Autonomous Water Quality Sampler

Operations Manual – April 2012

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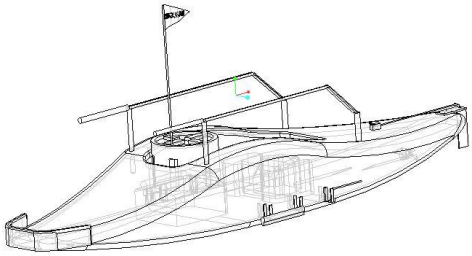

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1 General Information

1.1 Introduction

AWQuSam is a turn-key autonomous water quality sampler to be utilized for acquiring hydrographic and water quality data by the Florida State University Department of Oceanography. As requested in the solicitation, the system was designed and implemented to support the gathering of water quality and hydrographic data along Florida's coastal environment. The AWQuSam is a propeller-driven kayak capable of driving itself across a bay, at least 5km, navigating with GPS, recording key oceanographic parameters, and relaying samples of data to a base station.

To accomplish these tasks, the AWQuSam employs means that facilitate acquisition of useful scientific data, such as temperature and salinity, in the shallow environments of the Florida shelf. Signal processing is performed via a PIC microcontroller aboard the AWQuSam. All acquired data is logged onto an SD memory card for analysis by researchers.

A GPS system has been incorporated into the AWQuSam for use by the navigation, guidance and recovery systems. In addition to the AWQuSam, a base station was developed in order to receive streamed data from the AWQuSam.

The primary objective of the AWQuSam is to remain autonomous, navigating and performing the aforementioned tasks, for the duration of the trip.

Prior to the implementation of this design, there was no such autonomous system for effectively collecting hydrographic data in shallow environments. The team believes their creative and potentially transformative design implementation will revolutionize oceanographic research by advancing discovery in this area.

1.2 Operating Environment

The AWQuSam will be operated in the shallow environment of the Florida coastal shelf. It will be operated and/or stored in a salt-air atmosphere with humidity levels potentially reaching 100%. While operating, the AWQuSam may experience extended exposure to sunlight. During the summer months, the AWQuSam may be stored in temperatures of up to +70°C and while operating, may be exposed to temperatures of up to +55°C. In addition, the AWQuSam may experience winter storage temperatures as low as -20°C and operating temperatures of -5°C. The AWQuSam may experience crashing waves of up to 1m in height, winds of 40knots, and driving rainfall. These conditions have all been considered in the design of the AWQuSam.

1.3 Intended Users

The AWQuSam is intended to be used by oceanographic researchers. It will primarily be deployed by users with at least a Bachelor's degree and knowledge of the system. However, the AWQuSam may be deployed by individuals with no knowledge of the system, and it shall be designed to allow such a user to deploy the system with the aid of user documentation which will be provided among project deliverables (See Section 1.6). Untrained personnel will be able to program a new mission path into the AWQuSam with only the aide of instructional documentation which will be provided by the project team. Once deployed, the AWQuSam will be fully autonomous. Collected data will be analyzed by oceanographic researchers.

The AWQuSam will be used to collect precise hydrographic and water quality parameters near the surface of the Apalachicola bay area and other shallow water environments. It will record water temperature and conductivity information. The AWQuSam will be used to collect this oceanographic data in an environment where there is presently no effective method for collecting such data. It is not intended to collect data on land or in deep ocean environments.

2 Specifications

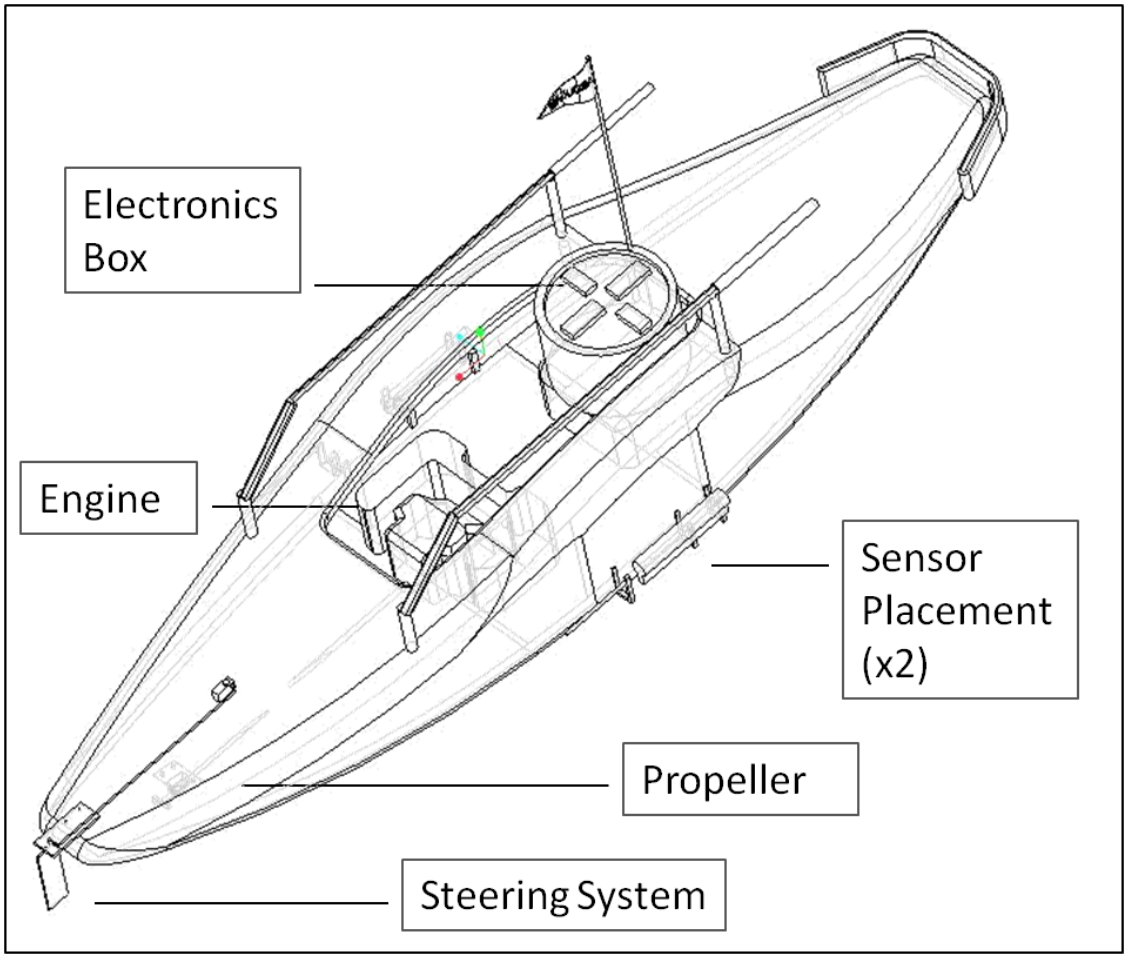
Autonomous Water Quality Sampler, AWQuSam

Engine	
Type	Air cooled 4 stroke OHC petrol engine
Cylinder Sleeve Type	Aluminum Cylinder
Bore x Stroke	39 x 30mm
Displacement	35.8 cm3
Compression	8.0 : 1
Net Power	1.0 kW (1.3 HP) / 7000 rpm
Max net torque	1.5 Nm / 0.16 Kgm / 5500 rpm
Ignition System	Transistorised
Starting System	Recoil
Fuel Tank Capicity	0.63 l
Fuel consumption at rated power	0.71 L/hr – 7000 rpm
Lubrication	Crankcase Pressure Driven
Engine Oil Capacity	0.1 l
Dimensions (L x W x H)	198 x 234 x 240 mm
Dry Weight	3.33 kg
Performance	
Minimum turning radius	3.0 m
Cruising Range	~10 km
Max speed	~6.0 knots
Dimensions	
Overall length	7.8 ft
Overall width	1.6 ft
Overal height	1.2 ft
Hull mass	33 lbs
Fuel tank capacity	2 gallons
Electrical Equipment	
Development board	Microship Explorer16
Power supply	Microship 9V Wall Mount
Programming module	Microship dsPIC PIM
Data logging	Microship SD PICtail Daughter Card
Hardware debugger	Microship In-Circuit Debugger
Software	Microship MPLAB IDE
Battery	SRM-24 12V Battery
Conductivity Sensor	SBE-4
Temperature Sensor	Omega OL-710
Transmission Equipment	
Radio transceivers	Dakota Alert MURS Radio
Antenna	Firestik MURS45 Antenna
Navigation Equipment	
GPS	Sparkfun 20 Channel EM-406A SiRF III Receiver with Antenna
Autopilot	Sparkfun ArduPilot - Arduino Compatible UAV

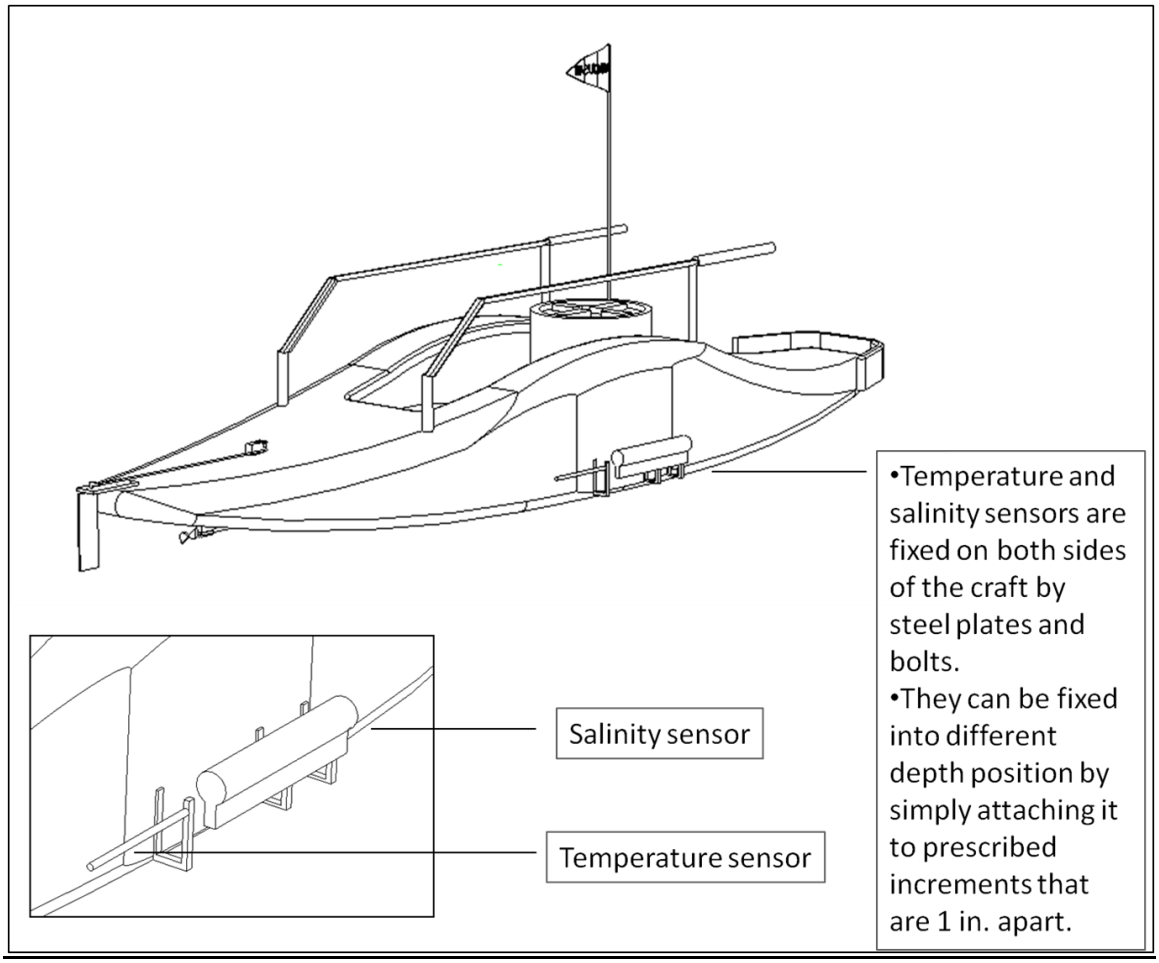
	Controller w/ ATMega328
In-Circuit Debugger	FTDI Basic Breakout - 5V & USB Mini-B Cable - 6 Foot
Servo	TRX2075-Digital Waterproof Servo
GPS	Sparkfun 20 Channel EM-406A SiRF III Receiver with Antenna
Autopilot	Sparkfun ArduPilot - Arduino Compatible UAV Controller w/ ATMega328
Mechanical Equipment	
Hull	Riot Kayak Trickster
Propeller	Prather 2.8 in diameter, 4.5 inch pitch counterclockwise
Engine	Honda GX35

3 Parts Location and Component Diagrams

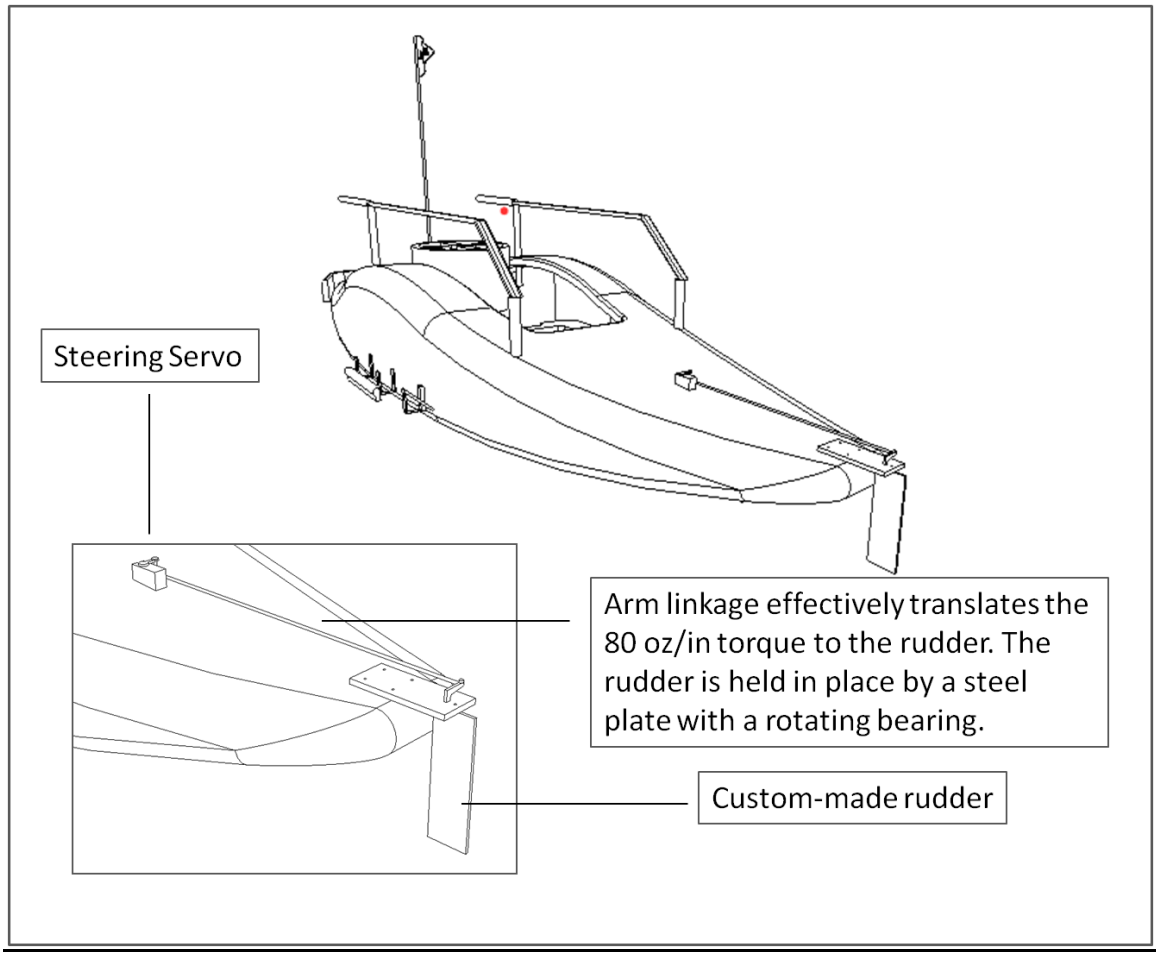
Main components location



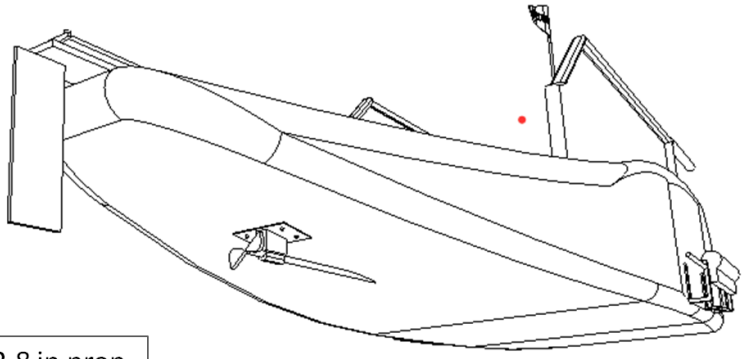
Sensor placement



Steering system

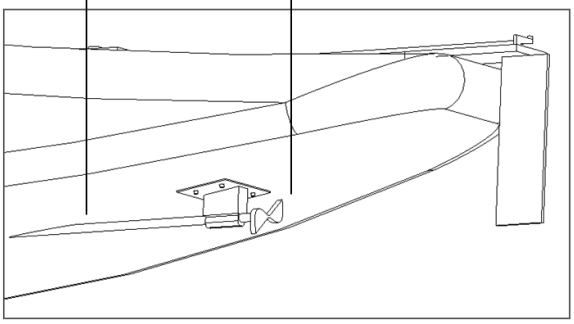


Propulsion system



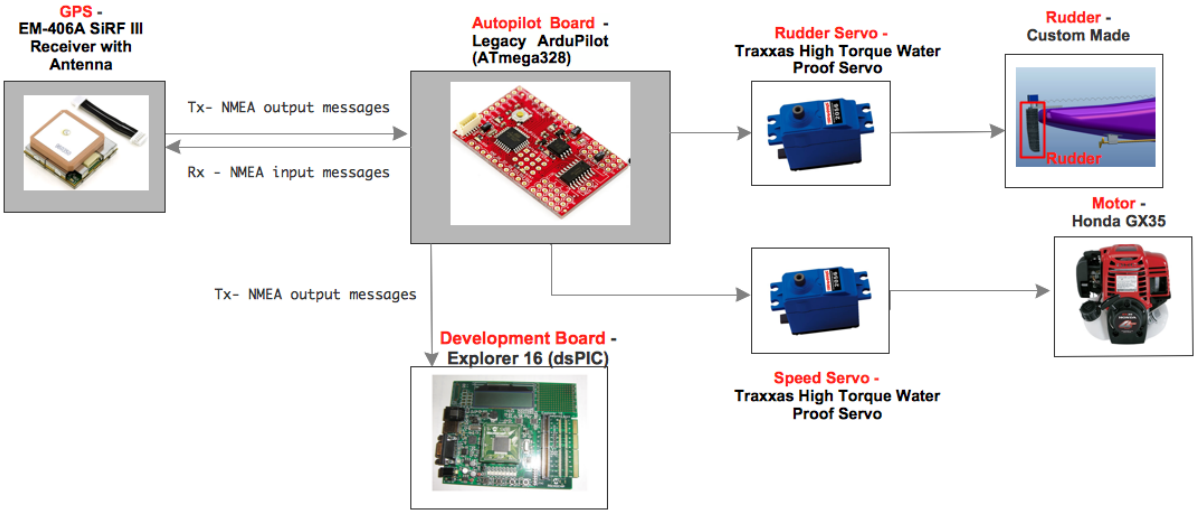
Flexible shaft

2.8 in prop.

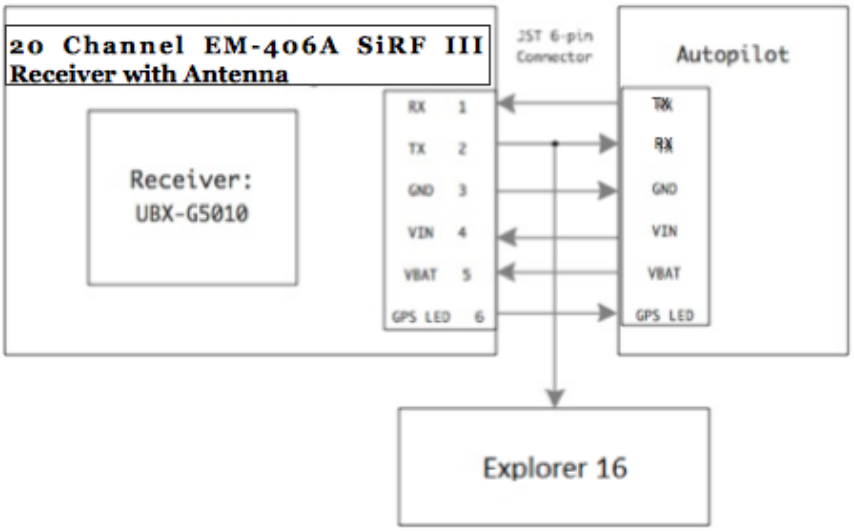


•Torque from the motor is transmitted to the propeller through a flexible shaft. This allows for the motor to be placed in a stable operating-friendly position.
•The shaft is held in position by an aluminum strut bolted to the bottom of the kayak and all the force is transmitted there.

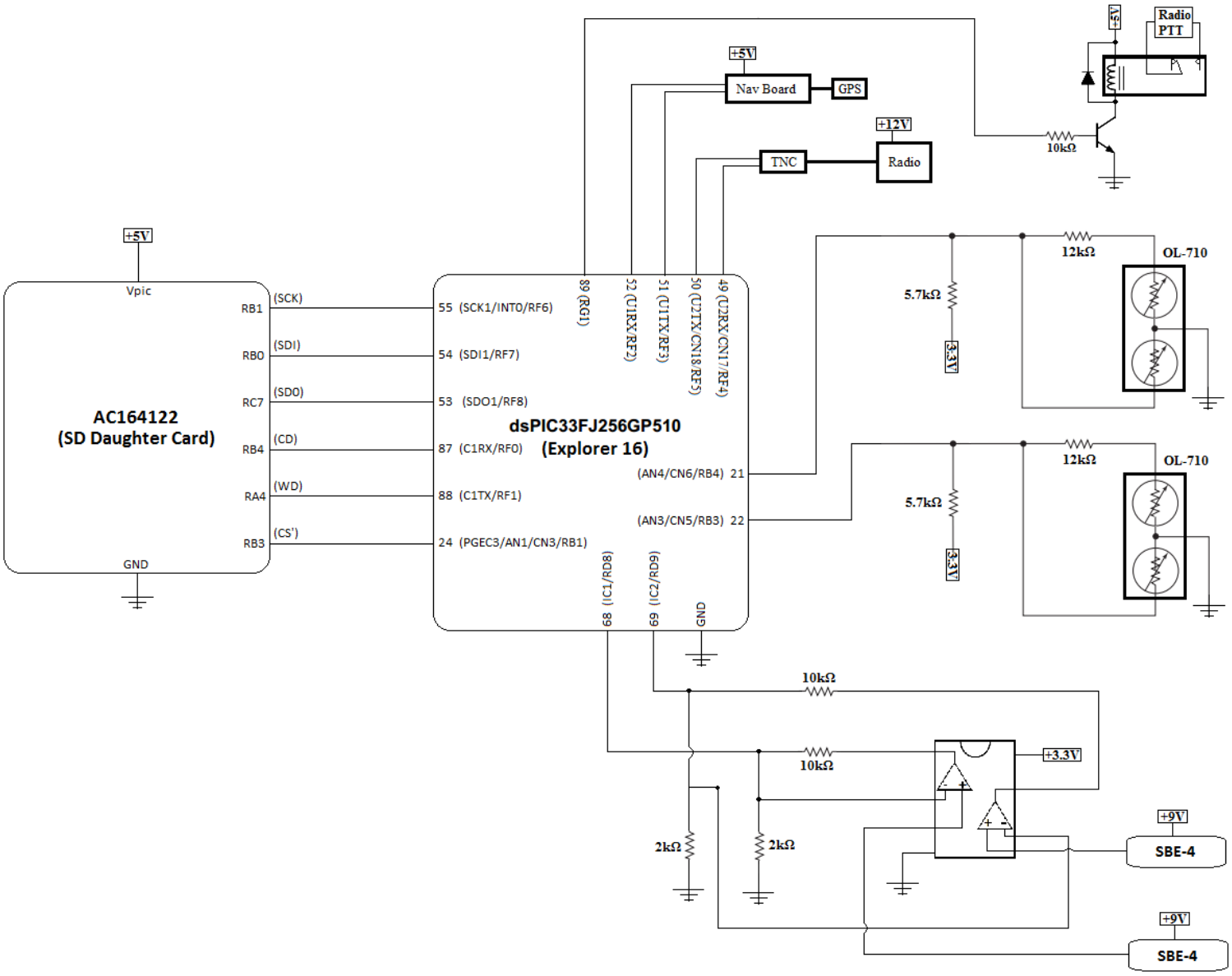
Top level architecture for navigation system



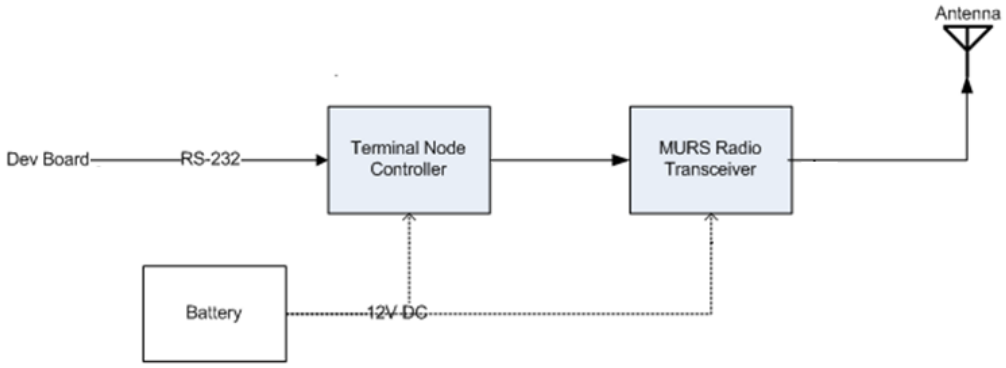
GPS Smart Antenna Engine Board

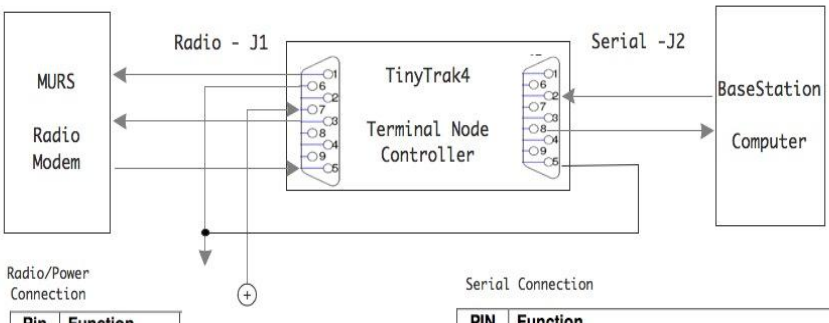


Explorer16 System Schematics



Top-level block diagram of Data Transmission System



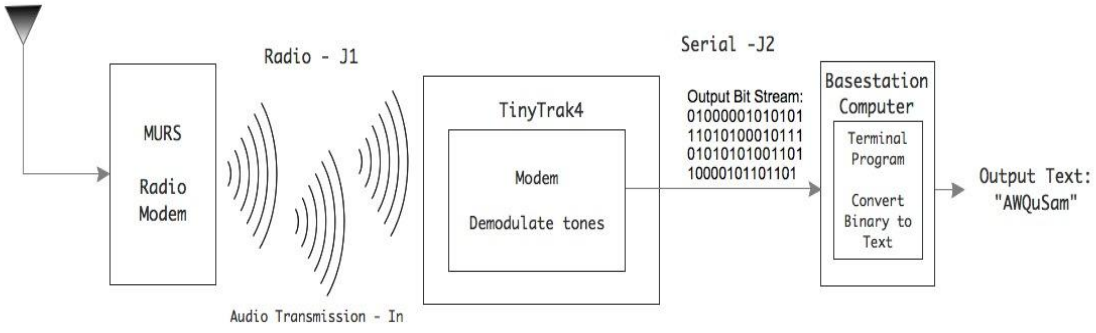


Radio/Power Connection

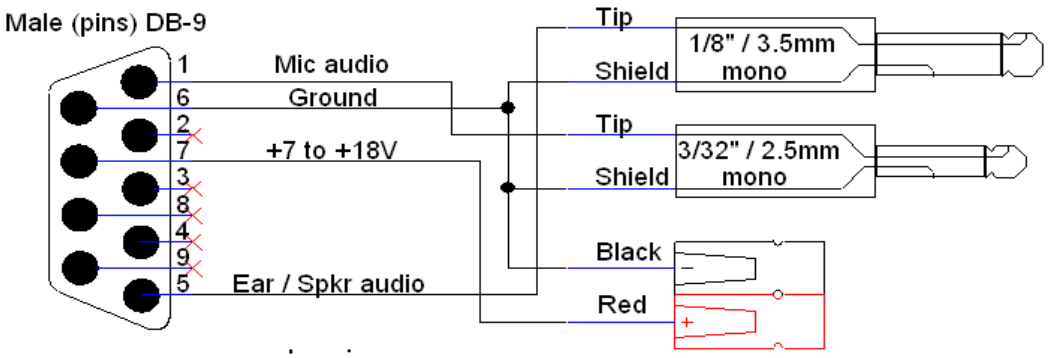
Pin	Function
1	Audio out
2	Carrier Detect
3	PTT Out
4	JP1
5	Audio in
6	Ground
7	Power In
8	PTT In
9	No connection

Serial Connection

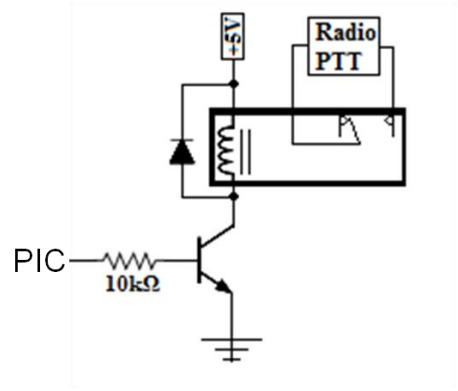
PIN	Function
1	No Connection
2	Primary Serial data in from a GPS or computer
3	Primary Serial data out to a GPS or computer
4	Power out for GPS (Vin or 5V), or alternate power input
5	Ground
6	No Connection
7	Secondary Serial data out to a GPS or computer
8	Secondary Serial data in from a GPS or computer
9	No Connection



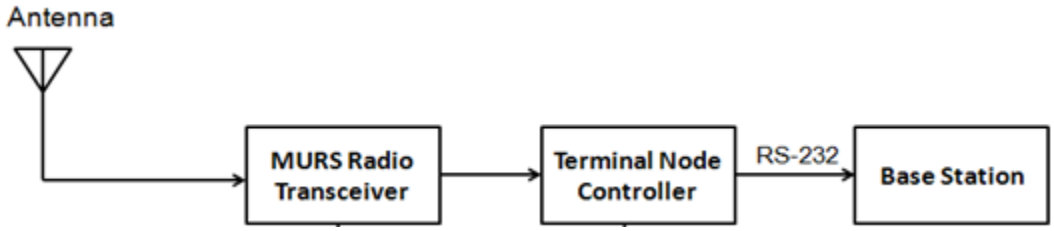
Terminal Node Controller to M538-BS Interface



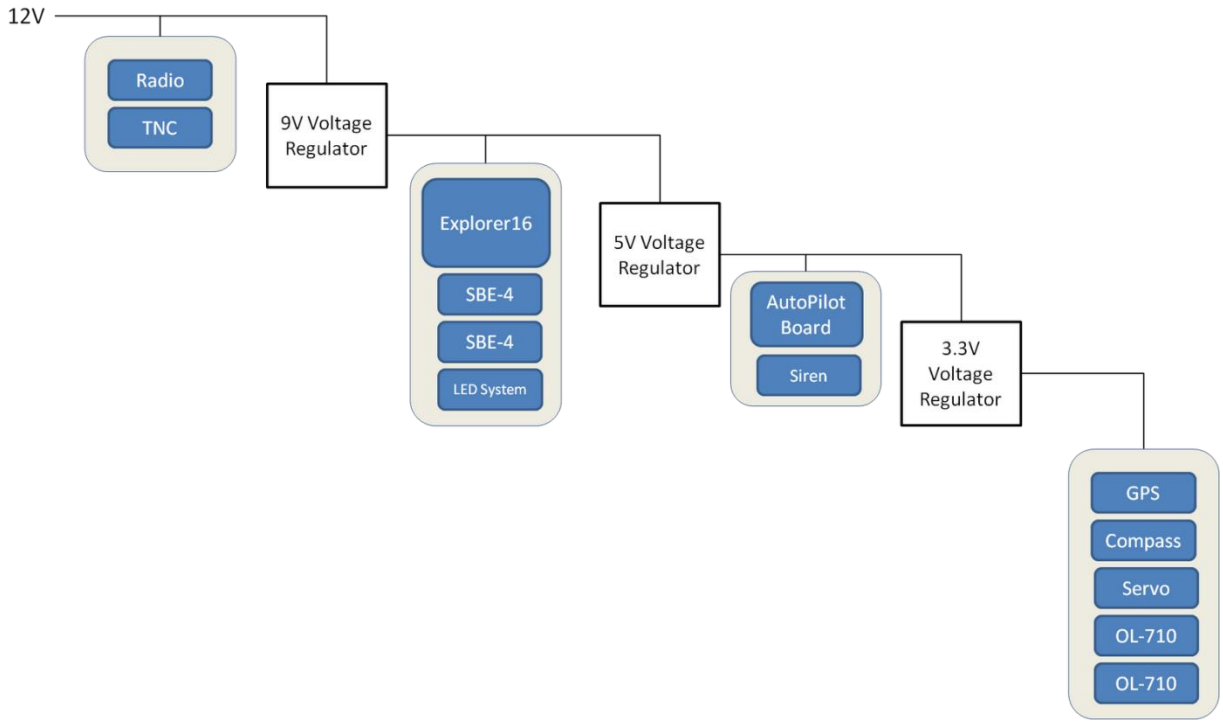
Radio PTT Switch



Top-level block diagrams of Base Station Receiver



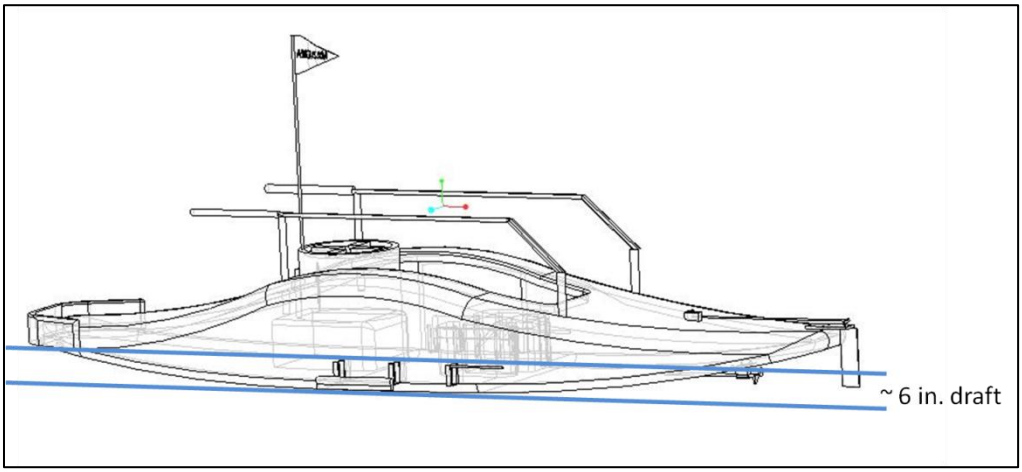
Power System Architecture



4 Operating Instructions

4.1 Operating Rules

- Always follow these rules when operating the AWQuSam.
- Always comply with any navigation rules in your area.
- Check the throttle and steering before starting the engine.
- Look carefully around you for other boats, objects, or people before setting up the navigation path.
- Always choose a path to avoid collisions.
- Operator should supervise the vehicle while in operation.
- Avoid operating the craft in waters full of weeds or debris.
- Avoid operating the craft in waters that are shallower than 6 inch.
- Avoid operating the craft through rough storms or heavy rain for it may sink it.
- The operator must judge what a safe speed is taking into consideration visibility, traffic, weather conditions, waves, etc.



4.2 Transporting

- The AWQuSam needs to be carried by a minimum of two people. It has two handles on each end.
- When transporting the vehicle on a trailer, observe the placement of the propeller and make sure it is not in any pressure. Also follow the trailer laws and regulations in your area.
- Be sure the trailer matches with the craft's weight and hull design.
- Securely fasten the craft and trailer.

4.3 Navigation

1. Setup

Download:

a. *Arduino software*: arduino.cc/hu/Main/Software
b. *Download Google Earth:* earth.google.com/download-earth.html
c. *Team #8 Ardupilot code*:
https://docs.google.com/open?id=0B6ErVucXM3pJV3haM21kaERfY00

2. Mission Planning

Utilize Google Earth to plan a mission.

i. Open Google Earth and navigate to mission location

ii. Click "Add Path" icon ->  , then plot several waypoints throughout the body of water that you are testing in.

iii. Click "Show Ruler" icon->  to ensure that the distance between waypoints is greater than the ***waypoint distance variable*** you set in defines.h file.

iv. Save path as a .kml file, then open file in a text editor application [i.e. notepad, textedit, etc.] so that you may copy and paste the latitude and longitude coordinates directly into the waypoint.h file.

--> When editing coordinates ensure that you (1) delete all the extra zeros and, (2) remove the comma at the end of the last coordinate

v. Optional: Default waypoint radius is 5 m. You may change it to a larger value if desired. ***Warning***: Do not set waypoint distance less than 5 m or AWQuSam will maneuver in circles while attempting to get as close to the waypoint as possible.

3. Programming Ardupilot

i. Ensure servos connections, gps connector and transmission pin to Explorer 16 are disconnected from the Ardupilot
ii. Plug the FTDI programmer into the board while ensuring that the pin labels on the device match the pin labels on the Ardupilot, then attach the usb cable to the other end of the programmer while its other end is connected to your computer.
iii. Compile the Ardupilot code to ensure there are no errors, then power the Ardupilot either via the AWQuSam's power supply or from a separate 5 V source. Once Ardupilot is powered download code to board, then power board off.
iv. Plug steering servo into Servo Out 2 and speed servo into Servo Out 1, ensuring to place the darkest of the three servo lines nearest the board edge.

v. Before powering board on, ensure that the rudder and blade? are free of obstacles. If powering the board in water ensure that you do not start it to close to the shore or the rudder will get restricted by the ground.

vi. When ready to begin mission, turn board on, ensure all containers containing electronics are sealed, and stand clear of propeller

vii. AWQuSam will begin to function on its own once a valid satellite fix is found. There will be times where it may find a satellite fix instantly or you may have to wait a 1-15 minutes for a satellite fix depending on how long it has been since the last time the gps was turned on.

4.4 System Power Up

1. Ensure desired GPS waypoints are entered into AWQuSam. See Section 4.3
2. Insert SD Card
3. Crank Motor. See Section 4.8
4. Place Power Switch in "ON" position
5. Vehicle will begin moving when GPS is acquired. Keep away from propeller!

4.5 System Shutdown

When retreiving AWQuSam, first disengage engine by pressing Motor Shutoff button.

When the final waypoint is reached, "Mission Complete" should be displayed on LCD. If so, it is safe to place Power Switch in "OFF" position.

If retrieving AWQuSam before final waypoint is reached, Press and hold S3 button on Explorer16 until "Mission Complete" message appears on LCD display.

Once "Mission Complete" message appears, it is safe to place Power Switch in "OFF" position. SD Card can be safely removed.

Important: If SD Card is removed before "Mission Complete" is displayed, data may become corrupted or lost. SD Card may require formatting before it will function properly.

4.6 Data Structure

Data on SD Card and data transmitted in real time is formatted as follows:

Time Latitude Longitude Cond1 Cond2 Temp1 Temp2

An example log entry is shown below.

152712.148 2955.4348N 08424.8626W 4.741 4.728 22.54 22.20

The first column represents a time of 15:27:12 (and 148ms) UTC. Latitude and longitude reports columns are to be intepreted as follows: The two digits immediately to the left of the decimal point are whole minutes, to the right are decimals of minutes, and the

remaining digits to the left of the whole minutes are whole degrees. For example, the second column of the above log entry represents 29 degrees and 55.4348 minutes. Similarly, the third column is 84 degrees and 24.8626 minutes.

The fourth column is the conductivity measured on the left side of theAWQuSam. The temperature corresponding to this measurement is shown in the sixth column. Similarly, the fifth and seventh columns represent data acquired from the right side of the AWQuSam.

4.7 Base Station Setup

Place components in the configuration shown in Figure 4.4.1

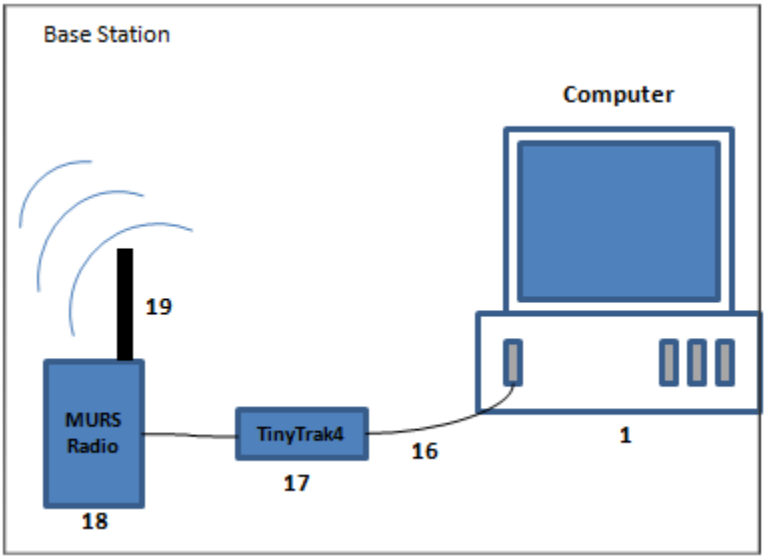


Figure4.4.1: Base Station Configuration

On the test computer, install a RS-232 terminal (such as Termite: http://www.compuphase.com/software_termite.htm)

Configuration terminal application to monitor the appropriate COM port with 19200 baud.

Data will be displayed as it is transmitted by the AWQuSam.

4.8 Propulsion

Check the general condition of the engine

1. Look around and underneath the engine for signs of oil or gasoline leaks.
2. Remove any excessive dirt or debris, especially around the muffler and recoil starter.

3. Look for signs of damage.
4. Check that all shields and covers are in place, and all nuts, bolts, and screws are tightened.
5. Check that there is enough fuel for the duration of the mission.
6. Check the air filter. A dirty air filter will restrict air flow to the carburetor, reducing engine performance.

Starting the engine

1. To start a cold engine, move the choke lever to the CLOSED position.
   To restart a warm engine, leave the choke lever in the OPEN position.
2. Press the priming bulb repeatedly until fuel can be seen in the clear-plastic-fuel-return tube.
3. Turn the engine switch to the ON position
4. Pull the starter grip lightly until you feel resistance, then pull briskly. Return the starter grip gently.
5. If the choke lever was moved to the CLOSED position to start the engine, gradually move it to the OPEN position as the engine warms up.

5 Storage

Whenever the craft will not be in use for more than 30 days, proper storage is essential. It consists of checking and replacing missing or wom parts; lubrication parts to ensure that they do not become rusted; and, in general, preparing the watercraft so that when the time comes to use it again, it will be in top condition.

- The AWQuSam should not be stored at a temperature greater than 50 ºC or below – 5 ºC.
- Empty fuel tank for gasoline will deteriorate.

6 Maintenance

6.1 Engine

Maintenance Schedule

- Engine oil should be changed after 10 hours of operation.
- Air filter should be clean after 25 hours of operation
- Spark plug needs to be replaced after 200 hours of use.
- Engine cooling fins need to be checked after 50 hours of use.
- Nuts, bolts, and fasteners need to be checked for every use.
- Clutch shoes need to be checked after 50 hours of use.
- Combustion chamber needs to be cleaned after 300 hours of use.
- Fuel filter needs to be checked after 100 hours of use.
- Fuel tank needs to be cleaned after 100 hours of use.
- Fuel tubes and oil tubes need to be replaced if necessary.

Recommended fuel: Pump octane rating 86 or higher.

Recommended Oil: 4-stroke automotive detergent oil. SAE 10W-30 is recommended by manufacturer.

Operating temperature range: -5 ºC to 40 ºC.