You have the option to use a 5 GHz omni antenna[1] for spot-beam coverage in high-density locations with numerous APs and clients, like a conference hall or event center.

Directional Coverage, Outdoors The UAP-AC-M is versatile.

You have the option to use a 5 GHz sector antenna[2] (wide beam in the azimuth plane and narrow in the elevation plane) for broad outdoor coverage.

Maximum Coverage, Outdoors The UAP-AC-M-PRO is ideal for applications requiring 3x3 MIMO data rates for close-in omni coverage.

Temporary Installations Deploy the UniFi AC Mesh models for outdoor installations requiring quick setup and takedown, such as a street fair, music festival, or concert venue.

[1] Different antenna gains are allowed for each regulatory domain or country. It is the installer's responsibility to check local regulations.

Application Example

Both UniFi AC Mesh models provide wireless coverage for a street fair in a city plaza.

4

DATASHEET

UniFi AC MESH

Hardware Overview

Model: UAP-AC-M

The UAP-AC-M provides simultaneous, dual-band, 2x2 MIMO technology and is available in single- and five-packs[1].

Compact Form Factor The UAP-AC-M discreetly integrates into any environment.

Weather-Resistant Enclosure The UAP-AC-M can be used indoors or outdoors.

Versatile Mounting The UAP-AC-M can be mounted on a wall, pole, or fast-mount of an optional Ubiquiti® high-gain antenna[2]. (All accessories are included.)

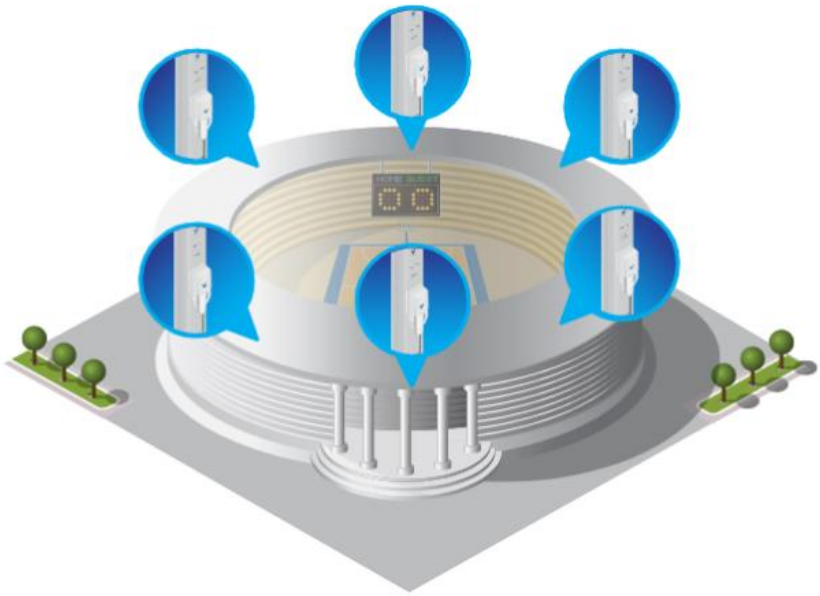
Multiple Power Options The UAP-AC-M is compatible with 802.3af PoE Alternative A and 24V passive PoE. You can power it with the included Gigabit PoE adapter[1] or an 802.3af Alternative A compatible switch, such as the UniFi PoE Switch or EdgePoint™ EP-R6.

Antenna Options Use the included omni antennas, or use the included fast-mount adapter to install the AP on an optional connectorized antenna[2] for expanded range coverage and customized pattern shaping.

[1] Five-packs do not ship with PoE adapters; we recommend powering the UniFi APs with the UniFi PoE Switch instead.

[2] Different antenna gains are allowed for each regulatory domain or country. It is the installer's responsibility to check local regulations.

Application Example



The UAP-AC-M utilizes the same antenna connector technology as airMAX® antennas.[2]

5

UAP-AC-M Specifications

UAP-AC-M	
Dimensions	353 x 46 x 34.4 mm (13.9 x 1.81 x 1.35")
Weight	152 g (5.36 oz) with Antennas
Networking Interface	(1) 10/100/1000 Ethernet Port
Buttons	Reset
Power Method	24V Passive PoE (Pairs 4, 5+; 7, 8 Return); 802.3af Alternative A (Pairs 1, 2+; 3, 6 Return) (Supported Voltage Range: 44 to 57VDC)
Power Supply	24V, 0.5A Gigabit PoE Adapter*
Power Save	Supported
Maximum Power Consumption	8.5W
Maximum TX Power 2.4 GHz 5 GHz	 20 dBm 20 dBm
Antennas 2.4 GHz 5 GHz	(2) External Dual-Band Omni Antennas 3 dBi 4 dBi
Wi-Fi Standards	802.11 a/b/g/n/r/k/v/ac
Wireless Security	WEP, WPA-PSK, WPA-Enterprise (WPA/WPA2, TKIP/AES)
BSSID	Up to 8 per Radio
Mounting	Wall/Pole/Fast-Mount (Kits Included)
Operating Temperature	-30 to 70° C (-22 to 158° F)
Operating Humidity	5 to 95% Noncondensing
Certifications	CE, FCC, IC

* Only the single-pack of the UAP-AC-M includes a PoE adapter.

Advanced Traffic Management	
VLAN	802.1Q
Advanced QoS	Per-User Rate Limiting
Guest Traffic Isolation	Supported
WMM	Voice, Video, Best Effort, and Background
Concurrent Clients	250+

Supported Data Rates (Mbps)	
Standard	Data Rates
802.11ac	6.5 Mbps to 867 Mbps (MCS0 - MCS9 NSS1/2, VHT 20/40/80)
802.11n	6.5 Mbps to 300 Mbps (MCS0 - MCS15, HT 20/40)
802.11a	6, 9, 12, 18, 24, 36, 48, 54 Mbps
802.11g	6, 9, 12, 18, 24, 36, 48, 54 Mbps
802.11b	1, 2, 5.5, 11 Mbps

DATASHEET | UniFi AC MESH

7

UniFi Switch Compatibility

The UniFi switches are compatible with UniFi Access Points and UniFi G3 Video Cameras, as detailed below.

AP/Camera Model	US-8	US-8-60W	US-8-150W	US-16-150W	US-24-250W	US-24-500W	US-48-500W	US-48-750W
UVC-G3			✓	✓	✓	✓	✓	✓
UVC-G3-AF	✓	✓	✓	✓	✓	✓	✓	✓
UVC-G3-DOME	✓	✓	✓	✓	✓	✓	✓	✓
UAP			✓	✓	✓	✓	✓	✓
UAP-LR			✓	✓	✓	✓	✓	✓
UAP-PRO	✓	✓	✓	✓	✓	✓	✓	✓
UAP-AC-LITE	✓	✓	✓	✓	✓	✓	✓	✓
UAP-AC-LR	✓	✓	✓	✓	✓	✓	✓	✓
UAP-AC-PRO	✓	✓	✓	✓	✓	✓	✓	✓
UAP-AC-M	✓	✓	✓	✓	✓	✓	✓	✓
UAP-AC-M-PRO	✓	✓	✓	✓	✓	✓	✓	✓
UAP-AC-IW*	✓	✓	✓	✓	✓	✓	✓	✓
UAP-AC-IW-PRO*	✓	✓	✓	✓	✓	✓	✓	✓
UAP-AC-HD	–	–	✓	✓	✓	✓	✓	✓

✓ Compatible with the UniFi switch

Requires an Instant 802.3af Gigabit PoE Converter: INS-3AF-I-G or INS-3AF-O-G

Note:

* For the UAP-AC-IW and UAP-AC-IW-PRO, PoE passthrough is supported by all of the switches listed above except for models US-8 and US-8-60W.

Related Product Datasheets

UniFi Switch 8, UniFi Switch 8-60W:

dl.ubnt.com/datasheets/unifi/UniFi_Switch_8_DS.pdf

UniFi PoE Switches:

dl.ubnt.com/datasheets/unifi/UniFi_PoE_Switch.pdf

www.ubnt.com

DATASHEET | UniFi AC MESH

AUL01719

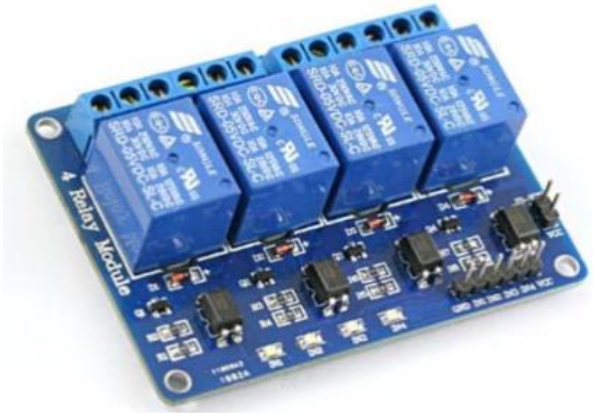
8. 4 Relay Module User Guide

Handson Technology

User Guide

4 Channel 5V Optical Isolated Relay Module

This is a LOW Level 5V 4-channel relay interface board, and each channel needs a 15-20mA driver current. It can be used to control various appliances and equipment with large current. It is equipped with high-current relays that work under AC250V 10A or DC30V 10A. It has a standard interface that can be controlled directly by microcontroller. This module is optically isolated from high voltage side for safety requirement and also prevent ground loop when interface to microcontroller.



Brief Data:

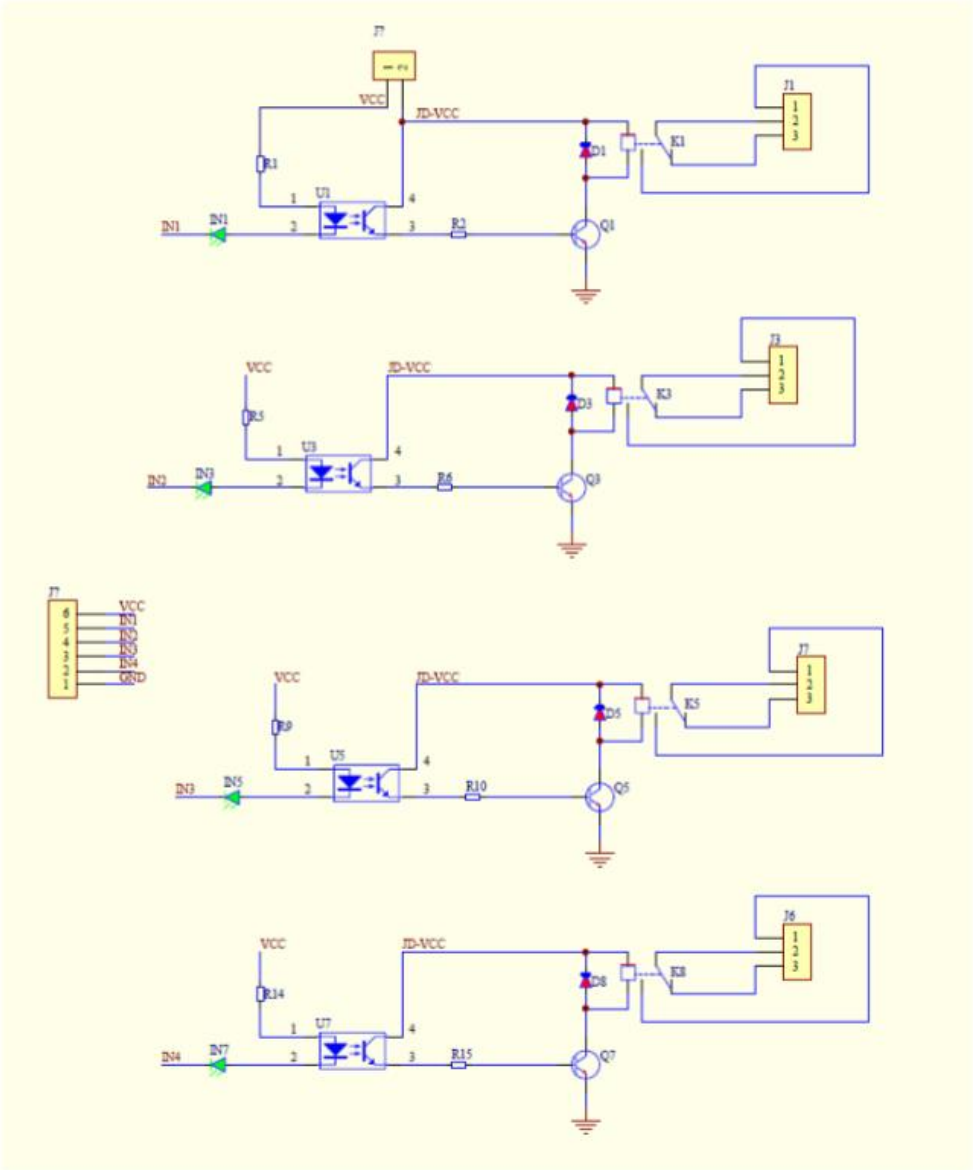
- Relay Maximum output: DC 30V/10A, AC 250V/10A.
- 4 Channel Relay Module with Opto-coupler. LOW Level Trigger expansion board, which is compatible with Arduino control board.
- Standard interface that can be controlled directly by microcontroller (8051, AVR, *PIC, DSP, ARM, ARM, MSP430, TTL logic).
- Relay of high quality low noise relays SPDT. A common terminal, a normally open, one normally closed terminal.
- Opto-Coupler isolation, for high voltage safety and prevent ground loop with microcontroller.

Schematic:

VCC and RY-VCC are also the power supply of the relay module. When you need to drive a large power load, you can take the jumper cap off and connect an extra power to RY-VCC to supply the relay; connect VCC to 5V of the MCU board to supply input signals.

NOTES: If you want complete optical isolation, connect "Vcc" to Arduino +5 volts but do NOT connect Arduino Ground. Remove the Vcc to JD-Vcc jumper. Connect a separate +5 supply to "JD-Vcc" and board Gnd. This will supply power to the transistor drivers and relay coils.

If relay isolation is enough for your application, connect Arduino +5 and Gnd, and leave Vcc to JD-Vcc jumper in place.



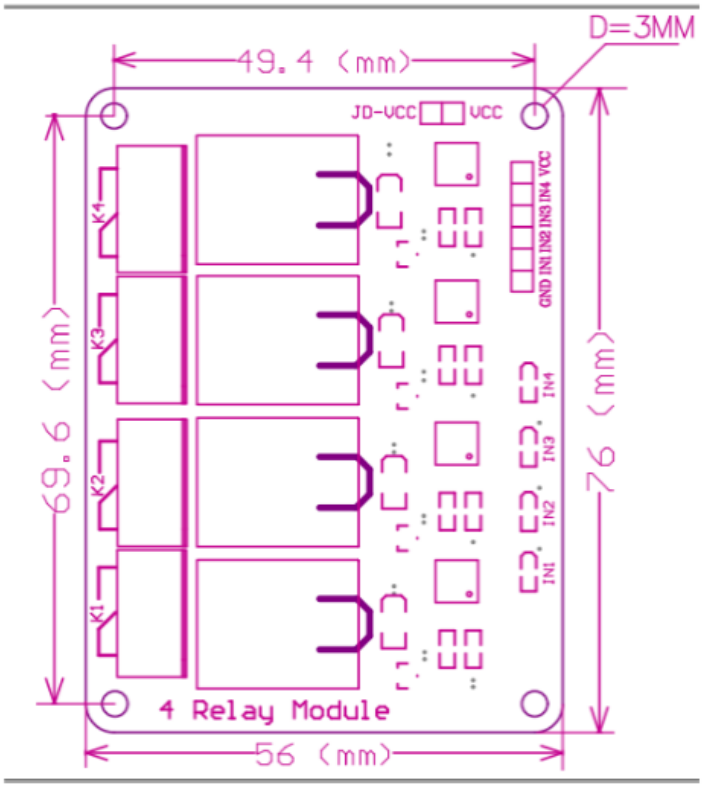
4 Channel Relay Module Schematic

It is sometimes possible to use this relay boards with 3.3V signals, if the JD-VCC (Relay Power) is provided from a +5V supply and the VCC to JD-VCC jumper is removed. That 5V relay supply could be totally isolated from the 3.3V device, or have a common ground if opto-isolation is not needed. If used with isolated 3.3V signals, VCC (To the input of the opto-isolator, next to the IN pins) should be connected to the 3.3V device's +3.3V supply.

NOTE: Some Raspberry-Pi users have found that some relays are reliable and others do not actuate sometimes. It may be necessary to change the value of R1 from 1000 ohms to something like 220 ohms, or supply +5V to the VCC connection.

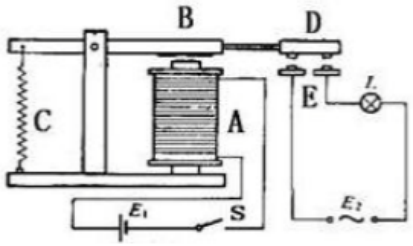
NOTE: The digital inputs from Arduino are Active LOW: The relay actuates and LED lights when the input pin is LOW, and turns off on HIGH.

Module Layout:



Operating Principle:

See the picture below: A is an electromagnet, B armature, C spring, D moving contact, and E fixed contacts. There are two fixed contacts, a normally closed one and a normally open one. When the coil is not energized, the normally open contact is the one that is off, while the normally closed one is the other that is on.



Supply voltage to the coil and some currents will pass through the coil thus generating the electromagnetic effect. So the armature overcomes the tension of the spring and is attracted to the core, thus closing the moving contact of the armature and the normally open (NO) contact or you may say releasing the former and the normally closed (NC) contact. After the coil is de-energized, the electromagnetic force disappears and the armature moves back to the original position, releasing the moving contact and normally closed contact. The closing and releasing of the contacts results in power on and off of the circuit.

Input:

VCC : Connected to positive supply voltage (supply power according to relay voltage)

GND : Connected to supply ground.

IN1: Signal triggering terminal 1 of relay module

IN2: Signal triggering terminal 2 of relay module

IN3: Signal triggering terminal 3 of relay module

IN4: Signal triggering terminal 4 of relay module

Output:

Each module of the relay has one NC (normally close), one NO (normally open) and one COM (Common) terminal. So there are 4 NC, 4 NO and 4 COM of the channel relay in total. NC stands for the normal close port contact and the state without power. NO stands for the normal open port contact and the state with power. COM means the common port. You can choose NC port or NO port according to whether power or not.

Testing Setup:

When a low level is supplied to signal terminal of the 4-channel relay, the LED at the output terminal will light up. Otherwise, it will turn off. If a periodic high and low level is supplied to the signal terminal, you can see the LED will cycle between on and off.

For Arduino：

Step 1：

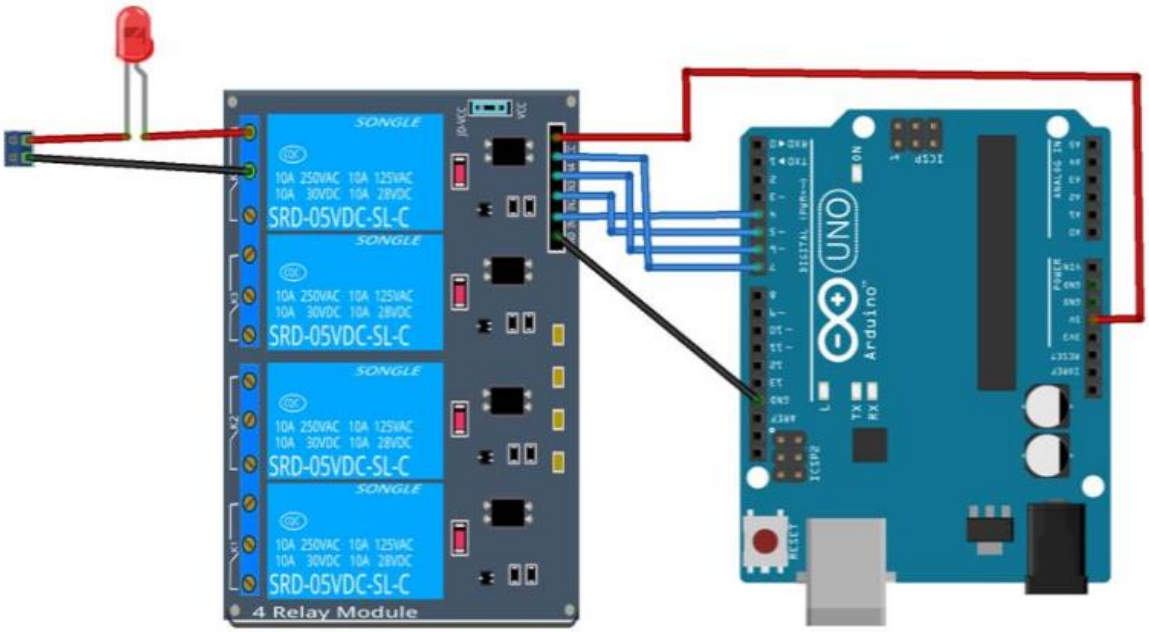
Connect the signal terminal IN1、IN2, IN3 & IN4 of 4-channel relay to digital pin 4, 5, 6, 7 of the Arduino Uno or ATMega2560 board, and connect an LED at the output terminal.

IN1> 4; IN2> 5; IN3>6; IN4>7

Step 2:

Upload the sketch "4 Channel Relay Demo " to the Arduino Uno or ATMega2560 board. Then you can see the LED cycle between on and off.

The actual figure is shown below:



Arduino Sketch: 4 Channel Relay Demo

```
/*****************************************************
   Name: 4 channel_relay
   Description: control the 4 channel relay module to ON or OFF
   Website: www.handsontec.com
   Email: techsupport@handsontec.com
******************************************************/

//the relays connect to

int RelayControl1 = 4;     // Digital Arduino Pin used to control the motor
int RelayControl2 = 5;
int RelayControl3 = 6;
int RelayControl4 = 7;


void setup()
{
  Serial.begin(9600);
  pinMode(RelayControl1, OUTPUT);
  pinMode(RelayControl2, OUTPUT);
  pinMode(RelayControl3, OUTPUT);
  pinMode(RelayControl4, OUTPUT);
}


void loop()
{

  digitalWrite(RelayControl1,HIGH);// NO1 and COM1 Connected (LED on)
  delay(1000);
```

```
  digitalWrite(RelayControl1,LOW);// NO1 and COM1 disconnected (LED off)
  delay(1000);
  digitalWrite(RelayControl2,HIGH);
  delay(1000);
  digitalWrite(RelayControl2,LOW);
  delay(1000);
  digitalWrite(RelayControl3,HIGH);
  delay(1000);
  digitalWrite(RelayControl3,LOW);
  delay(1000);
  digitalWrite(RelayControl4,HIGH);
  delay(1000);
  digitalWrite(RelayControl4,LOW);
  delay(1000);
}
```

9. Touchscreen Monitor User Manual

7inch HDMI LCD (B)

User Manual

CONTENT

7inch HDMI LCD (B)

OVERVIRE

7inch HDMI LCD (B) has 800x480 resolution, capacitive touch control, HDMI display supports various systems.

FEATURES

- 800×480 high resolution
- Capacitive touch control
- Supports popular mini-PCs like Raspberry Pi, BB Black, etc.
- When working with Raspberry Pi, supports Raspbian, Ubuntu, WIN10 IoT, single touch, and driver free
- When working with other mini-PCs, driver is required and should be developed by users
- Not only for mini-PCs, it can work as a computer monitor just like any other general HDMI screen
- When works as a computer monitor, supports Windows 10/8.1/8/7, five-points touch, and driver free
- Backlight can be turned off to lower power consumption

HOW TO USE

WORKING WITH PC

This product supports Windows 10/8.1/8/7 OS. For the Windows 10/8.1/8 OS, the touch screen supports multi-touch up to 5 points. For some Window 7 OS, the touch screen supports single touch only.

CONNECTION

1. Turn on the "backlight" switch
2. Connect the LCD to your PC

   - USB Port of LCD connect to USB Port of PC;

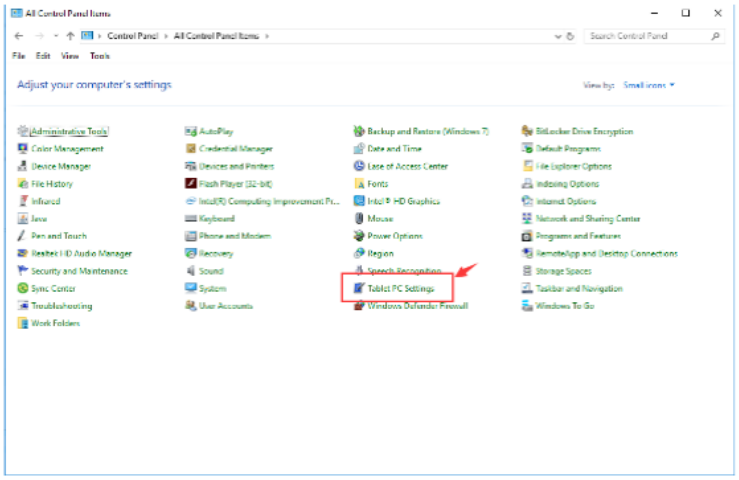
   - HDMI Port of LCD connect to HDMI Port of PC. (Please first connect the USB Ports then connect the HDMI Port).

   A new touch drive will be recognized by Windows and you can use the LCD as a human interface device. When multiple displays are detected by your PC.

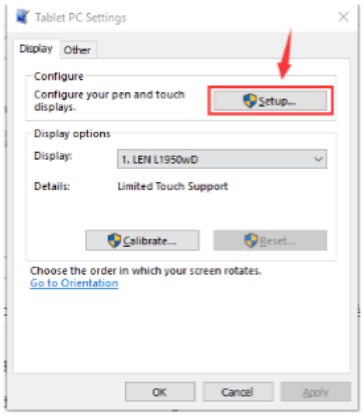
CONFIGURE THE TOUCH DISPLAY

As we know, the touch screen connected is set to control the main display by default, sometimes we need to make the touch to control other display than the main display if we set the touch screen as second display. Herein we show you how to configure it.

1. Open Tablet PC Settings from Control Panel



2. Open the Tablet PC Settings, and click Setup...:



3. Following the hint to finish setting:

hints:

Tap this screen with a single finger to identify it as the touchscreen. *If this is not the Tablet PC screen, press Enter to move to the next screen. To close the toll, press Esc.*

For example:

I connect a big size display and one touch screen to my PC (Windows 10), the big display is recognized as display 1 (the main display), the touch screen is recognized as display 2 (the second display). Before tablet setting, the touch screen controls the main display if I touch it. Now I want to make the touch screen to control itself-the second display.

So, I click Setup..., the hint appears on display 1 and display 2 is white. I press Enter, the hint turns to display 2 and display 1 is white. I tap the center of the touch screen (display 2). The setting is finish, and now if I tap the touch screen, I can control the display 2 with the touch screen instead of main display.

7inch HDMI LCD (B)

WORKIGN WITH RASPBERRY PI

When working with Raspberry Pi, you should set the resolution of the LCD manually, or else the LCD screen will not work. For more detail information, please read the following section.

1. Turn on the "backlight" switch
2. Connect the LCD to your Pi

   -HDMI Port of LCD -> HDMI Port of Pi;

   -USB Port of LCD -> USB Port of Pi;
3. Download the Raspbian image from Raspberry Pi web site.
4. Write the image to a TF card
5. Append the following lines to the config.txt file which is located in the root of your TF card:

```
max_usb_current=1
hdmi_group=2
hdmi_mode=87
hdmi_cvt 800 480 60 6 0 0 0
hdmi_drive=1
```

6. Save and connect the TF card to your Pi then power up.

ROTATION

Display Rotating

1. To rotating the display, you can append this statement to the config file

```
display_rotate=1 #1: 90; 2: 180; 3: 270
```

2. Reboot the Raspberry Pi

```
sudo reboot
```

Touch Rotating

Note: To rotate the touch, you can re-compile the kernel as well. There is an example for reference (use 7inch HDMI LCD (C).)

- Re-Compilation Method

Another way, you can set the libinput.

1. Install libinput

```
sudo apt-get install xserver-xorg-input-libinput
```

For Ubuntu-Mate OS, you need to install **xserver-xorg-input-libinput-hwe-16.04** instead.

2. create an xorg.conf.d folder

```
sudo mkdir /etc/X11/xorg.conf.d
```

3. copy file 40-libinput-conf to the folder which we created

```
sudo cp /usr/share/X11/xorg.conf.d/40-libinput.conf /etc/X11/xorg.conf.d/
```

4. Append a statement to touchscreen part of the file as below:

```
sudo nano /etc/X11/xorg.conf.d/40-libinput.conf
```

7inch HDMI LCD (B)

5. save and reboot your Pi

```
sudo reboot
```

After completing these steps. The LCD could rotate 90 degree both display and touch.

【Note】

90 degree: Option "CalibrationMatrix" "0 1 0 -1 0 1 0 0 1"

180 degree: Option "CalibrationMatrix" "-1 0 1 0 -1 1 0 0 1"

270 degree: Option "CalibrationMatrix" "0 -1 1 1 0 0 0 0 1"

9 / 9

10. Intel NUC PC Datasheet and Technical Reference Pages

Essentials

Export specifications

Product Collection	Intel® NUC Kit with 8th Generation Intel® Core™ Processors
Code Name	Products formerly BEAN CANYON
Status	Launched
Launch Date	Q3'18
Board Form Factor	UCFF (4" x 4")
Socket	Soldered-down BGA
Internal Drive Form Factor	M.2 SSD
# of Internal Drives Supported	1
Lithography	14 nm
TDP	28 W
DC Input Voltage Supported	12-19 VDC
Processor Included	Intel® Core™ i5-8259U Processor (6M Cache, up to 3.80 GHz)
Warranty Period	3 yrs
Recommended Customer Price	$361.00 - $363.00

Supplemental Information

Embedded Options Available	No
Datasheet	View now
Description	Other features: Includes Thunderbolt 3 (40Gbps) USB 3.1 Gen 2 (10Gbps) and DP 1.2 via USB-C; also includes microSDXC card slot, dual microphones

Memory & Storage

Max Memory Size (dependent on memory type) ?	32 GB
Memory Types ?	DDR4-2400 1.2V SO-DIMM
Max # of Memory Channels ?	2
Max Memory Bandwidth ?	38.4 GB/s
Max # of DIMMs ?	2
ECC Memory Supported ‡ ?	No

Processor Graphics

Integrated Graphics ‡ ?	Yes
Graphics Output ?	HDMI 2.0a; USB-C (DP1.2)
# of Displays Supported ‡	3

Expansion Options

PCI Express Revision ?	Gen3
PCI Express Configurations ‡ ?	M.2 slot with PCIe X4 lanes
Removable Memory Card Slot ?	microSDXC with UHS-I support
M.2 Card Slot (storage) ?	22x42/80

I/O Specifications

# of USB Ports	6
USB Configuration	2x front and 3x rear USB 3.1 Gen2; 2x USB 2.0 via internal headers
USB Revision	2.0, 3.1 Gen2
USB 2.0 Configuration (External + Internal)	0 + 2
USB 3.0 Configuration (External + Internal)	2B 2F + 0
Total # of SATA Ports	2
Max # of SATA 6.0 Gb/s Ports	2
Audio (back channel + front channel)	7.1 digital (HDMI mDP); L+R mic (F)
Integrated LAN	Intel® Ethernet Connection I219-V
Integrated Wireless‡	Intel® Wireless-AC 9560 + Bluetooth 5.0
Integrated Bluetooth	Yes
Consumer Infrared Rx Sensor	Yes
Additional Headers	CEC, 2x USB2.0, FRONT_PANEL
# of Thunderbolt™ 3 Ports	1

Package Specifications

Low Halogen Options Available	No

Advanced Technologies

Intel® Optane™ Memory Supported ‡	Yes
Intel® Virtualization Technology for Directed I/O (VT-d) ‡	Yes
Intel® vPro™ Platform Eligibility ‡	No
TPM	No
Intel® HD Audio Technology	Yes
Intel® Rapid Storage Technology	Yes
Intel® Virtualization Technology (VT-x) ‡	Yes
Intel® Platform Trust Technology (Intel® PTT)	Yes

Security & Reliability

Intel® AES New Instructions	Yes

2.2.4.2 Add-in Card Connectors

The board supports M.2 2242 and 2280 (key type M) modules.

- Supports M.2 SSD SATA drives
  — Maximum bandwidth is approximately 540 MB/s
- Supports M.2 SSD Gen 3 PCIe AHCI and NVMe drives (PCIe x1, x2, and x4)
  — Using PCIe x4 M.2 SSD maximum bandwidth is approximately 4000 MB/s

2.2.4.3 Type C connector

The board has several features that are supported via the Type C connector.

- Supports USB 3.1 Gen 2.0
  — Maximum bandwidth is approximately 10 Gbit/s
- Supports Display port 1.2
  — Maximum bandwidth is approximately 17.28 Gbit/s
- Supports Thunderbolt 3 PCIe x4 connection
  — Maximum bandwidth is approximately 40 Gbit/s

2.2.4.4 Front Panel Header (2.0 mm Pitch)

This section describes the functions of the front panel header. Table 21 lists the signal names of the front panel header. Figure 13 is a connection diagram for the front panel header.

Table 21. Front Panel Header (2.0 mm Pitch)

Pin	Signal Name	Description	Pin	Signal Name	Description
1	HDD_POWER_LED	Pull-up resistor (750 Ω) to +5V	2	POWER_LED_MAIN	[Out] Front panel LED (main color)
3	HDD_LED#	[Out] Hard disk activity LED	4	POWER_LED_ALT	[Out] Front panel LED (alt color)
5	GROUND	Ground	6	POWER_SWITCH#	[In] Power switch
7	RESET_SWITCH#	[In] Reset switch	8	GROUND	Ground
9	+5V_DC	Power	10	Key	No pin

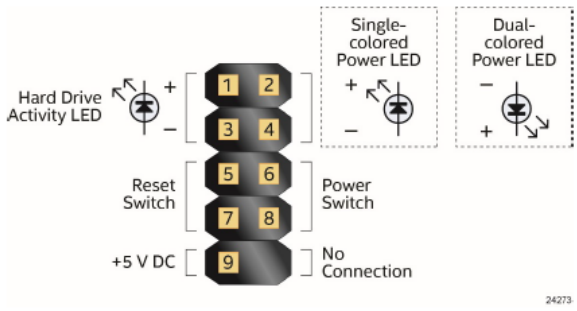


Figure 13. Connection Diagram for Front Panel Header (2.0 mm Pitch)

2.2.4.4.1 Hard Drive Activity LED Header

Pins 1 and 3 can be connected to an LED to provide a visual indicator that data is being read from or written to a hard drive. Proper LED function requires a SATA hard drive or optical drive connected to an onboard SATA connector.

2.2.4.4.2 Reset Switch Header

Pins 5 and 7 can be connected to a momentary single pole, single throw (SPST) type switch that is normally open. When the switch is closed, the board resets and runs the POST.

2.2.4.4.3 Power/Sleep LED Header

Pins 2 and 4 can be connected to a one- or two-color LED. Table 22 and Table 23 show the possible LED states.

Table 22. States for a One-Color Power LED

LED State	Description
Off	Power off
Blinking	Standby
Steady	Normal operation

Table 23. States for a Dual-Color Power LED

LED State	Description
Off	Power off
Secondary color blinking (amber)	Standby
Primary color steady (white)	Normal operation

NOTE

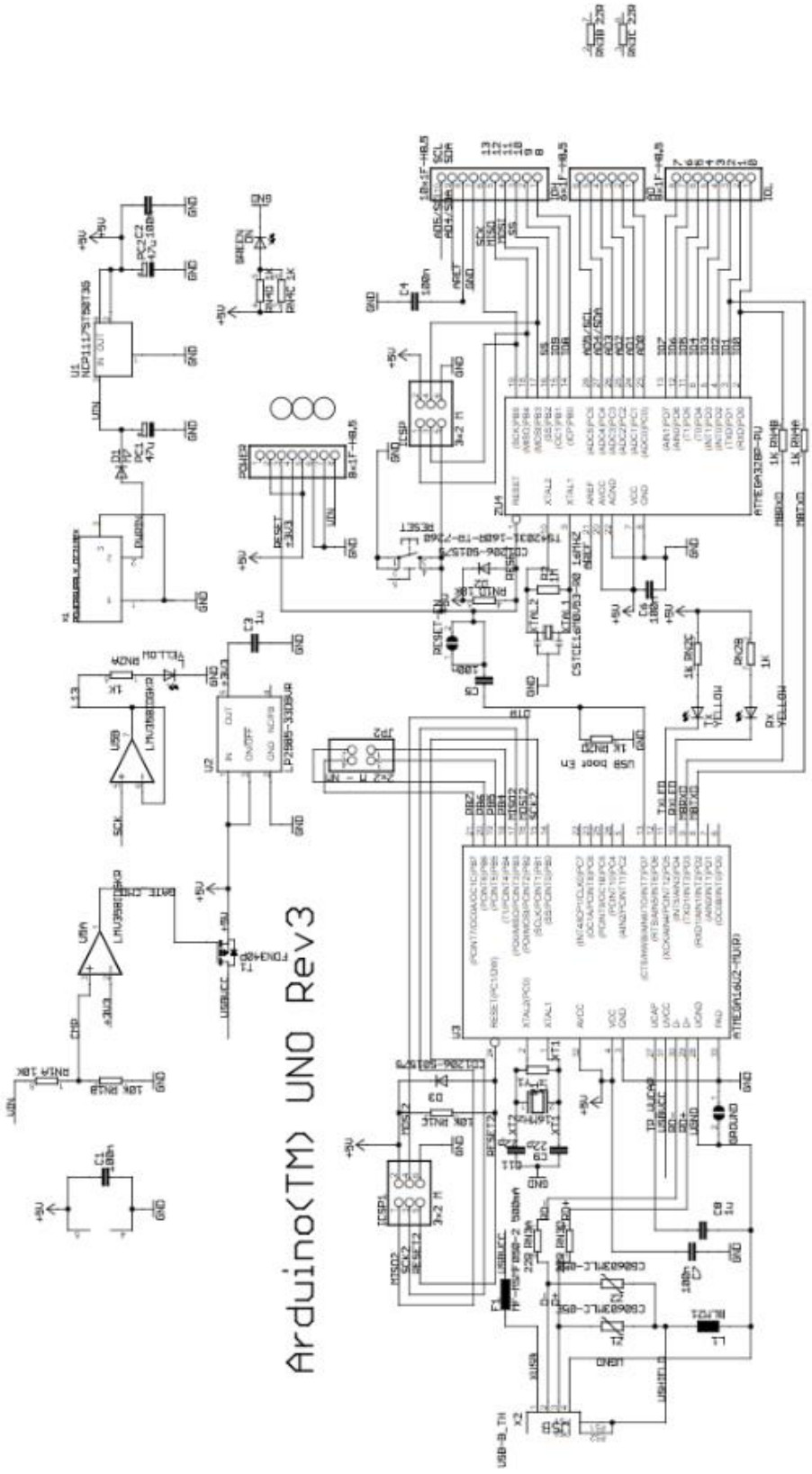
The LED behavior shown in Table 22 is default – other patterns may be set via BIOS setup.

2.2.4.4.4 Power Switch Header

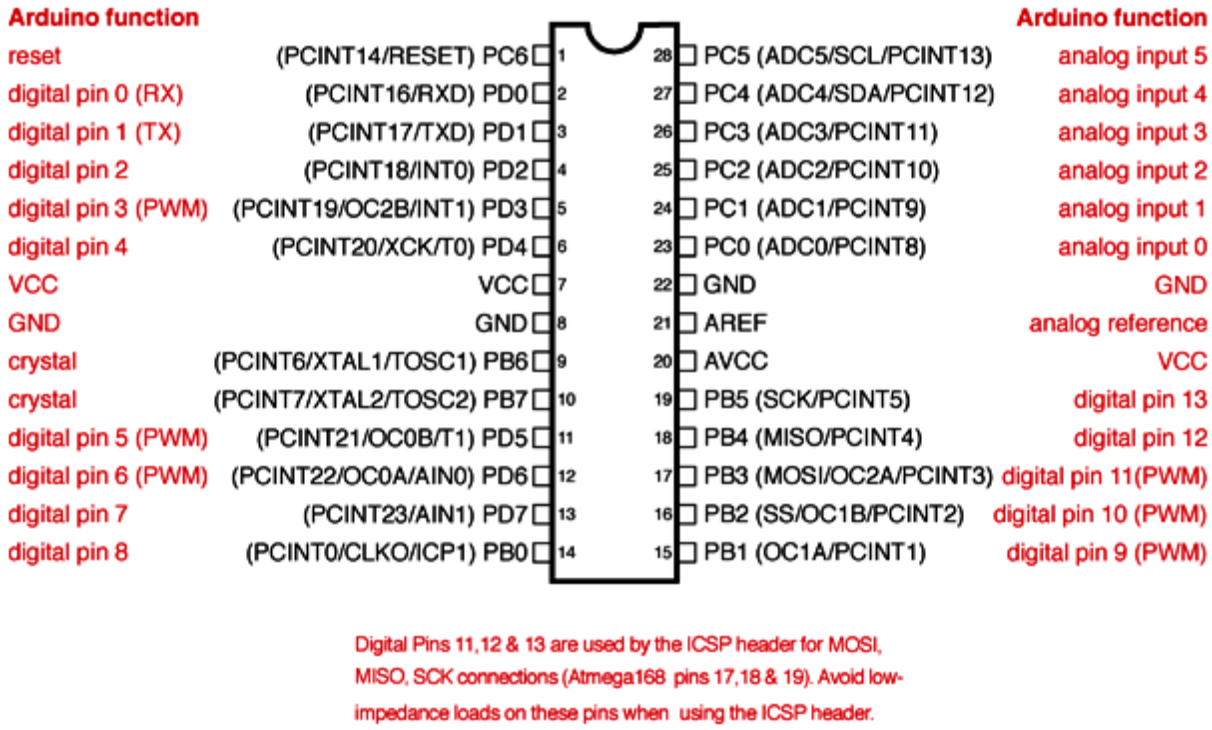
Pins 6 and 8 can be connected to a front panel momentary-contact power switch. The switch must pull the SW_ON# pin to ground for at least 50 ms to signal the power supply to switch on or off. (The time requirement is due to internal debounce circuitry on the board.) At least two seconds must pass before the power supply will recognize another on/off signal.

11. Arduino UNO Rev 3 Datasheet

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g


Arduino(TM) UNO Rev3

Atmega168 Pin Mapping



Digital Pins 11,12 & 13 are used by the ICSP header for MOSI, MISO, SCK connections (Atmega168 pins 17,18 & 19). Avoid low-impedance loads on these pins when using the ICSP header.

12. Voltage Sensor

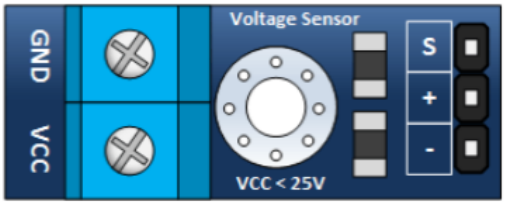
The Basics

The Arduino analog input is limited to a 5 VDC input. If you wish to measure higher voltages, you will need to resort to another means. One way is to use a voltage divider. The one discussed here is found all over Amazon and eBay.

It is fundamentally a 5:1 voltage divider using a 30K and a 7.5K Ohm resistor.

Keep in mind, you are restricted to voltages that are less than 25 volts. More than that and you will exceed the voltage limit of your Arduino input.

Basic Connection



Inputs

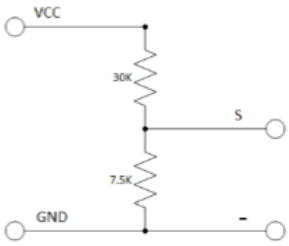
- **GND –** This is where you connect the low side of the voltage you are measuring. Caution! : This is the same electrical point as your Arduino ground.
- **VCC:** The is where you connect the high side of the voltage you are measuring

Outputs

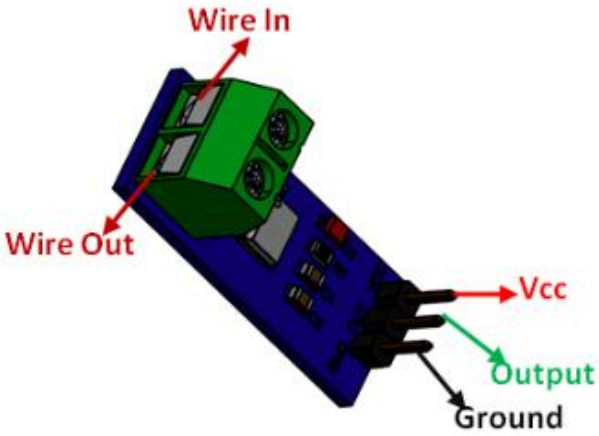
- **S:** This connects to your Arduino analog input.
- **– (or minus):** This connects to your Arduino ground.
- **+:** This is not connected. It does absolutely nothing... zilch... nada... jack diddly doo doo.

Schematic

The schematic for this is pretty straight forward. As previously mentioned, its just a couple of resistors. In fact, you could build your own in a pinch.



13. Current Sensor



Pin Configuration

Pin Number	Pin Name	Description
1	Vcc	Input voltage is +5V for typical applications
2	Output	Outputs Analog voltage proportional to current
3	Ground	Connected to ground of circuit
T1	Wire In	The wire through current has to be measured is connected here
T2	Wire Out	

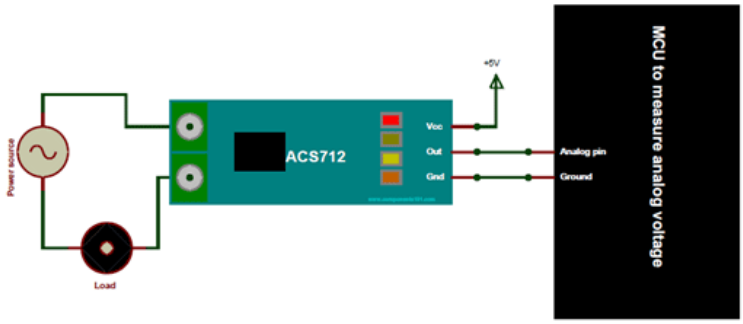
Specifications

- Measures both AC and DC current
- Available as 5A, 20A and 30A module
- Provides isolation from the load
- Easy to integrate with MCU, since it outputs analog voltage
- Scale Factor

5A Module	20A Module	30A Module
185mV/Amp	100mV/Amp	66mV per Amp

How to use the ACS712 Module

As told earlier it is very simple to **interface the ACS712 Module with Microcontrollers**. The below diagram would be more illustrative



The ACS712 module has two phoenix terminal connectors (green colour ones) with mounting screws as shown above. These are the terminals through which the wire has to be passed. In our case I am measuring the current drawn by the motor so the wires that is going to the load (motor) is passed through the ACS 712 Module. Make sure the module is connected in series with the load and be extra cautious to avoid shorts.

On the other side we have three pins. The Vcc is connected to +5V to power the module and the ground is connected to the ground of the MCU (system). Then the analog voltage given out by the ACS712 module is read using any analog pin on the Microcontroller.

Programming for ACS712 Module

There are few things to know before we could program our Microcontrollers to read current from ACS712 Module. By default when no current is flowing through the module terminals the output voltage will be +2.5V (Vcc/2), when the current flows in one direction the value will increase from 2.5V and when it flows in other direction the values will decrease from 2.5V. This way the module enables us to measure both AC current and DC current.

Let us assume that the microcontroller you are using has a 10-bit ADC and operates at 5V with a reference voltage of 5V for ADC conversion in that case the microcontroller will read the values of ADC from 0 to 1024. Then you can use the formulae below to calculate the Output Voltage from ADC values.

Vout (mV) = (ADC Value/ 1023)*5000

After calculating the output voltage we can, calculate the value of current from the voltage using the below formulae

Current Through the Wire (A) = (Vout(mv)-2500)/Scale factor

Note that the value of scale factor changes for every module based on its range. The values of scale factor for all three modules are given in the specifications above.

14. Magewell Capture Card Technical Specifications

MAGEWELL

USB Capture HDMI Gen 2 Technical Specifications

Specifications are based on current hardware, firmware and software revisions, and are subject to change without notice.

Revised 28/9/2018

Supported OS

- Windows
  - Windows 7/8/8.1/10/Server 2008/Server 2008 R2/Server 2012/Server 2016 (x86 & x64)
- Linux (support x86, x64 & ARM architecture)
  - Ubuntu 12.04/14.04/16.04/17.04/17.10 (x86 & x64)
  - CentOS 6.5/7 (x86 & x64)
  - Fedora 25/26/27 (x86 & x64)
  - Red hat 6.5 and above (x86 & x64)
  - Other Linux OS with kernel version 2.6.35 and above
- Mac
  - OS X 10.9/10.10/10.11
  - macOS 10.12/10.13
- Chrome OS

Recommended OS (tested)

- Windows
  - Windows 7 Ultimate/8.1 Enterprise/10 Enterprise/Server 2008 R2 DataCenter/Server 2012 R2 DataCenter/Server 2016 R2 DataCenter (x86 & x64)
- Linux
  - Ubuntu 12.04/14.04/16.04 (x86 & x64)
  - Ubuntu 17.04/17.10 (x64)
  - CentOS 6.5/7.2 (x86 & x64)
  - Fedora 25/26 (x64)
  - Red hat 6.5 (x86 & x64)
- Mac
  - OS X 10.9.5/10.10/10.11.2/10.11.3/10.11.4
  - macOS 10.12/10.13.2/10.13.3

Supported APIs

- Windows
  - DirectShow
  - Wave API/DirectSound/WASAPI
- Linux
  - V4L2
  - ALSA
- OS X/macOS
  - QuickTime
  - AV Foundation

Supported Software

- VLC
- VirtualDub
- OBS
- XSplit

- vMix
- VidBlaster
- Wirecast
- Microsoft Media Encoder
- Adobe Flash Media Encoder
- Any other DirectShow, V4L2, QuickTime, AV Foundation based encoding or streaming software

Input Interfaces

- HDMI
  - DVI-D 1.0
  - HDMI 1.4a

Host Interface

- USB 3.0
  - compatible with USB 2.0
  - compatible with USB 3.1 Gen 1

Input features

- Support for input video resolutions up to 2048x2160

HDMI Specific Features

- 165MHz HDMI receiver
- Adaptive HDMI equalizer support for cables lengths up to 30M
- Support for customized EDID
- Support for extraction of AVI/Audio/SPD/MS/VS/ACP/ISRC1/ISRC2/Gamut InfoFrames
- Full colorimetry support
- Support for 8/10/12-bit color depth
- Support for RGB 4:4:4、YCbCr 4:4:4、YCbCr 4:2:2 color sampling
- Support for 2 channel IEC60958 audio streams
- Support for extraction of audio formation information & channel status data
- Support for extraction of video timing information
- Support for extraction of 3D format information
- Support for Side-by-Side Half, Top-and-Bottom, Frame Packing 3D mode.

Video Capture format

- Support for capture resolutions up to 2048x2160
- Support for capture frame rates up to 120fps (Actual capture frame rate can be limited by the USB bandwidth and internal working frequency. Typical capture frame rates on the Intel USB3.0 controller are as follows.)
  - 1920x1080 YUY2 (up to 75fps)
  - 1920x1080 RGB24 (up to 60fps)
- Support for YUY2 & UYVY 4:2:2 8-bit
- Support for RGB24 & RGB32 4:4:4 8-bit
- The default capture format is YUY2. More capture formats can be set using USB Capture Utility.

Video Processing Features

- Video processing pipelines with 160 Mpixels/s processing bandwidth
- Video cropping
- Video scaling
- Video de-interlacing
  - Weave
  - Blend top & bottom field
  - Top field only
  - Bottom field only
- Video aspect ratio conversion
  - Auto or manual selection of input aspect ratio
  - Auto or manual selection of capture aspect ratio
  - Three aspect ratio conversion modes: Ignore (Anamorphic), Cropping or Padding (Letterbox or Pillarbox)
- Video color format conversion

    - Auto or manual selection of input color format & quantization range
    - Auto or manual selection of capture color format, quantization range & saturation range
    - Support for RGB, YCbCr 601, YCbCr 709 color formats
    - Support for Limited or Full quantization range
    - Support for Limited, Full & 'Extended gamut' saturation range
- Video frame rate conversion
- Vertical flip and mirror

Multiple devices on one computer

- Support for connecting multiple USB devices to one system
- Support for setting the device serial number as the device name shown in the system using USB Capture Utility

SDK

- The USB Capture SDK provide functions including signal status extraction, capture configuration, etc.

Firmware Upgrade

- Multiple devices in one system can be upgraded simultaneously

LED Indicator

- Status LEDs indicate the working state of each channel:
    - Pulsing slowly: idle
    - On: input signal locked
    - Off: input signal unlocked
    - Double blinks: memory failed or FPGA configuration failed

Form Factor

- 92.2mm (L) x 40.2mm (W) x 12.3mm (H)

Accessories

- USB 3.0 cable

Power Consumption

- 5V max current: ~0.5 A
- max power consumption: ~2.5 W

Working Environment

- Operating temperature: 0 to 50 deg C
- Storage temperature: -20 to 70 deg C
- Relative Humidity: 5% to 90% non-condensing

15. HopCentury Capture Card

USB 3.0 HD Video Capture Card HDMI 1080P 60FPS Game Recorder Box Device Live Streaming - HDMI OUT

Tips: Please read the user manual carefully before use, thanks!

Specifications:
Interface: USB 3.0
A/V Input: HDMI v1.4
A/V Output: HDMI
Resolution: 1920 x 1080p 60fps Max.
Support Software:
OBS Studio (windows, OS X); Windows Media Encoder (Windows); Adobe Flash Media Live - Encoder (Windows, OS X); Real Producer Plus (Windows); VLC (Windows, OS X, Linux); QuickTime Broadcaster (OS X); QuickTime Player (OS X); Wirecast (Windows, OS X); vMix(Windows); Potplayer(Windows) and etc.
Operation System Requirement: Windows 7, 8, 10, OS X 10.9 or later, Linux

Hardware Requirement: *** Note: Maybe the recording or streaming will not smoothly enough if the hardware does not meet the requirement.**
PC: Intel Core i5-3400 + NVIDIA GT630
Laptop: Intel Core i7-3537U 2.0 GHz + NVIDIA GT735
Mac: i5 quad-core or above, VGA card supporting DirectX 10
Sound card, 4GB RAM, Powered USB 3.0 port: Intel chipset with native USB 3.0 host controller (Renesas, Fresco ¡)

Dimension: 3.77 x 2.28 x 0.74 inch (96x58x19mm)
Net Weight: 2.0 OZ (57g)
Color: Black+Red
Shell Material: Plastic

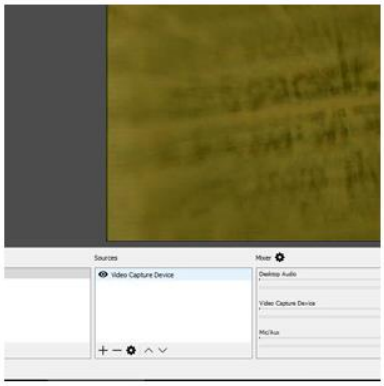
High Speed USB 3.0 Data Interface

1080P 60FPS HD Quality:
Based on the high speed USB 3.0 technology, you can get the high quality recorded video file with the USB 3.0 video capture device

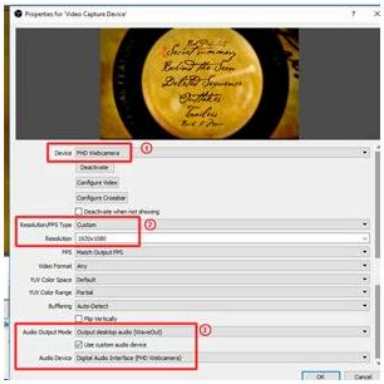
Universal HDMI v1.4 AV Port

Universal Design:
Compatible with most HDMI output, so with one recorder you can capture footage from Wii U, Xbox 360, Xbox One, PS4, PS3 game consoles, laptop, DVD player, Media player, TV box etc., which has a HDMI OUTPUT port
Built-in a HDMI OUTPUT port, it is convenient for you to check the video or game on TV set at the same time

How to Use:



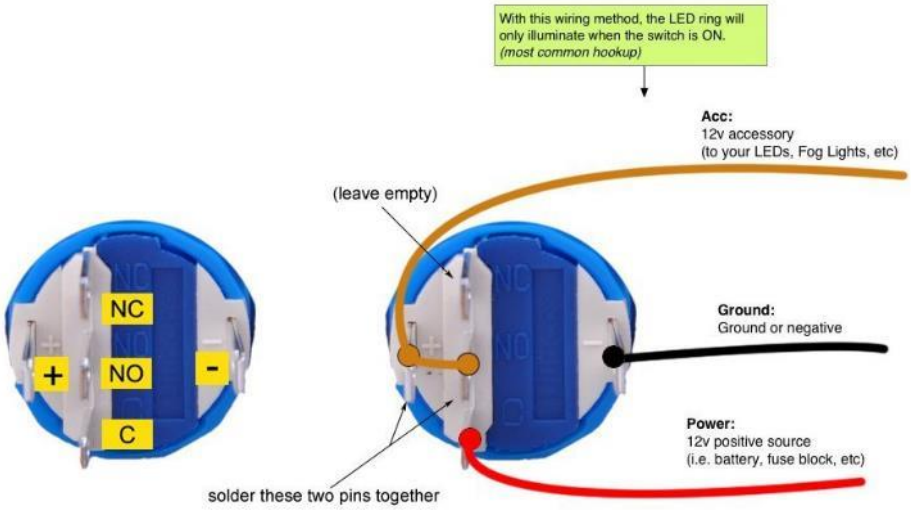
1. connect the USB3.0 video capture card to a laptop with the enclosed USB3.0 cable, and a video source with a HDMI cable.
2. after the laptop install the driver automatically, run the capture software (such as OBS Studio)
3. add "Video Capture Device" at the Source section.



4. adjust some settings in the option menu of the Video Capture Device:
4.1 Device: FHD Webcamera
4.2 Resolution/FPS Type: Custom
Resolution: 1920x1080 or you like
4.3 Audio Output Mode: Output desktop audio (WaveOut)
Audio Device: Digital Audio Interface (FHD Webcamera)

5. then the video image would show on the capture software, and you could hear the video sound.
Press the Start Recording , and press the button again to stop after some minutes.
Then you could get the recorded video file on the laptop.
That's all, very easy to enjoy your own video!

16. Non-latching pushbutton wiring schematic



Program Flowcharts

Mission Planner: Android Application

1. Facility Roof Inspection Page Flowchart

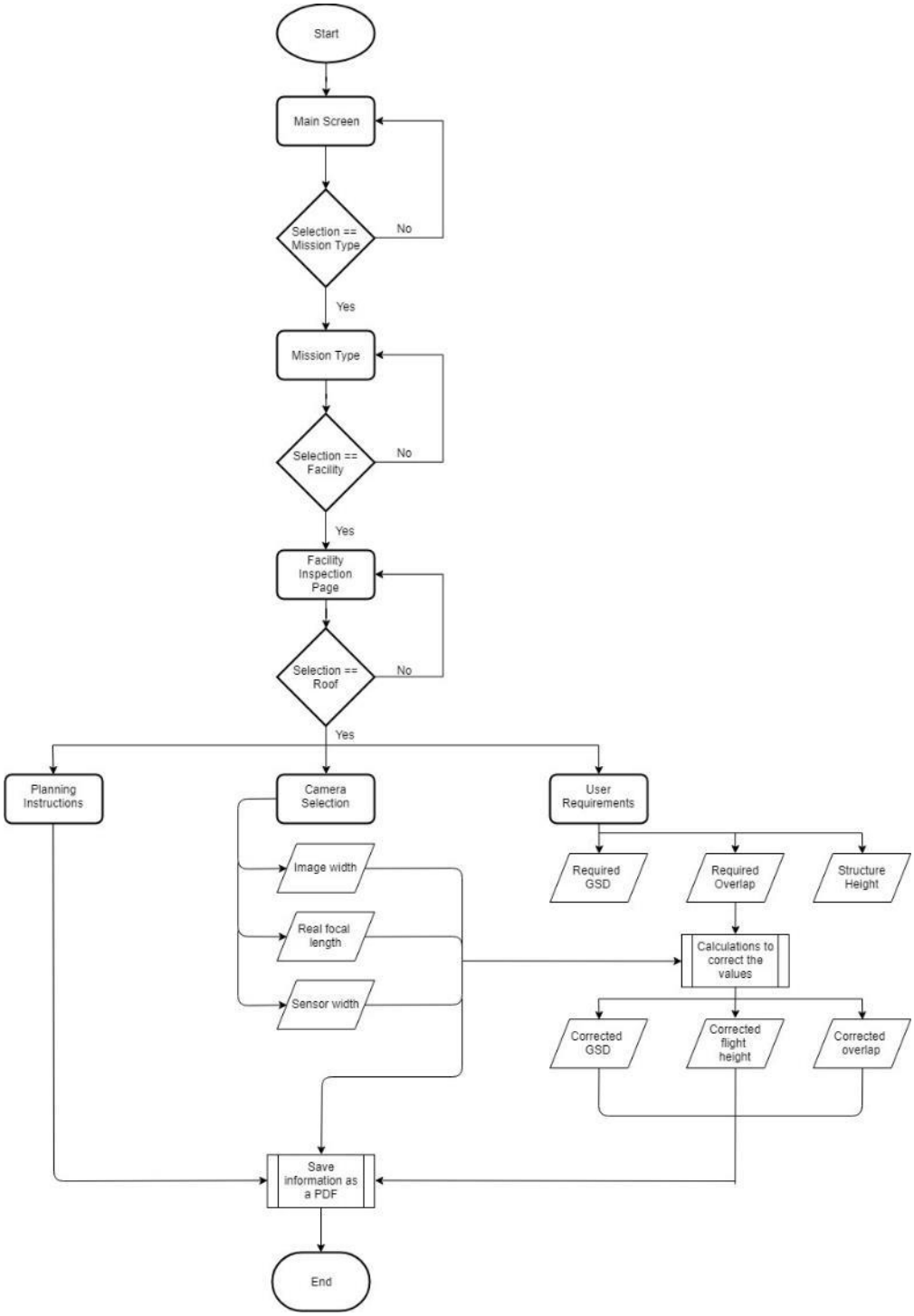


Figure 54: Facility Roof Inspection Page Flowchart

2. Facility Façade Inspection Page Flowchart

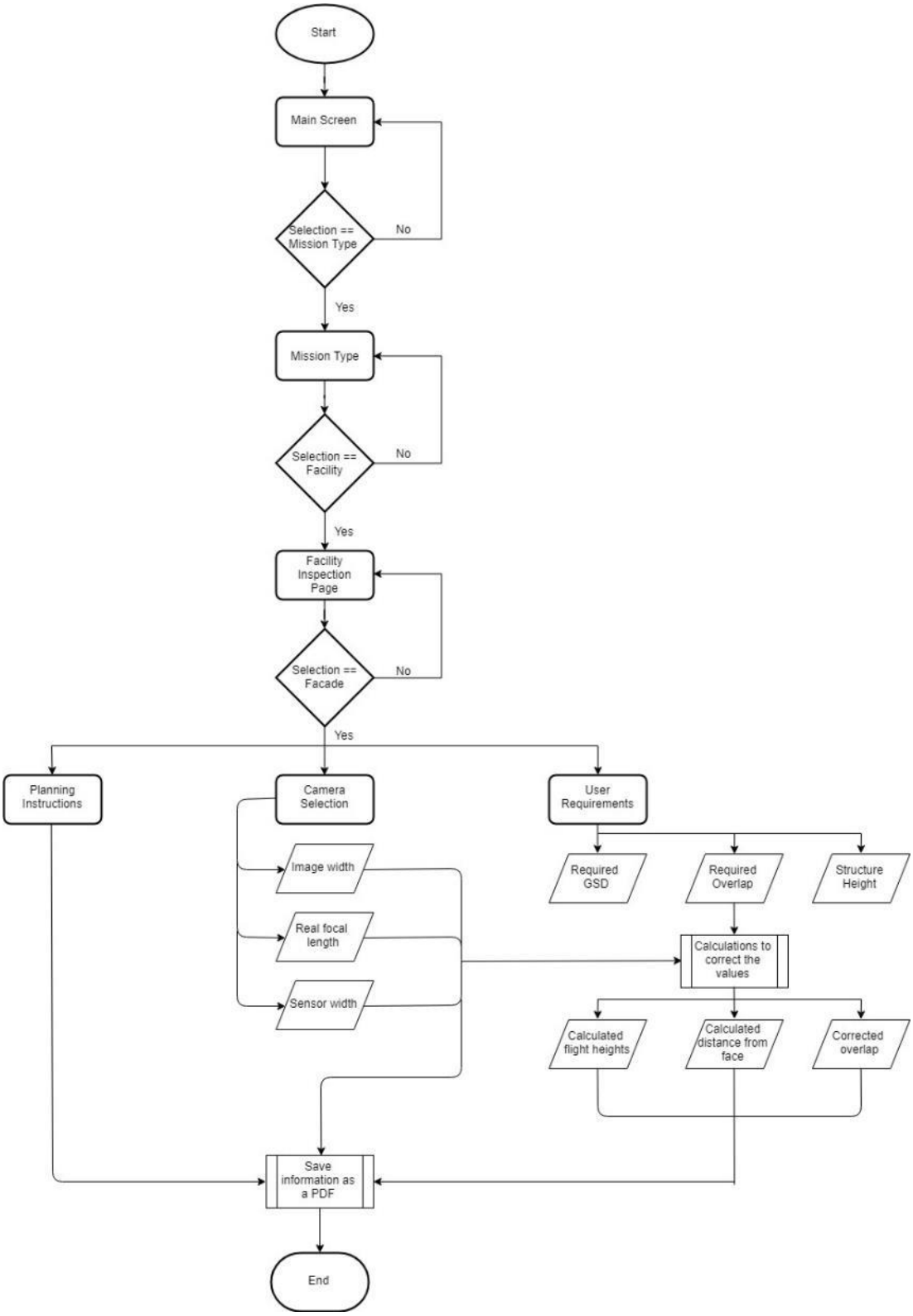


Figure 55: Facility Façade Inspection Page Flowchart

3. Facility 3D Inspection Page Flowchart

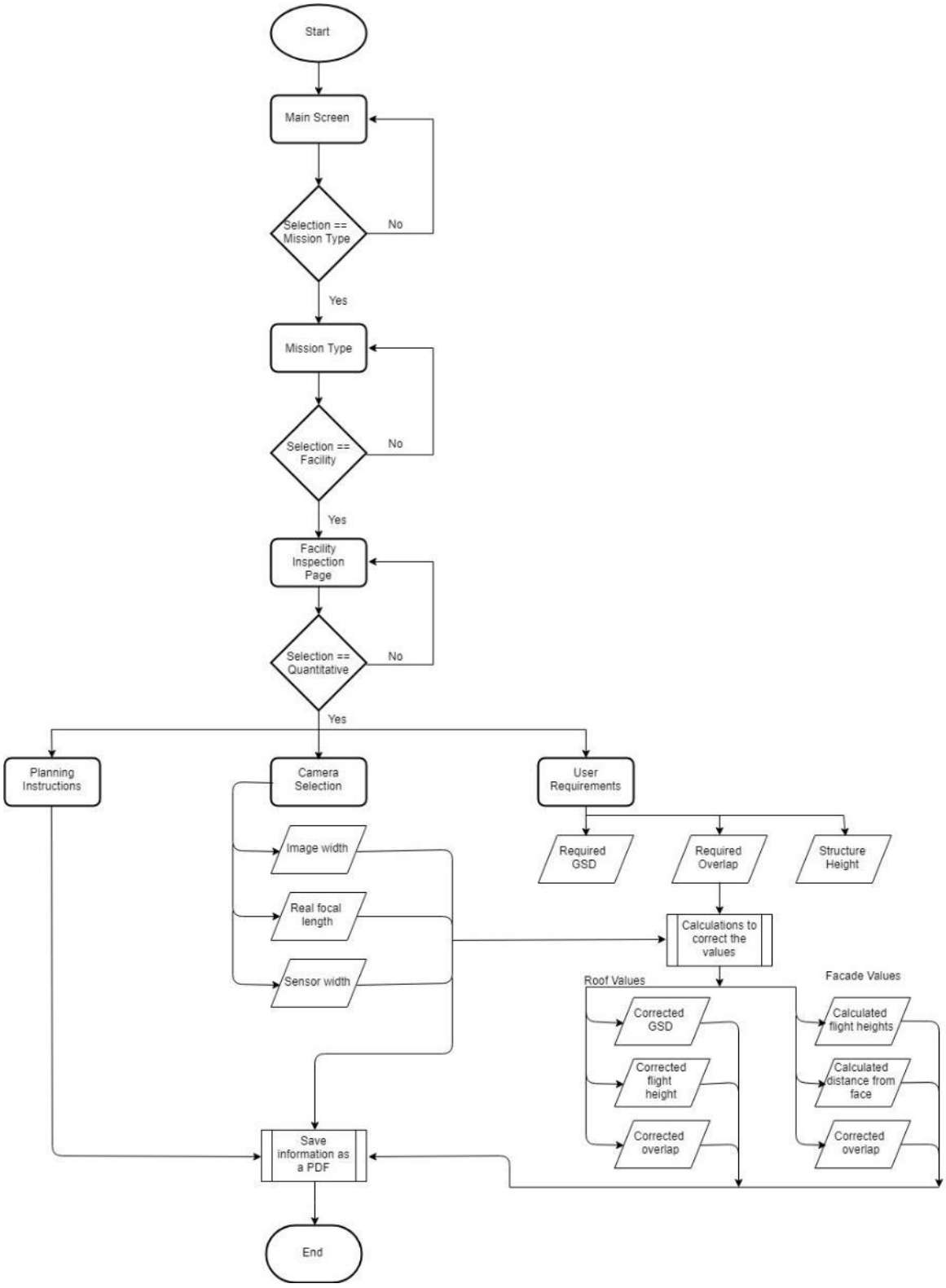


Figure 56: Facility 3D Inspection Page Flowchart

4. Saved Missions Page Flowchart

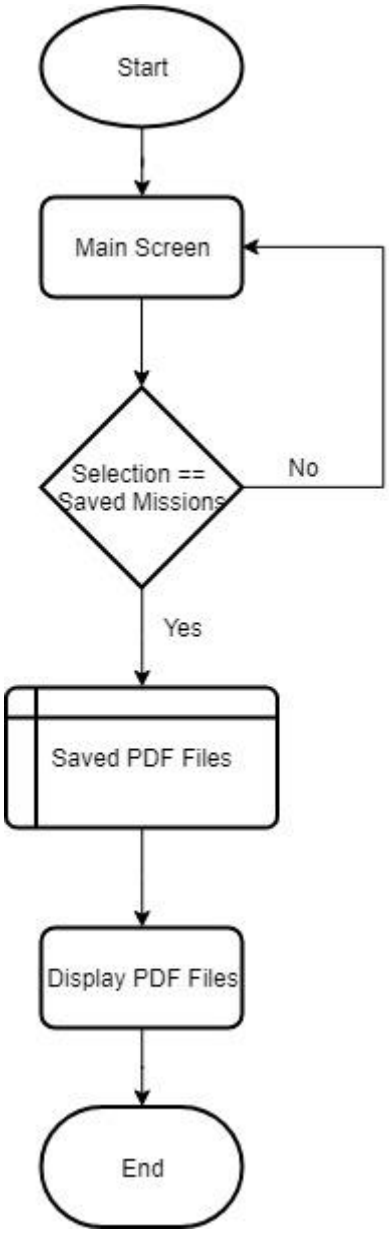


Figure 57: Saved Missions Page Flowchart

5. DJI Z3 Camera Information Page Flowchart

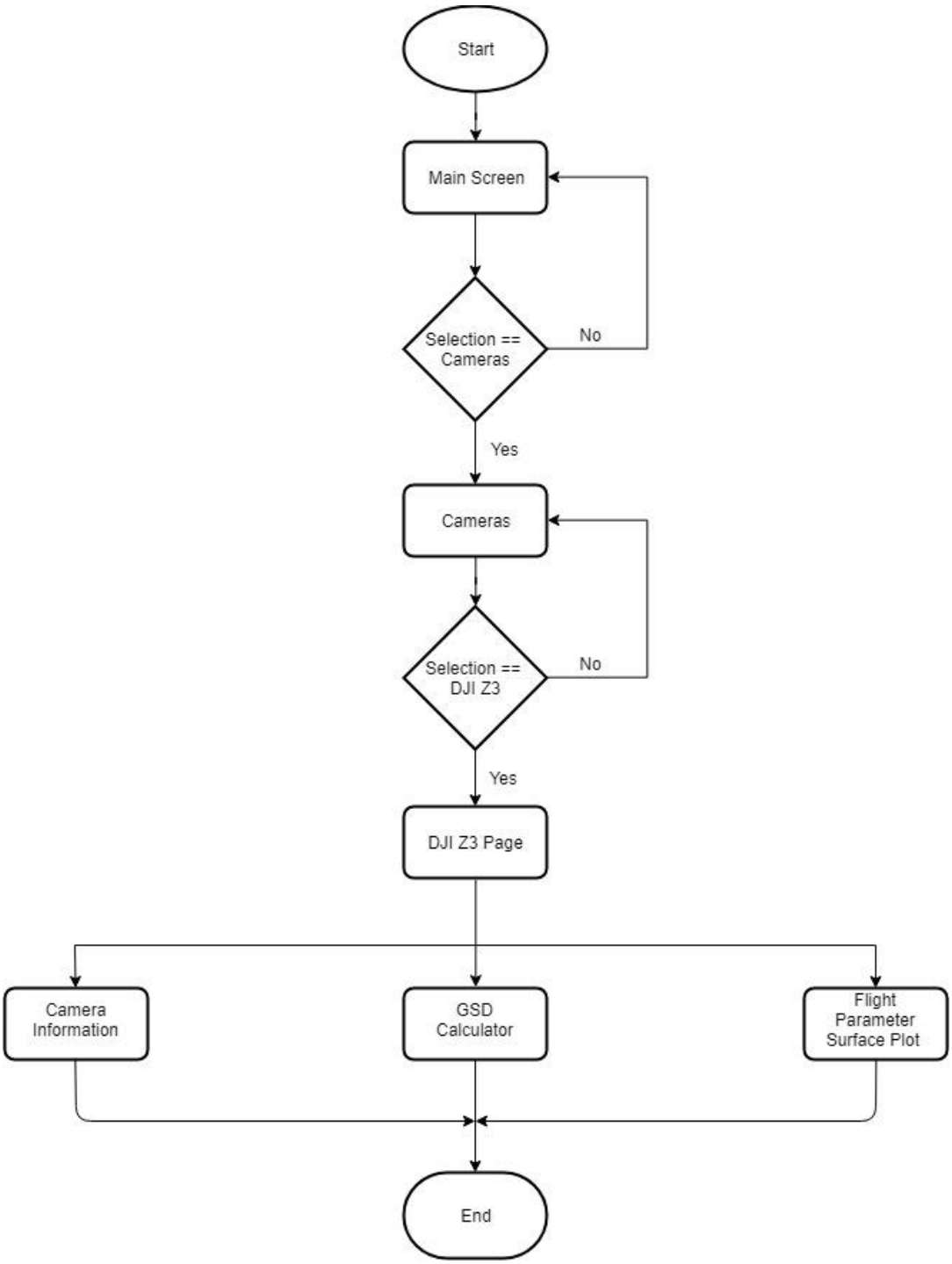


Figure 58: DJI Z3 Camera Information Page Flowchart

6. DJI X5 (45mm) Camera Information Page Flowchart

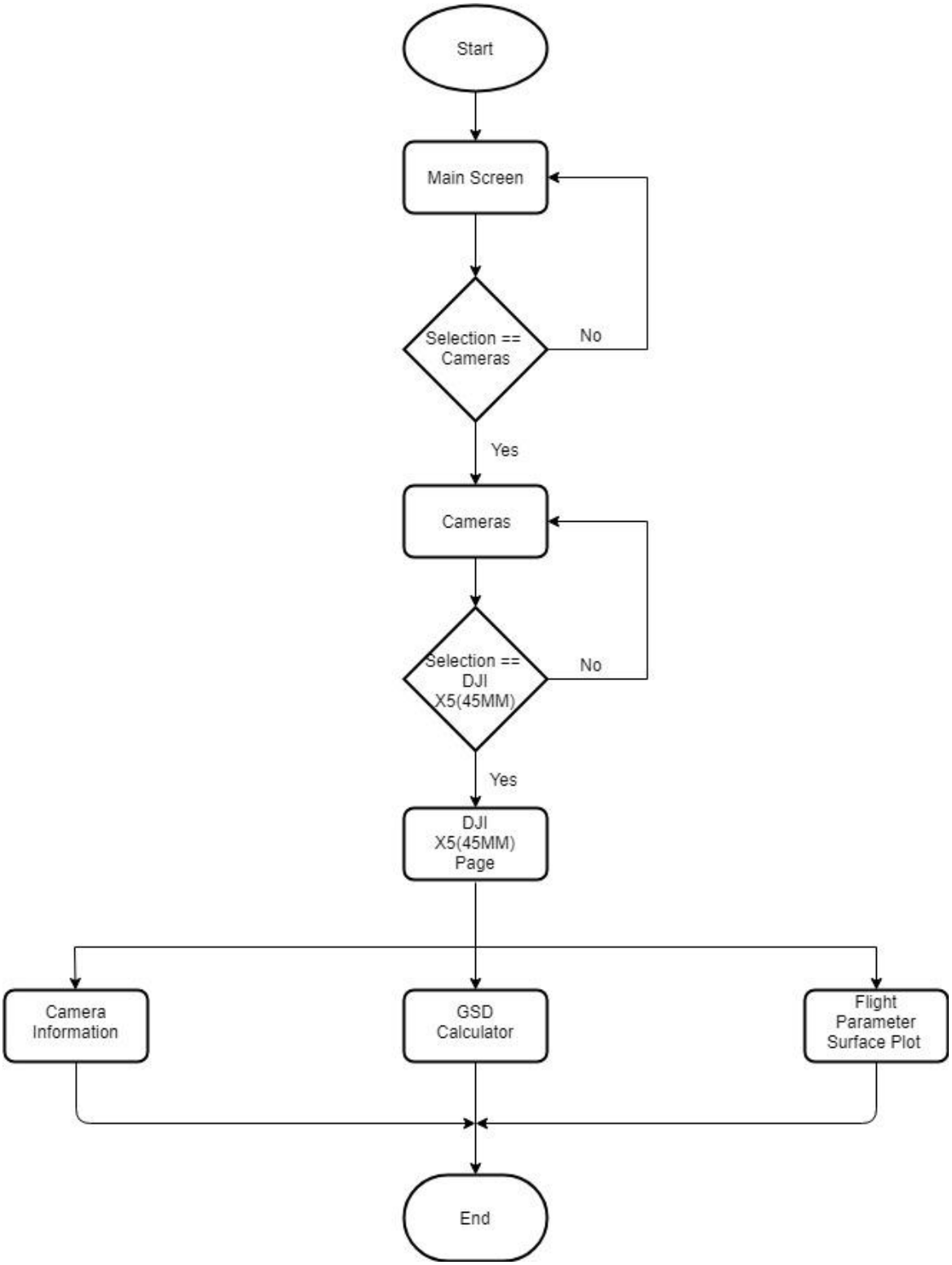


Figure 59: DJI X5 (45mm) Camera Information Page Flowchart

7. DJI X5 (15mm) Camera Information Page Flowchart

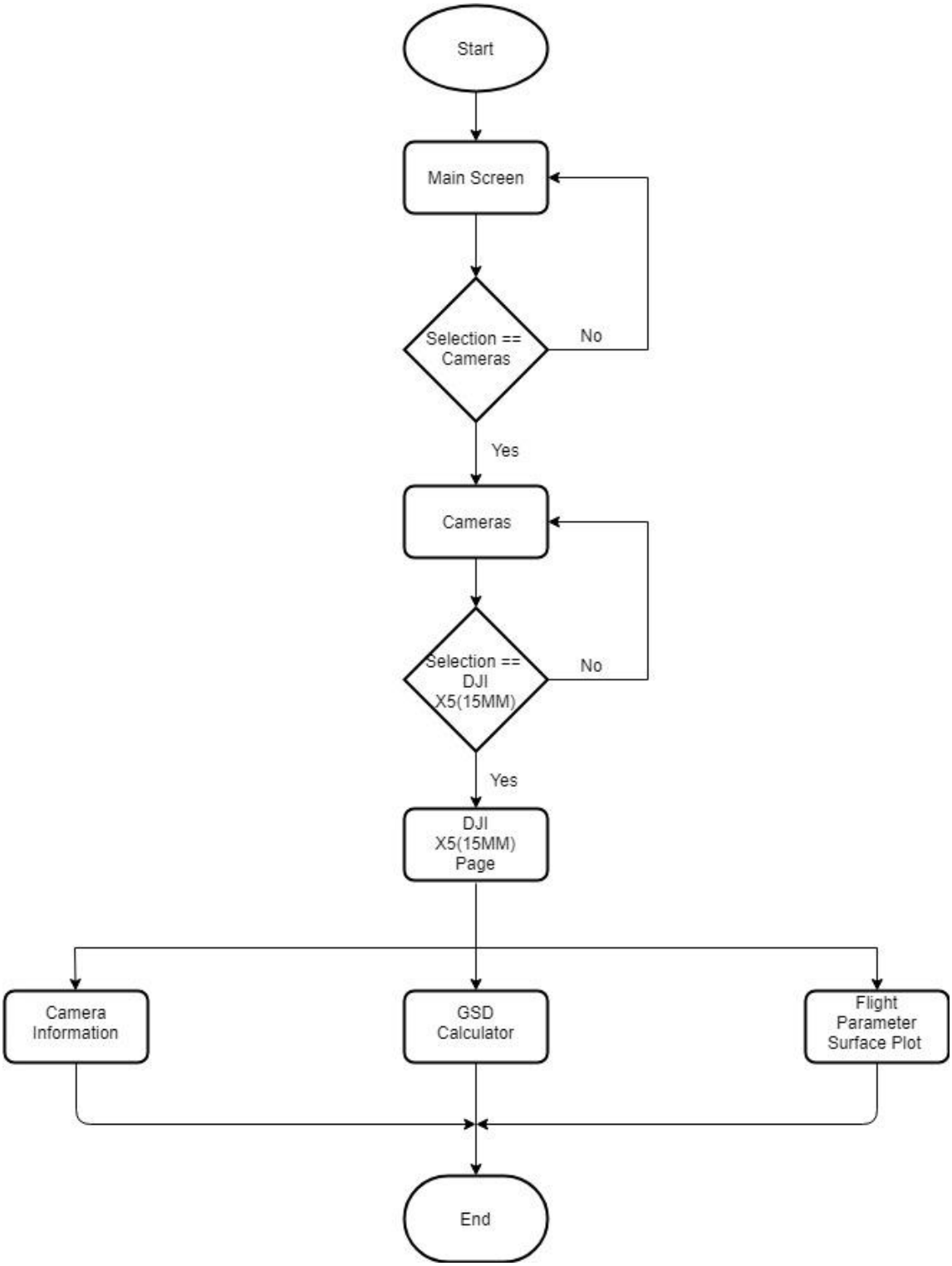


Figure 60: DJI X5 (15mm) Camera Information Page Flowchart

8. DJI X5s (45mm) Camera Information Page Flowchart

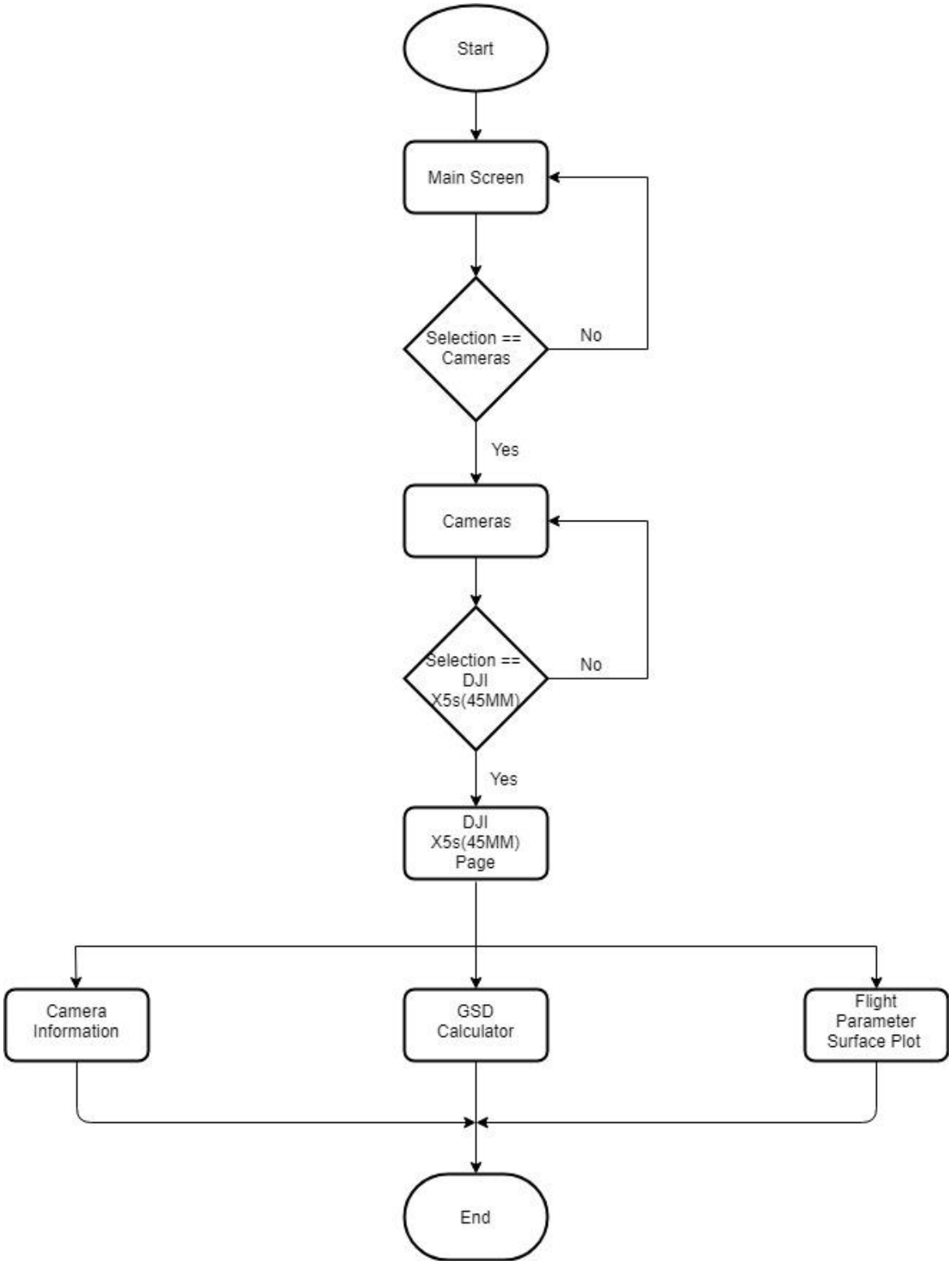


Figure 61: DJI X5s (45mm) Camera Information Page Flowchart

9. DJI X5s (15mm) Camera Information Page Flowchart

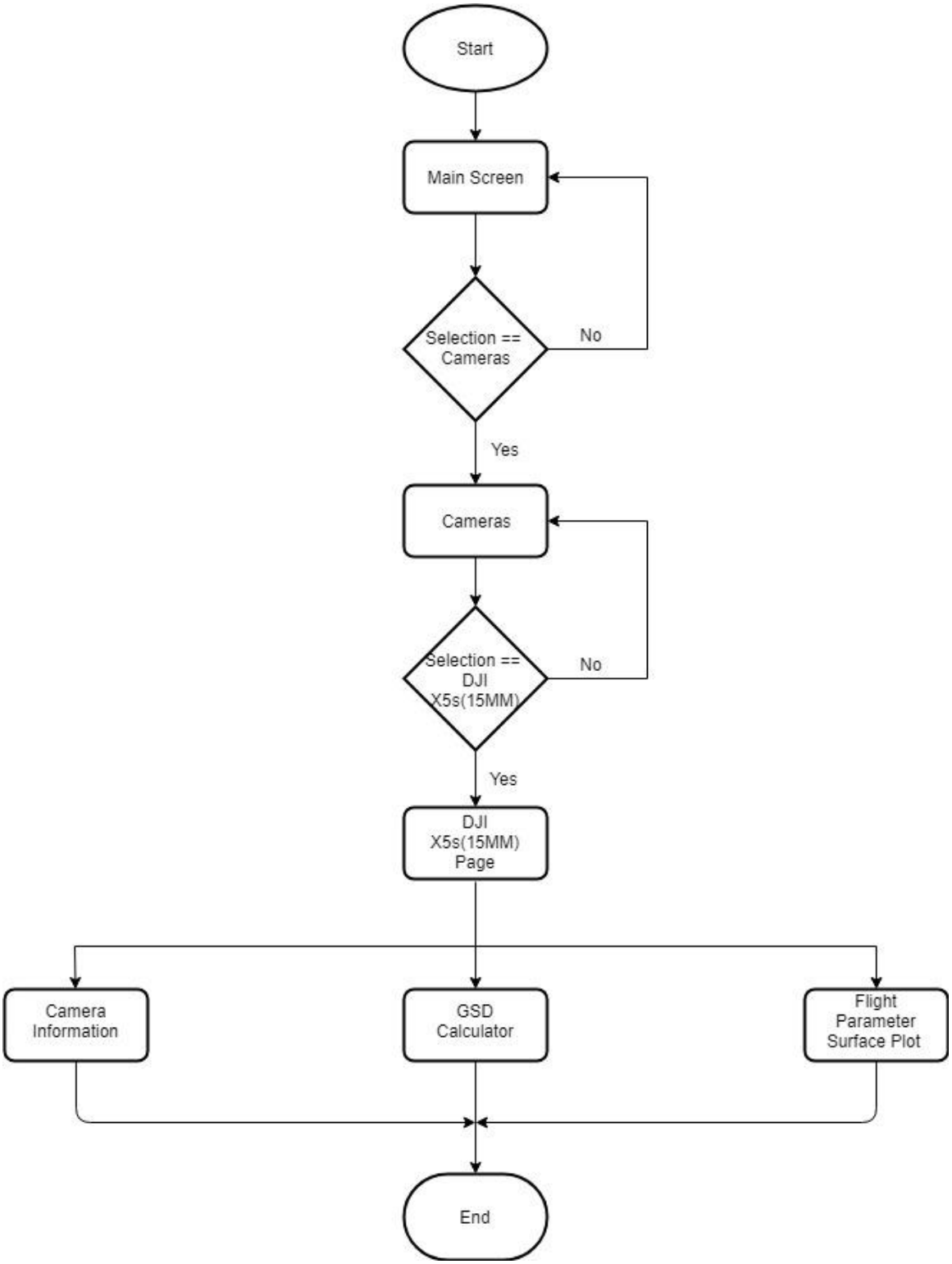


Figure 62: DJI X5s (15mm) Camera Information Page Flowchart

10. DJI XTR Camera Information Page Flowchart

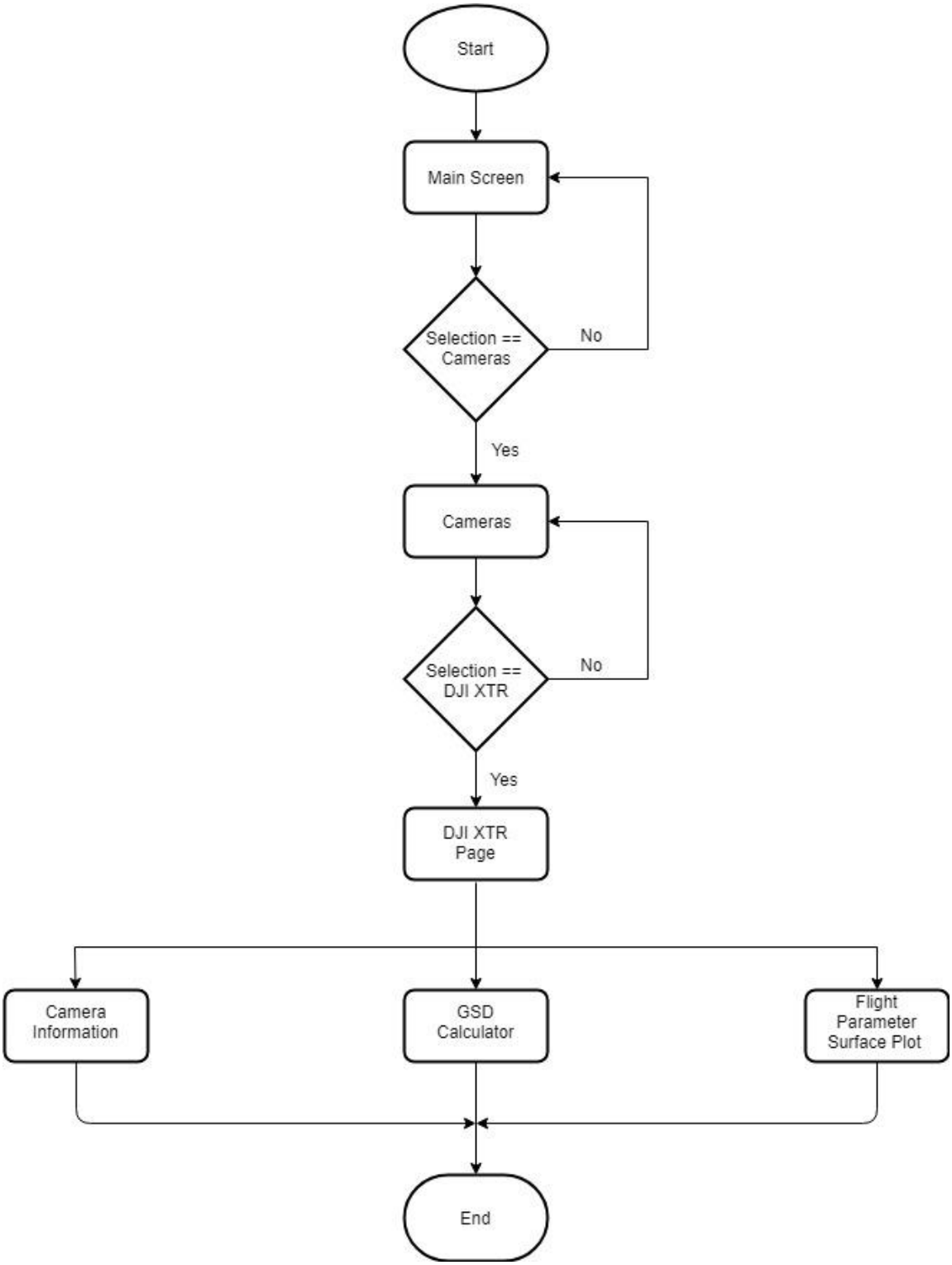


Figure 63: DJI XTR Camera Information Page Flowchart

11. DJI Z30 Camera Information Page Flowchart

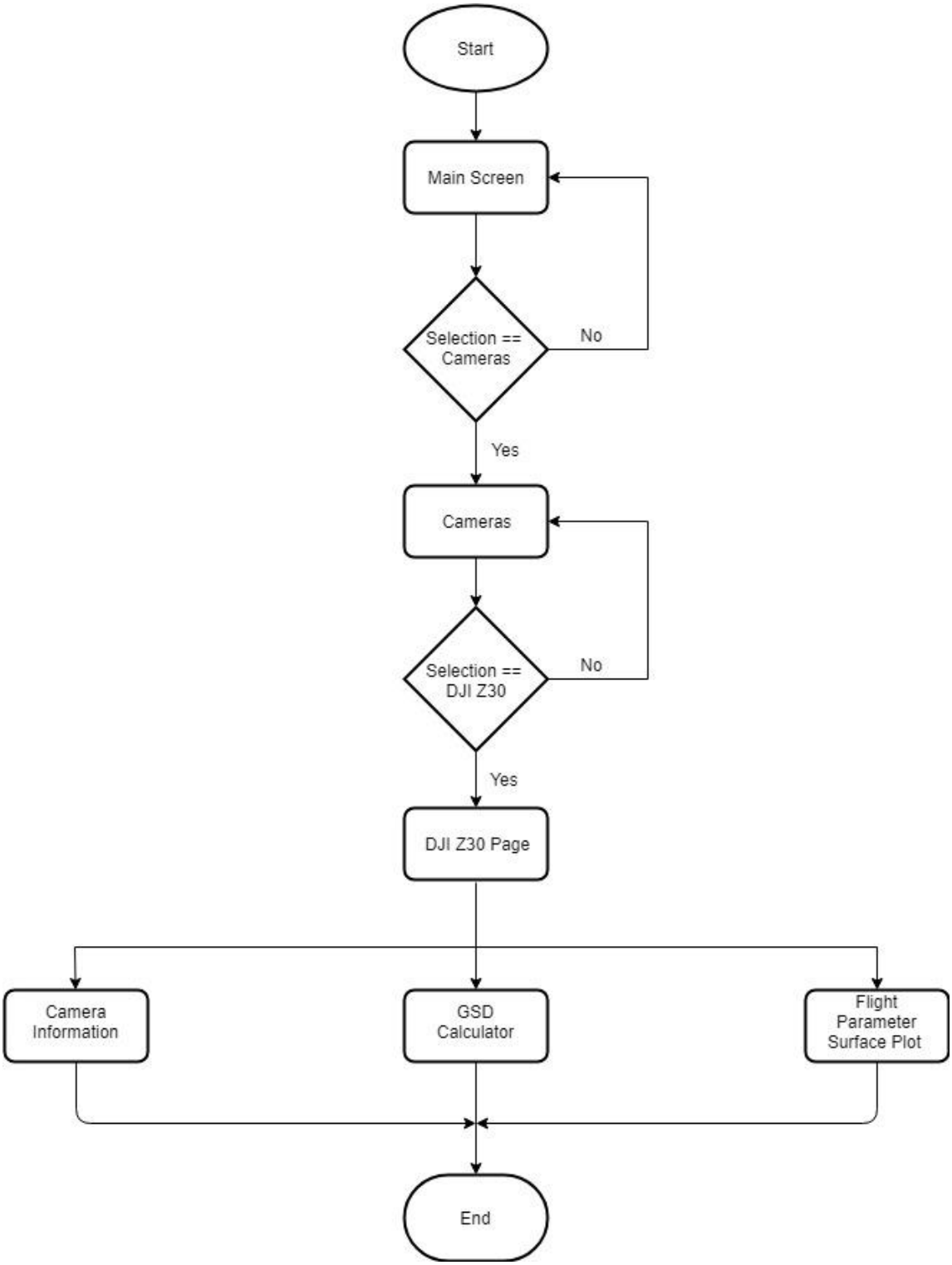


Figure 64: DJI Z30 Camera Information Page Flowchart

12. GSD Calculator Page Flowchart

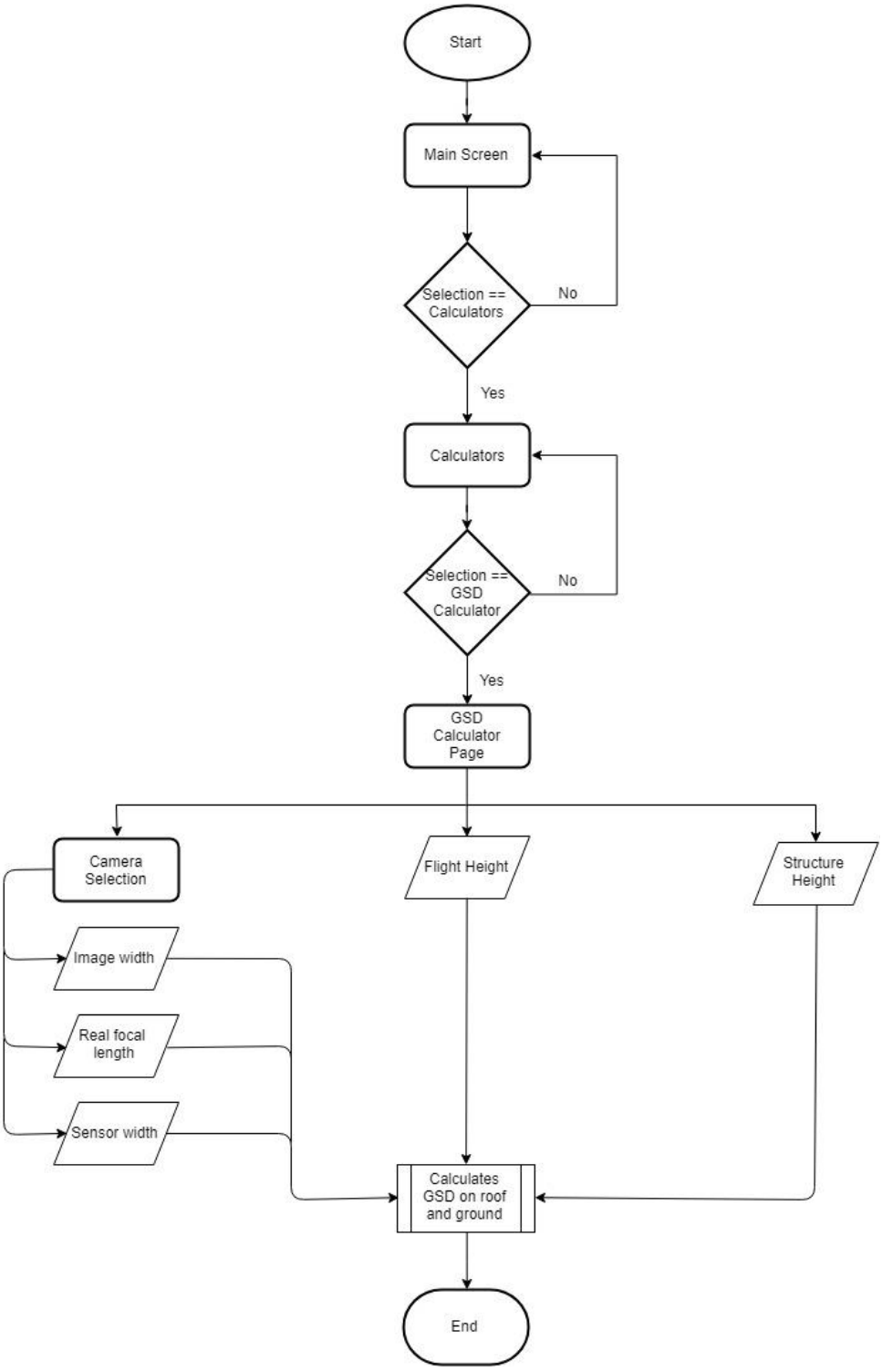


Figure 65: GSD Calculator Page Flowchart

13. Image Overlap Calculator Page Flowchart

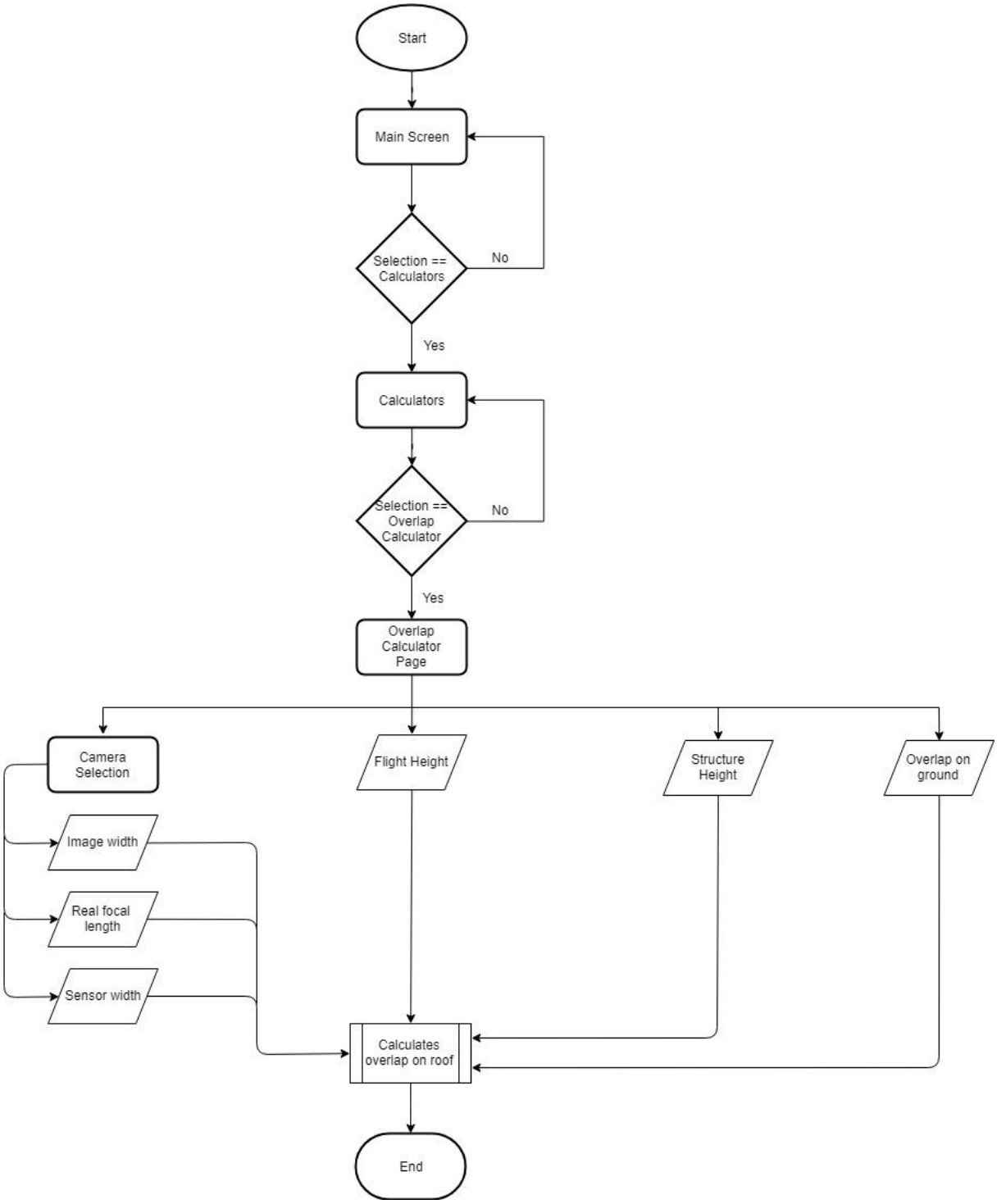


Figure 66: Image Overlap Calculator Page Flowchart

14. Flight Parameter Surface Plot Generator Page Flowchart

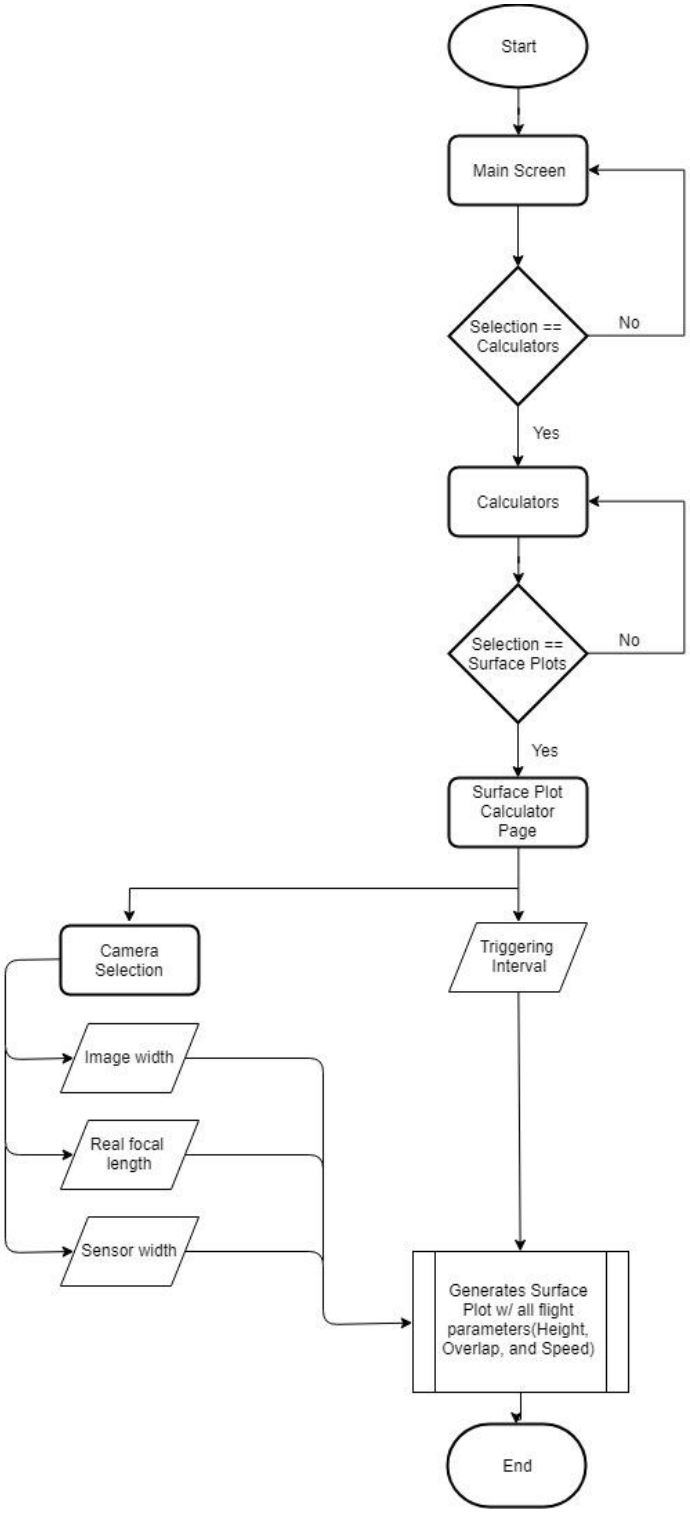


Figure 67: Flight Parameter Surface Plot Generator Page Flowchart

15. Distance Between Coordinates Calculator Page Flowchart

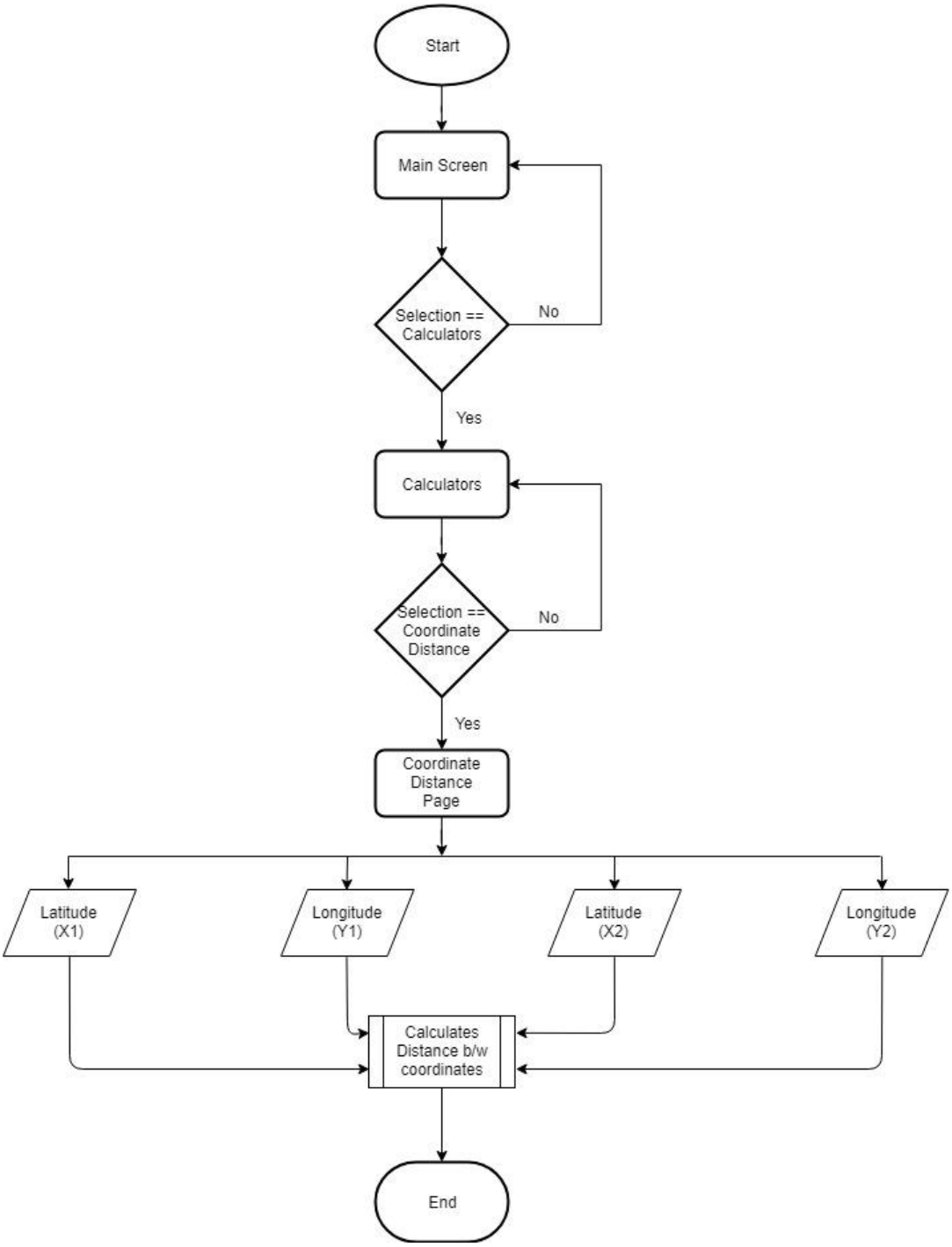


Figure 68: Distance Between Coordinates Calculator Page Flowchart

16. Application Information Page Flowchart

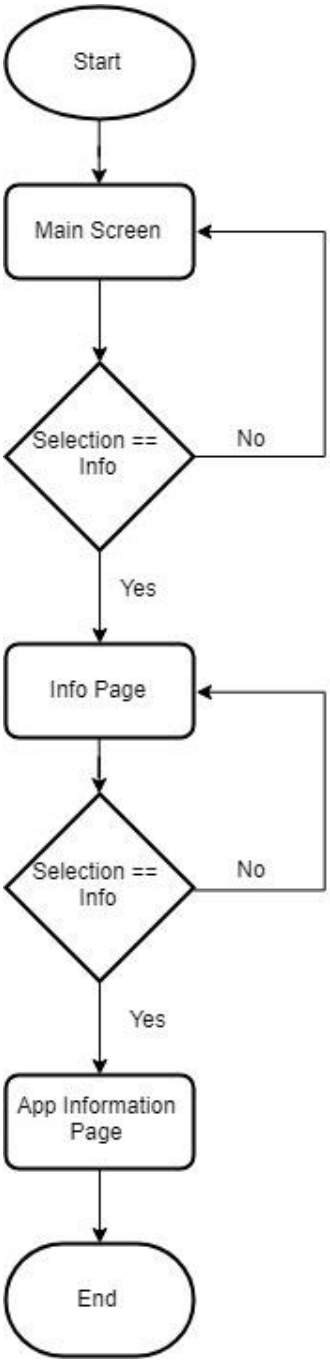


Figure 69: Application Information Page Flowchart

17. Application FAQ Page Flowchart

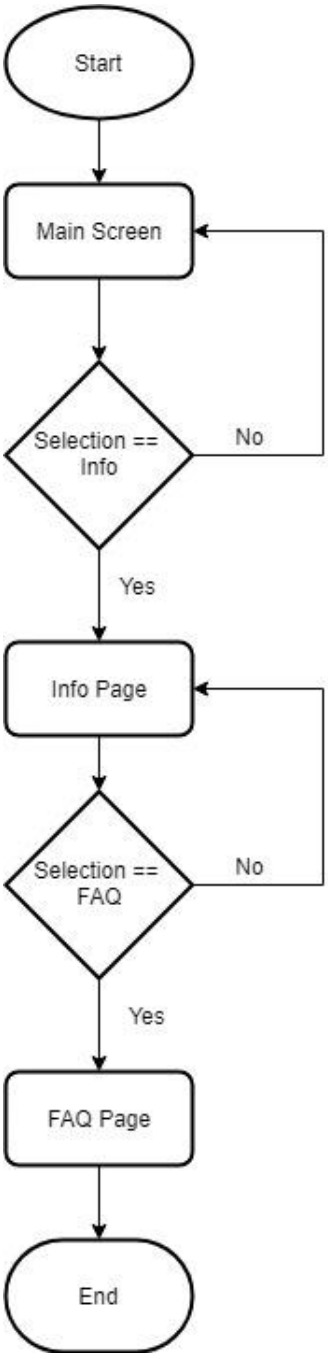


Figure 70: Application FAQ Page Flowchart

18. Standard Operating Procedures Page Flowchart

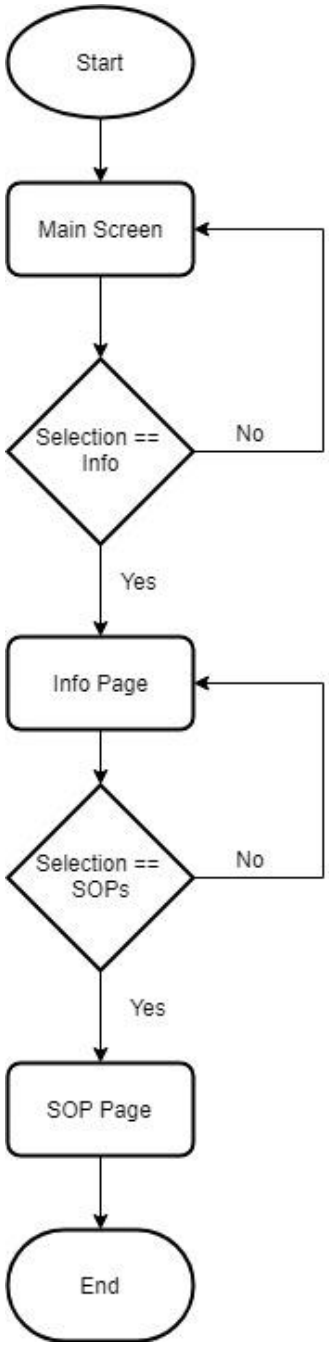


Figure 71: Standard Operating Procedures Page Flowchart