ΑΕΙ ΠΕΙΡΑΙΑ Τ.Τ.
ΣΧΟΛΗ ΤΕΧΝΟΛΟΓΙΚΩΝ ΕΦΑΡΜΟΓΩΝ
ΤΜΗΜΑ ΜΗΧΑΝΙΚΩΝ ΗΛΕΚΤΡΟΝΙΚΩΝ ΥΠΟΛΟΓΙΣΤΙΚΩΝ ΣΥΣΤΗΜΑΤΩΝ

ΠΤΥΧΙΑΚΗ ΕΡΓΑΣΙΑ

Μελέτη - ανάπτυξη αυτόνομου σκάφους

Κωνσταντίνος Ι. Σεϊνταρίδης – Παναγιώτης Δ. Μουστής

Εισηγητής: Δρ Σταμάτιος Αλατσαθιανός, Καθηγητής

ΑΘΗΝΑ
Μάρτιος 2017

ΠΤΥΧΙΑΚΗ ΕΡΓΑΣΙΑ

Μελέτη - ανάπτυξη αυτόνομου σκάφους

Κωνσταντίνος Ι. Σεϊνταρίδης
Α.Μ. 34244

Παναγιώτης Δ. Μουστής
Α.Μ. 34431

Εισηγητής:

Δρ Σταμάτιος Αλατσαθιανός, Καθηγητής

Εξεταστική επιτροπή:

Ημερομηνία εξέτασης:

ΔΗΛΩΣΗ ΣΥΓΓΡΑΦΕΑ ΠΤΥΧΙΑΚΗΣ ΕΡΓΑΣΙΑΣ

Ο/Ηκάτωθι υπογεγραμμένος/η ……………………………………………………, του ……………………………………………, με αριθμό μητρώου …………………….. φοιτητής/τρια του Τμήματος Μηχανικών Η/Υ Συστημάτων Τ.Ε. του Α.Ε.Ι. Πειραιά Τ.Τ. πριν αναλάβω την εκπόνηση της Πτυχιακής Εργασίας μου, δηλώνω ότι ενημερώθηκα για τα παρακάτω:

«Η Πτυχιακή Εργασία (Π.Ε.) αποτελεί προϊόν πνευματικής ιδιοκτησίας τόσο του συγγραφέα, όσο και του Ιδρύματος και θα πρέπει να έχει μοναδικό χαρακτήρα και πρωτότυπο περιεχόμενο.

Απαγορεύεται αυστηρά οποιοδήποτε κομμάτι κειμένου της να εμφανίζεται αυτούσιο ή μεταφρασμένο από κάποια άλλη δημοσιευμένη πηγή. Κάθε τέτοια πράξη αποτελεί προϊόν λογοκλοπής και εγείρει θέμα Ηθικής Τάξης για τα πνευματικά δικαιώματα του άλλου συγγραφέα. Αποκλειστικός υπεύθυνος είναι ο συγγραφέας της Π.Ε., ο οποίος φέρει και την ευθύνη των συνεπειών, ποινικών και άλλων, αυτής της πράξης.

Πέραν των όποιων ποινικών ευθυνών του συγγραφέα σε περίπτωση που το Ίδρυμα του έχει απονείμει Πτυχίο, αυτό ανακαλείται με απόφαση της Συνέλευσης του Τμήματος. Η Συνέλευση του Τμήματος με νέα απόφασης της, μετά από αίτηση του ενδιαφερόμενου, του αναθέτει εκ νέου την εκπόνηση της Π.Ε. με άλλο θέμα και διαφορετικό επιβλέποντα καθηγητή. Η εκπόνηση της εν λόγω Π.Ε. πρέπει να ολοκληρωθεί εντός τουλάχιστον ενός ημερολογιακού 6μήνου από την ημερομηνία ανάθεσης της. Κατά τα λοιπά εφαρμόζονται τα προβλεπόμενα στο άρθρο 18, παρ. 5 του ισχύοντος Εσωτερικού Κανονισμού.»

ΕΥΧΑΡΙΣΤΙΕΣ

Η παρούσα πτυχιακή εργασία ολοκληρώθηκε μετά από επίμονες προσπάθειες, σε ένα ενδιαφέρον γνωστικό αντικείμενο, όπως αυτό της ρομποτικής. Την προσπάθειά μας αυτή υποστήριξε ο επιβλέπων καθηγητής μας, κ. Σταμάτιος Αλατσαθιανός τον οποίο θα θέλαμε να ευχαριστήσουμε.

ΠΕΡΙΛΗΨΗ

Η παρούσα πτυχιακή εργασία πραγματεύεται τη δημιουργία ενός αύτονομου - μη επανδρομένου σκάφους. Για την υλοποίηση του έχουν χρησιμοποιηθεί καινοτόμες τεχνολογίες, με πολλά πλεονεκτήματα και δυνατότητες.

Αρχικά, αξίζει να σημειωθεί πως προκειμένου να επιτευχθεί το τελικό αποτέλεσμα, το σχήμα του σκάφους προήλθε από ένα συνδυασμό σχεδίασης και προσομοίωσης με την βοήθεια των προγραμμάτων autocad και flowdesign. Τα κύρια υλικά κατασκευής του σκάφους είναι τα ανθρακόνηματα και τα υαλονήματα.

Παράλληλα επισημαίνεται πως ο κύριος ελεγκτής του συστήματος είναι το raspberry pi A+ με λειτουργικό σύστημα Raspbian/Debian με cpu στα 700mhz και ram στα 256mb.

Στη συνέχεια είναι αξιοπρόσεκτο πως η ώθηση επιτυγχάνεται με δύο ηλεκτροκινητήρες τεχνολογίας brushless, ελεγχόμενοι από αντίστοιχους microcontrollers τεχνολογίας esc, όπου και γίνεται σύγκριση με τεχνολογίες κινητήρων παλαιότερου τύπου.

Επιπροσθέτως, τα ηλεκτρονικά εξαρτήματα τροφοδοτούνται από μία μπαταρία τεχνολογίας li-polymer και οι κινητήρες από δύο μπαταρίες fast discharge li-polymer.

Τέλος, το σκάφος συνδέεται στο διαδίκτυο μέσω mobile broadband modem(3G) και ο χειρισμός του πραγματοποιείται απομακρυσμένα μέσω σύνδεσης SSH με cloud server της IoT(internet of things) εταιρείας Weaved Inc.

Συμπεραίνουμε, λοίπον, ότι η σχεδίαση και η κατασκευή του αυτόνομου σκάφους έγινε με γνώμονα την ασφάλεια, την ευελιξία στην χρήση και την οικονομία ενέργειας κατά την διάρκεια της πλεύσης.

ABSTRACT

In the present study, the construction of an autonomous - unmanned vessel is presented. Several innovative technologies have been used for its implementation, each has a great amount of advantages and potentials.

First of all, we have to notice that for the final result, the shape of the vessel came from the combination of the design and simulation, helped by the Autocad and Flowdesign tools. The vessel is constructed mainly by carbon and fiberglass.

Furthermore, it is noted that the main system controller is the Raspberry Pi A+(cpu: 700mHz, ram: 256mb) with the Raspbian/Debian operating system.

It is also remarkable that the propulsion is achieved by two electric brushless motors, which are controlled by corresponding ESC micro controllers. At this point, there is a comparison with older types of motors.

Moreover, the electronic components are supplied by a li-polymer battery and the motors by two fast discharge li-polymer batteries.

In addition, it is important to say that the vessel is connected to the internet via a mobile broadband modem(3G) and the remote control depends on SSH connection with a cloud server provided by the IoT(internet of things) company Weaved Inc.

To conclude, the design and the structure of this vessel have been done based on the safety, the flexibility in use and the energy efficiency during the flow.

ΕΠΙΣΤΗΜΟΝΙΚΗ ΠΕΡΙΟΧΗ: Ρομποτική, Λειτουργικά συστήματα, Προγραμματισμός

SCIENTIFIC FIELD: Robotics, Operating systems, Programming

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ / KEY WORDS: Autocad, Flow design, Raspberry pi, Autonomous boat, Vessel, Brushless, Motor, Python, remote control, Σκάφος.

Table of Contents

CHAPTER 4 - Rotatory brush and brushless DC motor technologies

CHAPTER 5 - Lithium polymer battery

CHAPTER 6 - Mobile broadband modem

CHAPTER 10 - The making of the autonomous surface vehicle

CHAPTER 11 - APPENDIX A

Figure catalogue

Picture Catalogue

Table Catalogue

ΣΥΝΤΟΜΟΓΡΑΦΙΕΣ

.NET	Software framework developed by Microsoft
2.5G	2.5 generation
2D	2 dimension
2G	2 generation
3.5G	3.5 generation
3D	3 dimension
3G	3 generation
Ac	alternating current
API	Application Programming Interface
ARX	AutoCAD Runtime eXtension
BA	BinaryAlphaBlocks
BAP	Binary Alpha Planes
BEC	Battery eliminator circuit
Bldc	Brushless DC
BLM	Brushless motor
BMA	Block Matching Algorithm
Bsd	Berkeley Software Distribution
C	commulator
CAD	Computer-aided design
CDMA2000	code-division multiple access
CDPD	Cellular digital packet data
CID	Current interrupting device
CNC	Computerized Numerical Control
CPU	Computer processing unit
Dc	Direct current
DC-HSPA+	Dual-Carrier High Speed Packet Access
DRY SPE	dry solid polymer electrolyte
DWF	Design Web Format
DWG	autocad file format .dwg (from drawing)
DXF	Drawing Exchange Format

EDGE	Enhanced Data rates for GSM Evolution
ESC	Electronic speed control
ESRI	Environmental Systems Research Institute
EVDO	Evolution-Data Optimized
Fltk	Fast, Light Toolkit
FRP	fiber-reinforced plastics
Gmbh	Gesellschaft mit Beschrankter Haftung (German:Limited Liability Company; business entity)
GPIO	General Purpose Input/Output
GPRS (2.5G)	General Packet Radio Service
GPS	Global Positioning System
GPU	Graphics Processing Unit
GSM	Global System for Mobile Communication
Gui	Graphical User Interface
HiperMAN (**pre-4G**)	High Performance Radio Metropolitan Area Network
HSCSD	High-Speed Circuit-Switched Data (GSM technology)
HSDPA	High Speed Data Packet Access
HTTP	HyperText Transfer Protocol
I2C	Inter-Integrated Circuit
iBurst (**pre-4G**)	iBurst is a mobile broadband wireless access system
IMO	The International Maritime Organization
IOS	iPhone Operating System (Apple)
IOT	internet of things
IP	Multimedia Subsystem
ISP	internet service provider
ISYBAU	file format(Germany)
Kodi	(formerly XBMC) is a free and open-source media player
li-ion	Lithium Ion (battery)
Lipo	lithium polymer
LISP	List Processing (programming language)
LT	low cost version(light)
LTE	Long Term Evolution (3GPP 4G technology)
MEP	Mechanical, Electrical, Plumbing (architectural)

MSRP	Manufacturer's Suggested Retail Price
MX	GENIO file format
NARD SDK	Not Another Raspberry Distribution Software Development Kit
NiCd	Nickel Cadmium (battery technology)
NiMH	Nickel Metal Hydride (battery technology)
NTP	Normal Temperature & Pressure
OKSTRA	file format(Germany)
open ELEC	Open Embedded Linux Entertainment Center
open WRT	Linux distribution for embedded devices
PC	Personal Computer
PCMCIA	Personal Computer Memory Card International Association
PDF	Portable Document Format (Adobe Acrobat)
PISTE	file format(France)
PMC	polymeric matrix composites
porous SPE	porous solid polymer electrolyte
PPP	Point-to-Point Protocol (Internet)
PTC	positive temperature coefficient
RCT	Runtime Compilation Target
SDN	software defined networking
SIM	Subscriber Identity Module (ETSI GSM technical specification)
SoC	system on a chip
SPI	Service Provider Interface
SSH	Secure Shell
SSL	Secure Sockets Layer (Netscape; web security protocol)
TCP/IP	Transmission Control Protocol/Internet Protocol
UK	United Kingdom
UMTS	Universal Mobile Telecommunications System
USB	Universal Serial Bus
VBA	Visual BASIC for Applications (Microsoft)
WCDMA	Wideband Code Division Multiple Access
WiBro	Wireless Broadband
WIFI	[not an acronym] (IEEE 802.11b wireless networking; coined from Wireless Fidelity, a play on High Fidelity)

WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network
XBMC	Xbox Media Center
XML	Extensible Markup Language

Chapter 1: Introduction

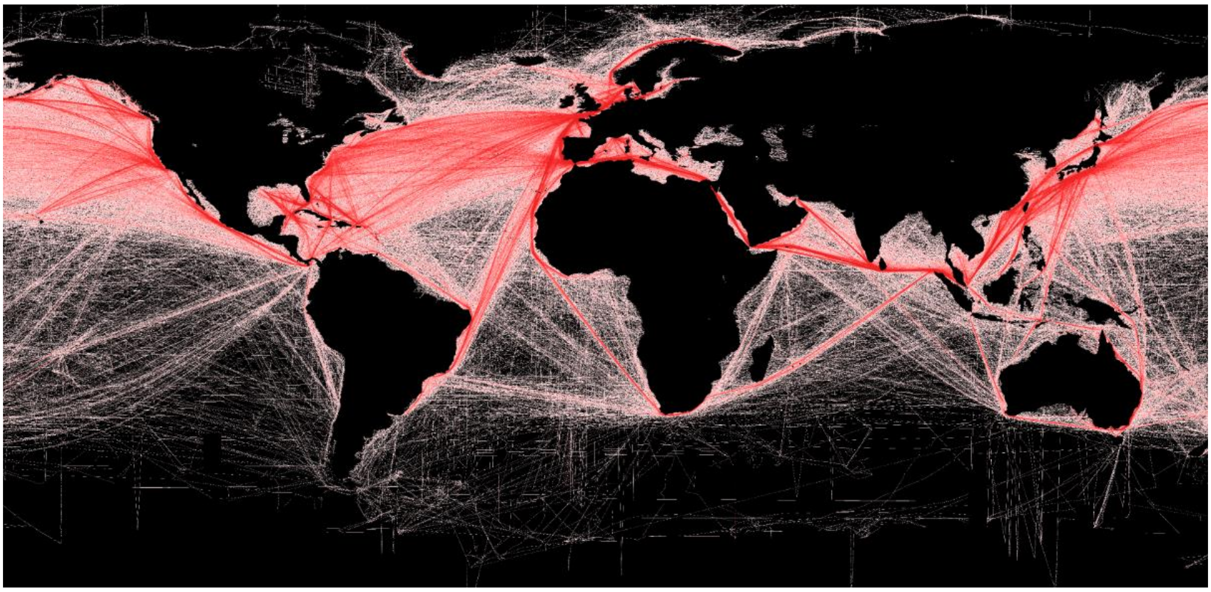

IMAGE 1.1: Global shipping routes

Having lived more than 25 years in the country with the largest merchant marine, we would like to emphasize the following disadvantages which led us to the main concept of the project.

- Due to maritime traffic on the world's oceans has increased four-fold over the past 20 years, more and more people have to be exposed in the hard work environment of a ship crew. Around 150 deaths annually caused by work accidents and wracks.
- The physical presence of the crew is still mandatory if needs to transfer a cargo from point A to point B.
- The crew stays on the ship for months or years, causing a problem to young people to start a family or to grow up children without absence of a parent.
- Higher final price for the products because of the limit automation and limit of human resources.
- The environmental impact of shipping includes greenhouse gas emissions, acoustic, and oil pollution. The International Maritime Organization (IMO)

estimates that Carbon dioxide emissions from shipping were equal to 2.2% of the global human-made emissions in 2012 and expects them to rise by as much as 2 to 3 times by 2050 if no action is taken.

- Extra cost for the shipping companies and extra space in the ship for the facilities and supplies for the crew.

Trying decrease or eliminate the above problems our goal was to create a prototype small scale vessel with the following features: light and strong materials, aerodynamics, hydrodynamics, electric high-efficient motors for propulsion and remote control without range limit.

CHAPTER 2

Materials

2.1 Fibers

Fibers are the principal components in a fiber - reinforced composite material. They occupy the largest volume fraction in a composite laminate and share the Major portion of the load acting on a composite structure. Proper selection of the fiber type, fiber volume fraction , fiber length, and fiber orientation is very important, since it influences the following characteristic s of a composite laminate:

1. Density
2. Tensile strength and modulus
3. Compressive strength and modulus
4. Fatigue strength as well as fatigue failure mechanisms
5. Electrical and thermal conductivities
6. Cost

A number of commercially available fibers and their properties are listed in Table 2.1. The first point to note in this table is the extremely small filament diameter for the fiber s. Since such small sizes are difficult to handle, the useful form of commercial fiber s is a bundle, which is produced by gathering a large number of continuous filaments, either in untwisted or twisted form. The untwisted form is called strand or end for glass and Kevlar fibers and tow for carbon fibers (Figure 2.1). The twisted form is called yarn (Figure 2.2). Tensile properties listed in Table 2.1 are the average values reported by the fiber manufacturers. One of the test methods used for determining the tensile properties of filaments is the single filament test. In this test method, designated as ASTM D3379, a single filament is mounted along the centerline of a slotted

TABLE 2.1: Properties of selected commercial reinforcing fibers

Fiber	Typical Diameter (μm)[a]	Density (g/cm^3)	Tensile Modulus GPa (Msi)	Tensile Strength GPa (ksi)	Strain-to-Failure (%)	Coefficient of Thermal Expansion (10^{-6}/°C)[b]	Poisson's Ratio
Glass							
E-glass	10 (round)	2.54	72.4 (10.5)	3.45 (500)	4.8	5	0.2
S-glass	10 (round)	2.49	86.9 (12.6)	4.30 (625)	5.0	2.9	0.22
PAN carbon							
T-300[c]	7 (round)	1.76	231 (33.5)	3.65 (530)	1.4	−0.6 (longitudinal) 7-12 (radial)	0.2
AS-1[d]	8 (round)	1.80	228 (33)	3.10 (450)	1.32		
AS-4[d]	7 (round)	1.80	248 (36)	4.07 (590)	1.65		
T-40[c]	5.1 (round)	1.81	290 (42)	5.65 (820)	1.8	−0.75 (longitudinal)	
IM-7[d]	5 (round)	1.78	301 (43.6)	5.31 (770)	1.81		
HMS-4[d]	8 (round)	1.80	345 (50)	2.48 (360)	0.7		
GY-70[e]	8.4 (bilobal)	1.96	483 (70)	1.52 (220)	0.38		
Pitch carbon							
P-55[c]	10	2.0	380 (55)	1.90 (275)	0.5	−1.3 (longitudinal)	
P-100[c]	10	2.15	758 (110)	2.41 (350)	0.32	−1.45 (longitudinal)	
Aramid							
Kevlar 49[f]	11.9 (round)	1.45	131 (19)	3.62 (525)	2.8	−2 (longitudinal) 59 (radial)	0.35
Kevlar 149[f]		1.47	179 (26)	3.45 (500)	1.9		
Technora[g]		1.39	70 (10.1)	3.0 (435)	4.6	−6 (longitudinal)	
Extended chain polyethylene							
Spectra 900[h]	38	0.97	117 (17)	2.59 (375)	3.5		
Spectra 1000[h]	27	0.97	172 (25)	3.0 (435)	2.7		
Boron	140 (round)	2.7	393 (57)	3.1 (450)	0.79	5	0.2
SiC							
Monofilament	140 (round)	3.08	400 (58)	3.44 (499)	0.86	1.5	
Nicalon[i] (multifilament)	14.5 (round)	2.55	196 (28.4)	2.75 (399)	1.4		
Al_2O_3							
Nextel 610[j]	10-12 (round)	3.9	380 (55)	3.1 (450)		8	
Nextel 720[j]	10-12	3.4	260 (38)	2.1 (300)		6	
Al_2O_3-SiO_2							
Fiberfrax (discontinuous)	2-12	2.73	103 (15)	1.03-1.72 (150-250)			

[a] 1 μm = 0.0000393 in.
[b] m/m per °C = 0.556 in./in. per °F.
[c] Amoco.
[d] Hercules.
[e] BASF.
[f] DuPont.
[g] Teijin.
[h] Honeywell.
[i] Nippon carbon.
[j] 3-M.

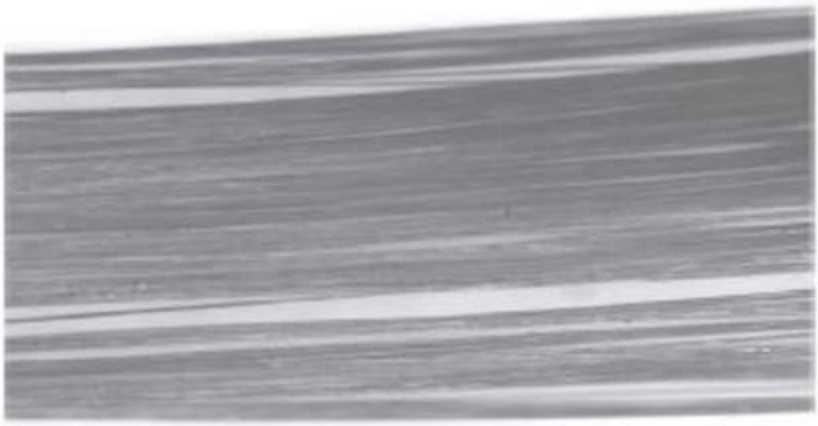

FIGURE 2.1 Untwisted fiber bundle

FIGURE 2.2 twisted fiber bundle

tab by means of a suitable adhesive (Figure 2.3). After clamping the tab in the grips of a tensile testing machine, its midsection is either cut or burned away. The tension test is carried out at a constant loading rate until the filament fractures .

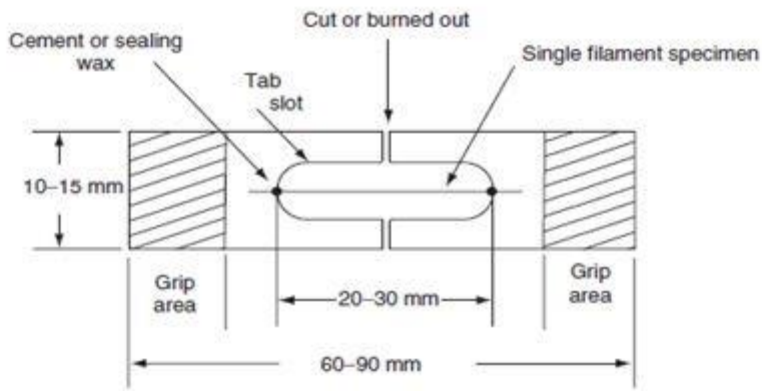

FIGURE 2.3 :Mounting tab for tensile testing of single filament

2.1.1 Glass fibers

Glass fibers are the most common of all reinforcing fibers for polymeric matrix composites (PMC). The principal advantages of glass fibers are low cost, high tensile strength, high chemical resistance, and excellent insulating properties. The disadvantages are relatively low tensile modulus and high density (among the commercial fibers), sensitivity to abrasion during handling (which frequently decreases its tensile strength), relatively low fatigue resistance, and high hardness (which causes excessive wear on molding dies and cutting tools). The two types of glass fibers commonly used in the fiber-reinforced plastics (FRP) industry are E-glass and S-glass. Another type, known as C-glass, is used in chemical applications requiring greater corrosion resistance to acids than is provided by E-glass. E-glass has the lowest cost of all commercially available reinforcing fibers, which is the reason for its widespread use in the FRP industry. S-glass, originally developed for aircraft components and missile casings, has the highest tensile strength among all fibers in use. However, the compositional difference and higher manufacturing cost make it more expensive than E-glass. A lower cost version of S-glass, called S-2-glass, is also available. Although S-2-glass is manufactured with less-stringent nonmilitary specifications, its tensile strength and modulus are similar to those of S-glass. The chemical compositions of E- and S-glass fibers are shown in Table 2.3. As in common soda-lime glass (window and container glasses), the principal ingredient in all glass fibers is silica (SiO2). Other oxides, such as B2O3 and Al2O3, are added to modify the network structure of SiO2 as well as to improve its workability. Unlike soda-lime glass, the Na2O and K2O content in E- and S-glass fibers is quite low, which gives them a better corrosion resistance to water as well as higher surface resistivity. The internal structure of glass fibers is a three-dimensional, long network of silicon, oxygen, and other atoms arranged in a random fashion. Thus, glass fibers are amorphous (non crystalline) and isotropic (equal properties in all directions).

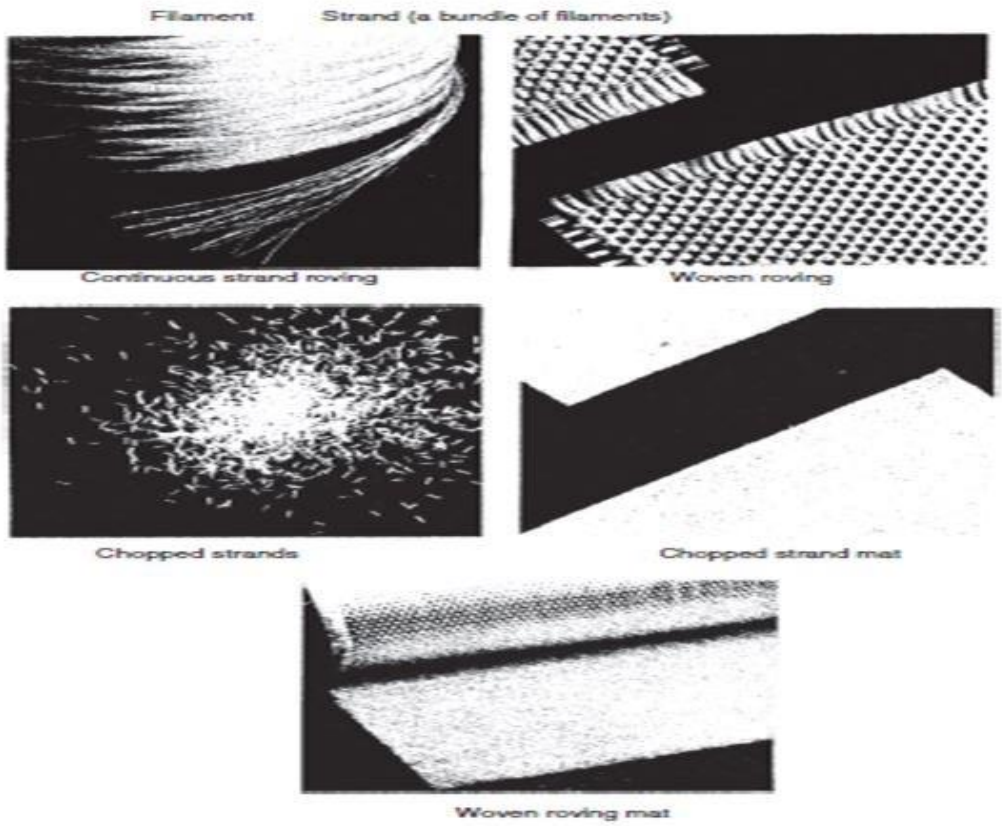

FIGURE 2.4: Common form of glass fibers

2.1.2 Carbon fibers

carbon fibers are known for their exceptionally high tensile strength–weight ratios as well as tensile modulus–weight ratios, high fatigue strengths, and high thermal conductivity (which is even higher than that of copper). The disadvantages are their low strain-to-failure, low impact resistance, and high electrical conductivity, which may cause ‘‘shorting’’ in unprotected electrical machinery. Their high cost has so far excluded them from widespread commercial applications. They are used mostly in the aerospace industry, where weight saving is considered more critical than cost.

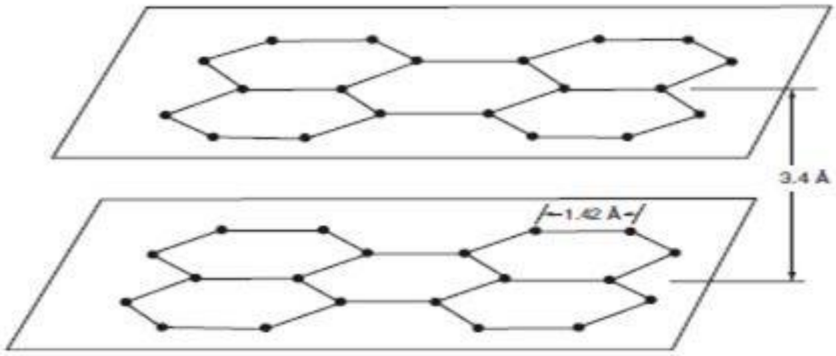

FIGURE 2.5: Arrangement of carbon atoms in a graphite crystal

Structurally, carbon fibers contain a blend of amorphous carbon and graphitic carbon. Their high tensile modulus results from the graphitic form , in which carbon atoms are arranged in a crystallographic structure of parallel planes or layers. The carbon atoms in each plane are arranged at the corners of interconnecting regular hexagons (Figure 2.5) . The distance between the planes is larger than that between the adjacent atoms in each plane. Strong covalent bonds exist between the carbon atoms in each plane, but the bond between the planes is due to van der Waals -type forces , which is much weaker. This results in highly anisotropic physical and mechanical properties for the carbon fiber . The basal planes in graphite crystals are aligned along the fiber axis. However, in the transverse direction, the alignment can be either circumferential, radial, random, or a combination of these arrangements (Figure 2.6) . Depending on which of these arrangements exists, the thermo elastic properties, such as modulus (E) and coefficient of thermal expansion (a), in the radial (r) and circumferential (u) directions of the fiber can be different from those in the axial (a) or longitudinal direction. For example, if the arrangement is circumferential, Ea¼Eu>Er, and the fiber is said to be circumferentially orthotropic. For the radial arrangement, Ea¼Er>Eu, and the fiber is radially orthotropic. When there is a random arrangement, Ea>Eu¼Er, the fiber is transversel isotropic. In commercial fibers, a two-zone structure with circumferential arrangement in the skin and either radial or random arrangement in the core is commonly observed [4].

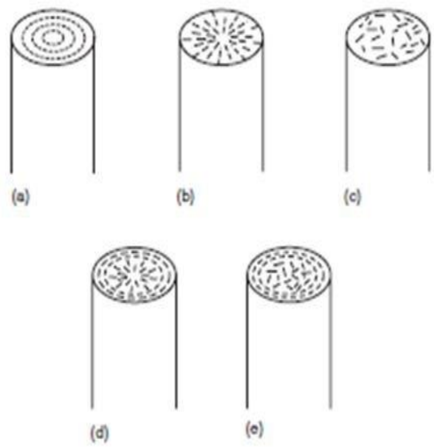

FIGURE 2.6: Arrangement of graphic crystals in a direction transverse to the fiber axis

2.1.3 Marine applications

Glass fiber-reinforced polyesters have been used in different types of boats ever since their introduction as a commercial material in the 1940s . Today, nearly 90% of all recreational boats are constructed of either glass fiber-reinforced polyester or glass fiber-reinforced vinylester resin. Among the applications are hulls, decks, and various interior components. The manufacturing process used for making a majority of these components is called contact molding. Even though it is a labor-intensive process, the equipment cost is low, and therefore it is affordable to many of the small companies that build these boats. In recent years, Kevlar fiber is replacing glass fibers in some of these applications because of its higher tensile strength–weight and modulus–weight ratios than those of glass fibers. Among the application areas are boat hulls, decks, bulkheads, frames, masts, and spars. The principal advantage is weight reduction, which translates into higher cruising speed, acceleration, maneuverability, and fuel efficiency. Carbon fiber-reinforced epoxy is used in racing boats in which weight reduction is extremely important for competitive advantage. In these boats, the complete hull, deck, mast, keel, boom, and many other structural components are constructed using carbon fiber-reinforced epoxy laminates and sandwich laminates of carbon fiber-reinforced epoxy skins with either honeycomb core or plastic foam core.

Carbon fibers are sometimes hybridized with other lower density and higher strain-to-failure fibers, such as high-modulus polyethylene fibers, to improve impact resistance and reduce the boat's weight. The use of composites in naval ships started in the 1950s and has grown steadily since then . They are used in hulls, decks, bulkheads, masts, propulsion shafts, rudders, and others of mine hunters, frigates, destroyers, and aircraft carriers.

CHAPTER 3

Raspberry Pi

The Raspberry Pi is a credit-card sized low-cost ($20-$35) Linux computer. It was developed by the Raspberry Pi Foundation and manufactured and sold in partnership with the worldwide industrial distributors Premier Farnell/Element 14 and RS Components, and the Chinese distributor Egoman Technology Corp.

The first model is based on the Broadcom BCM2835 system on a chip (SoC), with an ARM1176JZF-S 700 MHz processor included, VideoCore IV GPU, and was shipped with 256 megabytes of RAM, later upgraded (models B and B+) to 512 MB. The system has Secure Digital (SD) or MicroSD sockets for storage and bootable media.

There are available Debian and Arch Linux ARM distributions for download. Tools are available for Python as the main programming language, supporting BBC BASIC , C, C++, Java, Perl and Ruby.

Raspberry Pi is the fastest selling British personal computer with sales around 5 to 6 million units until 8 June 2015.

The Raspberry Pi hardware has several versions with variations in hardware performance, memory capacity, and peripheral device support.

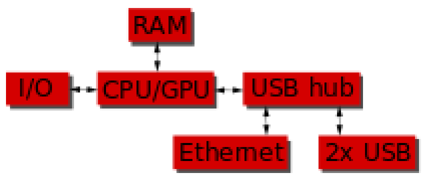

FIGURE 3.1: Block diagram of raspberry pi

The block diagram above describes models *A*, *A+*, *B* and *B+*. The models *A* and *A+* are without Ethernet and USB hub components and their USB port is connected to the SoC directly. The model *B+* has a five-point USB hub, and model *B* has two.

3.1 Processor

The SoC used in the first Raspberry Pi likes to the chip used in older smartphones. It has two levels of cache one of 16KB and a 128KB. GPU mainly uses the 2nd one. Only the edge of SoC is visible because it is underneath the RAM chip.

3.2 First generation model performance

The performance of first generation Raspberry Pi was equivalent to 0.041 GFLOPS. The CPU performance is similar to a 1997-1999 300 MHz Pentium II. The GPU provides graphics processing of 1 Gpixel/s or 1.5 Gtexel/s. The Raspberry Pi graphics are roughly equivalent to the level of a 1998 desktop computer.

Raspberry Pi 2 uses a quad-core Cortex-A7 900MHz CPU, same GPU and 1 GB RAM. It is 4–6 times more powerful than Raspberry Pi.

3.3 Overclocking

The first generation Raspberry Pi chip runs at 700 MHz and the second at 900 MHz, they dont need a heat sink or special cooling if they are not overclocked.

Most Raspberry Pi chips could be overclocked to 800 MHz and some even higher to 1000 MHz. There are some cases where the second generation overclocked to 1500MHz. It is possible with the Raspbian Linux distro to configure the Pi to automatic shut down of the overclocking if it reaches the temperature of 85 °C (185 °F) .There is a configuration to avoid this temperature control but it is suggested to use a heatsink and its is not supported by the warranty. Last versions of the firmware have option to choose between five overclock options. Monitoring the core temperature, and the CPU load, and dynamically adjusting clock speeds and the voltage it tries to maximize the performance without decreasing the life time.

3.4 Ram

First beta model B Raspberry Pis had 128MB allocated for CPU and 128MB for GPU. On the 256MB model B (and model A), three different splits were possible. The default split was 192 MB (RAM for CPU), which should be sufficient for standalone 1080p video decoding, or for simple 3D, but probably not for both together. 224 MB was for Linux only, with just a 1080pframebuffer, and was likely to fail for any video or 3D. 128 MB was for heavy 3D, possibly also with video decoding (e.g. XBMC).Comparatively the Nokia 701 uses 128 MB for the Broadcom VideoCore IV. For the new model B with 512 MB RAM initially there were new standard memory split files released(arm256_start.elf, arm384_start.elf, arm496_start.elf) for 256 MB, 384 MB and 496 MB CPU RAM (and 256 MB, 128 MB and 16 MB video RAM). But a week or so later the RPF released a new version of start.elf that could read a new entry in config.txt (gpu_mem=xx) and could dynamically assign an amount of RAM (from 16 to 256 MB in 8 MB steps) to the GPU, so the older method of memory splits became obsolete, and a single start.elf worked the same for 256 and 512 MB Raspberry Pis.

The second generation has 1 GB of RAM.

3.5 Networking

Though the model A and A+ do not have an 8P8C ("RJ45") Ethernet port, they can be connected to a network using an external user-supplied USB Ethernet or Wi-Fi adapter. On the model B and B+ the Ethernet port is provided by a built-in USB Ethernet adapter.

3.6 Peripherals

Any generic USB keyboard and a mouse are enough to operate a Raspberry Pi.

3.7 Video

The video controller is capable of standard modern TV resolutions, such as HD and Full HD, and higher or lower monitor resolutions and older standard CRT TV resolutions; capable of the following: 640×350 EGA; 640×480 VGA; 800×600 SVGA; 1024×768 XGA; 1280×720 720p HDTV; 1280×768 WXGA variant; 1280×800 WXGA variant; 1280×1024 SXGA; 1366×768 WXGA variant; 1400×1050 SXGA+; 1600×1200 UXGA; 1680×1050 WXGA+; 1920×1080 1080p HDTV; 1920×1200 WUXGA. It can generate 576i and 480i composite video signals for PAL-BGHID,PAL-M, PAL-N, NTSC and NTSC-J.

3.8 Real-time clock

The Raspberry Pi does not come with a real-time clock, which means it cannot keep track of the time of day while it is not powered on.

As alternatives, a program running on the Pi can get the time from a network time server or user input at boot time.

A real-time clock (such as the DS1307) with battery backup can be added (often via the I^2C interface).

	Raspberry Pi 1 Model A	**Raspberry Pi 1 Model A+**	**Raspberry Pi 1 Model B**	**Raspberry Pi 1 Model B+**	**Raspberry Pi 2 Model B**	**Compute Module *(Note: all interfaces are via 200-pin DDR2 SO-DIMMconnector.)***
Release Date:	February 2012	November 2014	N/A	July 2014	February 2015	N/A
Target price:	US$25	US$20	US$35	US$25	US$35	US$30 (in batches of 100)
SoC:	Broadcom BCM2835 (CPU, GPU, DSP, SDRAM, one USB port)				Broadcom BCM2836 (CPU,GPU, DSP,SDRAM, oneUSB port)	BroadcomBCM 2835 (CPU, GPU,DSP, SDRAM, one USBport)
CPU:	700 MHz single-core ARM1176JZF-S				900 MHz quad-core ARM Cortex-A7	700 MHz single-core ARM1176JZF-S

<table>
<tr><td>GPU:</td><td colspan="5">Broadcom VideoCore IV @ 250 MHz
OpenGL ES 2.0 (24 GFLOPS)
MPEG-2 and VC-1 (with license),1080p30 H.264/MPEG-4 AVC high-profile decoder and encoder</td></tr>
<tr><td>Memory (SDRAM):</td><td>256 MB (shared with GPU)</td><td colspan="2">512 MB (shared with GPU) as of 15 October 2012</td><td>1 GB (shared with GPU)</td><td>512 MB (shared with GPU)</td></tr>
<tr><td>USB 2.0 ports:</td><td>1 (direct from BCM2835 chip)</td><td>2 (via the on-board 3-port USB hub)</td><td colspan="2">4 (via the on-board 5-port USB hub)</td><td>1 (direct from BCM2835 chip)</td></tr>
<tr><td>Video input:</td><td colspan="4">15-pin MIPI camera interface (CSI) connector, used with the Raspberry Pi camera or Raspberry Pi NoIR camera</td><td>2× MIPI camera interface (CSI)</td></tr>
</table>

Video outputs:	HDMI (rev 1.3 & 1.4), 14 HDMI resolutions from 640×350 to 1920×1200 plus various PAL and NTSC standards, composite video (PAL and NTSC) via RCA jack	HDMI (rev 1.3 & 1.4), 14 HDMI resolutions from 640×350 to 1920×1200 plus various PAL and NTSC standards, composite video (PAL and NTSC) via 3.5 mm TRRS jack shared with audio out	HDMI (rev 1.3 & 1.4), 14 HDMI resolutions from 640×350 to 1920×1200 plus various PAL and NTSC standards, composite video (PAL and NTSC) via RCA jack	HDMI (rev 1.3 & 1.4), 14 HDMI resolutions from 640×350 to 1920×1200 plus various PAL and NTSC standards, composite video (PAL and NTSC) via 3.5 mmTRRS jack shared with audio out	HDMI, 2× MIPI display interface (DSI), MIPI display interface (DSI) for raw LCDpanels, composite video
Audio inputs	As of revision 2 boards, I²S				

Audio outputs:	Analog via 3.5 mm phone jack; digital via HDMI and, as of revision 2 boards, I^2S				Analog, HDMI, I^2S
On-board storage:	SD / MMC / SDIO card slot (3.3 V with card power only)	MicroSD slot	SD / MMC / SDIO card slot	MicroSD slot	4 GB eMMCflash memorychip; may or may not support external SD cards with configuration changes
On-board network:	None		10/100 Mbit/s Ethernet (8P8C) USB adapter on the third/fifth port of the USB hub (SMSC lan9514-jzx)		None

Low-level peripherals:	8× GPIO plus the following, which can also be used as GPIO:UART, I²C bus, SPI bus with two chip selects,I²S audio + 3.3 V, +5 V, ground	17× GPIO plus the same specific functions, and HAT ID bus	8× GPIO plus the following, which can also be used as GPIO:UART, I²C bus, SPIbus with two chip selects, I²S audio +3.3 V, +5 V, ground. An additional 4× GPIOare available on the P5 pad if the	17× GPIO plus the same specific functions, and HAT ID bus	46× GPIO, some of which can be used for specific functions including I²C,SPI, UART,PCM, PWM

			user is willing to make solder connections		

Power ratings:	300 mA (1.5 W)	200 mA (1 W)	700 mA (3.5 W)	600 mA (3.0 W)	800 mA(4.0 W)	similar to Model A+
Power source:	5 V via MicroUSB or GPIO header					5 V
Size:	85.60 mm × 56.5 mm (3.370 in × 2.224 in) – not including protruding connectors	65 mm × 56.5 mm (2.56 in × 2.22 in) – (same as HAT board) and 10 mm high	85.60 mm × 56.5 mm (3.370 in × 2.224 in) – not including protruding connectors			67.6 mm × 30 mm (2.66 in × 1.18 in)
Weight:	45 g (1.6 oz)	23 g (0.81 oz)	45 g (1.6 oz)			7 g (0.25 oz)
	Model A	**Model A+**	**Model B**	**Model B+**	**Generation 2 Model B**	**Compute Module**

TABLE 3.1: Technical characteristics of raspberry pi

3.9 Connectors

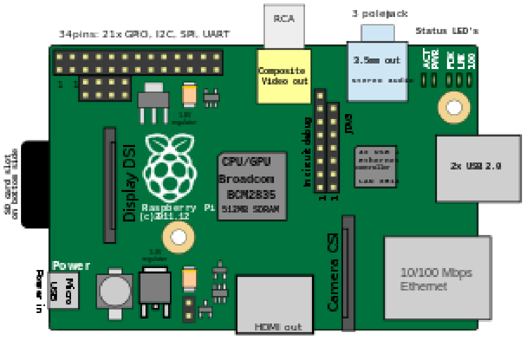

IMAGE 3.1: Location of connectors and main ICs on Raspberry Pi 1 model B revision 2

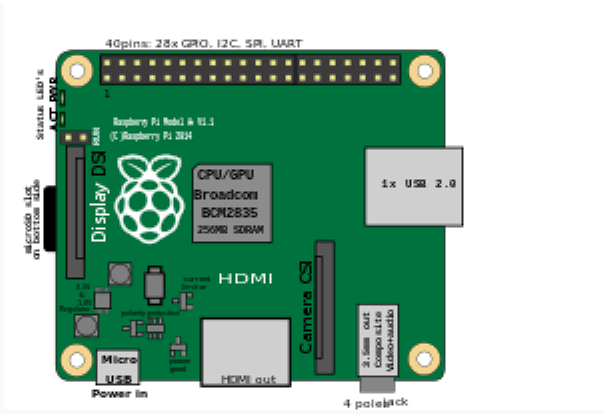

IMAGE 3.2: Location of connectors and main ICs on Raspberry Pi 1 model A+ revision 1.1

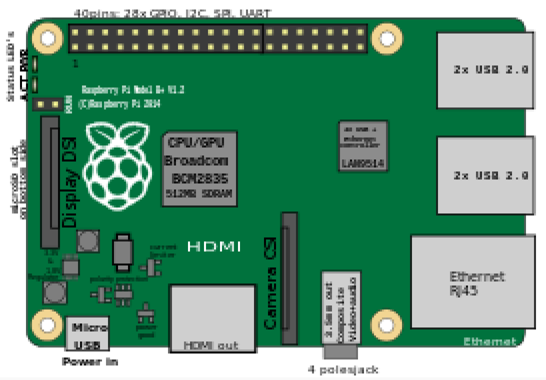

IMAGE 3.3: Location of connectors and main ICs on Raspberry Pi 1 model B+ revision 1.2, and Raspberry Pi 2 model B

3.9.1 GPIO connector

RPi A+, B+ and 2B GPIO J8 40-pin pinout. Models A and B have only the first 26 pins.

GPIO#	2nd func	pin#		pin#	2nd func	GPIO#
N/A	+3V3	1		2	+5V	N/A
GPIO2	SDA1 (I2C)	3		4	+5V	N/A
GPIO3	SCL1 (I2C)	5		6	GND	N/A
GPIO4	GCLK	7		8	TXD0 (UART)	GPIO14
N/A	GND	9		10	RXD0 (UART)	GPIO15
GPIO17	GEN0	11		12	GEN1	GPIO18
GPIO27	GEN2	13		14	GND	N/A
GPIO22	GEN3	15		16	GEN4	GPIO23
N/A	+3V3	17		18	GEN5	GPIO24
GPIO10	MOSI (SPI)	19		20	GND	N/A

GPIO9	MISO (SPI)	21		22	GEN6	GPIO25
GPIO11	SCLK (SPI)	23		24	CE0_N (SPI)	GPIO8
N/A	GND	25		26	CE1_N (SPI)	GPIO7
(Models A and B stop here)						
EEPROM	ID_SD	27		28	ID_SC	EEPROM
GPIO5	N/A	29		30	GND	N/A
GPIO6	N/A	31		32	-	GPIO12
GPIO13	N/A	33		34	GND	N/A
GPIO19	N/A	35		36	N/A	GPIO16
GPIO26	N/A	37		38	Digital IN	GPIO20
N/A	GND	39		40	Digital OUT	GPIO21

TABLE 3.2: GPIO J8 40-pin pinout

Model B rev 2 also has a pad (called P5 on the board and P6 on the schematics) of 8 pins offering access to an additional 4 GPIO connections.

Function	**2nd func**	**pin#**		**pin#**	**2nd func**	**Function**
N/A	+5V	1		2	+3V3	N/A
GPIO28	GPIO_GEN7	3		4	GPIO_GEN8	GPIO29
GPIO30	GPIO_GEN9	5		6	GPIO_GEN10	GPIO31
N/A	GND	7		8	GND	N/A

TABLE 3.3: additional GPIO connections

Models A and B provide GPIO access to the ACT status LED using GPIO 16. Models A+ and B+ provide GPIO access to the ACT status LED using GPIO 47, and the power status LED using GPIO 35.

3.10 Accessories

Camera – On 14 May 2013, the foundation and the distributors RS Components & Premier Farnell/Element 14 launched the Raspberry Pi camera board with a firmware update to accommodate it. The camera board is shipped with a flexible flat cable that plugs into the CSIconnector located between the Ethernet and HDMI ports. In Raspbian, one enables the system to use the camera board by the installing or upgrading to the latest version of the operating system (OS) and then running Raspi-config and selecting the camera option. The cost of the camera module is €20 in Europe (9 September 2013). It can produce 1080p, 720p and 640x480p video. The footprint dimensions are25 mm x 20 mm x 9 mm.

1. Gertboard – A Raspberry Pi Foundation sanctioned device, designed for educational purposes, that expands the Raspberry Pi's GPIO pins to allow interface with and control of LEDs, switches, analog signals, sensors and other devices. It also includes an optional Arduinocompatible controller to interface with the Pi.

2. Infrared Camera – In October 2013, the foundation announced that they would begin producing a camera module without an infrared filter, called the Pi NoIR.

3. HAT (Hardware Attached on Top) expansion boards – Together with the model B+, inspired by the Arduino shield boards, the interface for HAT boards was devised by the Raspberry Pi Foundation. Each HAT board carries a small EEPROM (typically a CAT24C32WI-GT3) containing the relevant details of the board, so that the Raspberry Pi's OS is informed of

the HAT, and the technical details of it, relevant to the OS using the HAT. Mechanical details of a HAT board, that use the four mounting holes .

3.11 Operating systems

The Raspberry Pi primarily uses Linux-kernel-based operating systems.

The ARM11 chip at the heart of the Pi (first generation models) is based on version 6 of the ARM. The current releases of several popular versions of Linux, including Ubuntu, will not run on the ARM11. It is not possible to run Windows on the original Raspberry Pi, though the new Raspberry Pi 2 will be able to run "Windows 10 IoT Core" Insider Preview. The Raspberry Pi 2 currently only supports Ubuntu Snappy Core, Raspbian, OpenELEC and RISC OS.

The install manager for the Raspberry Pi is NOOBS. The operating systems included with NOOBS are:

- Arch Linux ARM
- OpenELEC
- Pidora (Fedora Remix)
- Puppy Linux
- Raspbmc and the XBMC open source digital media center
- RISC OS – is the operating system of the first ARM-based computer.
- Raspbian (recommended for Raspberry Pi 1) – Maintained independently of the Foundation; based on the Debian ARM hard-float(armhf) architecture port originally designed for ARMv7 and later processors (with Jazelle RCT/ThumbEE, VFPv3, and NEON SIMD extensions), compiled for the more limited ARMv6 instruction set of the

Raspberry Pi 1. A minimum size of 4 GB SD card is required for the Raspbian images provided by the Raspberry Pi Foundation. There is a Pi Store for exchanging programs.

- The Raspbian Server Edition is a stripped version with fewer software packages bundled as compared to the usual desktop computeroriented Raspbian.

- The Wayland display server protocol enable the efficient use of the GPU for hardware accelerated GUI drawing functions. on 16 April 2014 a GUI shell for Weston called Maynard was released.

- PiBang Linux is derived from Raspbian.

- Raspbian for Robots – is a fork of Raspbian for robotics projects with LEGO, Grove, and Arduino.

Other operating systems

- Xbian – Using the Kodi (formerly XBMC) open source digital media center

- openSUSE

- Raspberry Pi Fedora Remix

- Slackware ARM – Version 13.37 and later runs on the Raspberry Pi without modification. The 128–496 MB of available memory on the Raspberry Pi is at least twice the minimum requirement of 64 MB needed to run Slackware Linux on an ARM or i386 system. (Whereas the majority of Linux systems boot into a graphical user interface, Slackware's default user environment is the textual shell /command line interface.) The Fluxbox window manager running under the X Window System requires an additional 48 MB of RAM.

- FreeBSD and NetBSD are general operating systems.

- Plan 9 from Bell Labs and Inferno (in beta)

- Moebius – A light ARM HF distribution based on Debian. It uses Raspbian repository, but it fits in a 128 MB SD card. It has just minimal services and its memory usage is optimized to keep a small footprint.
- OpenWrt – is primarily used on embedded devices to route network traffic.
- Kali Linux – is a Debian-derived distro designed for digital forensics and penetration testing.
- Pardus ARM – is a Debian-Based operating system which is the light version of the Pardus (operating system).
- Instant WebKiosk – is an operating system for digital signage purposes (web and media views).
- Ark OS – is designed for website and email self-hosting.
- Minepion – is a dedicated operating system for mining cryptocurrency.
- Kano OS
- Nard SDK for industrial embedded systems
- Sailfish OS with Raspberry Pi 2 (due to use ARM Cortex-A7 CPU; Raspberry Pi 1 uses different ARMv6 architecture and Sailfish requires ARMv7.)
- Tiny Core Linux – a minimal Linux operating system focused on providing a base system using BusyBox and FLTK. Designed to run primarily in RAM.
- "Windows 10 IoT Core" Insider Preview – Microsoft offers a free edition of Windows 10, known as IoT Core, that runs natively on the Raspberry Pi 2.

- IPFire – a dedicated firewall/router distribution for the protection of a SOHO LAN; runs only on a Raspberry Pi 1; porting to the Raspberry Pi 2 is not planned for now.
- xv6 – a modern reimplementation of Sixth Edition Unix OS for teaching purposes; it is ported to Raspberry Pi from MIT xv6; this xv6 port can boot from NOOBS.

CHAPTER 4

Rotatory brush and brushless DC motor technologies

4.1. Introduction

The simplest electric motor is a converter of electrical energy to useful mechanical energy. It operates with two magnetic fields within certain prescribed areas react upon each other. One field is produced by a permanent magnet assembly while the other field is produced by an electrical current flowing in the motor windings. These two fields result in a torque which tends to rotate the rotor. As the rotor turns, the current in the windings is commutated to produce a continuous torque output. Depending on the voltage source applied to the motor, we can basically divide them into: Direct Current motors (DC) and Alternate Current motors (AC). The DC motor was invented in 1880 by Werner Von Siemens. The AC induction motor came much later in 1924 invented by Nicolas Tesla. Since then, electric motors have changed substantially in design, but its basic principles have remained the same. Brush DC motors have been the most prominent variable speed technology for Direct Current Motors over last century. They have reached the top of their design, with better brushes, frame configurations, and drives with software control providing the best possible performance and reliability.

4.2. Electric motor principles

When a carrying current conductor I is in a magnetic field, a force F is exerted on it as follows: $F=B*I*L$ Where, B = flux density l = length of conductor being linked by flux I = current in conductor

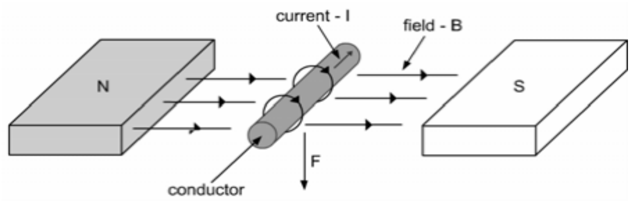

FIGURE 4.1: Electric motor principles I

Electromagnetic rotation I torque can be produced if current conductors are arranged such that they may pivot on an axis that is centered within a magnetic field. The flow between the north and south poles will interact with the flow produced by the current in the conductors and torque will be produced (see Figure 4.2).

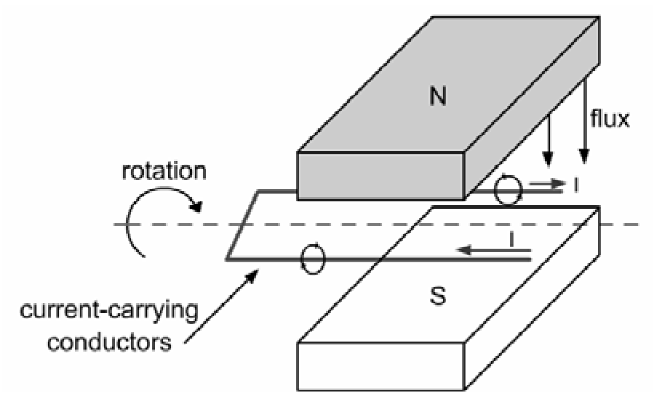

FIGURE 4.2: Electric motor principles II

If the direction of the current is switched as the conductors reach their relaxing position, the conductors will continue the rotation on the axis in the same direction. This process is known as commutation. Brush motors use mechanical commutation through its brushes, and the drive need no knowledge of motor position to regulate torque. Instead, brushless motors use electrical commutation and a feedback system is required to sense the electrical position of the motor and assure the appropriate commutation sequence and timing.

4.3. DC Brushed motors

DC brushed motors consist of a permanent magnet or a fixed electromagnet for a stator and a rotor with an armature with a set of windings[3]. Current is conducted to the windings through a set of slip-rings and brushes. The brushes make contact with a set of electrical contacts on the rotor , forming an electrical circuit between the DC electrical source and the armature coil-windings. As the rotor turns to align with the magnetic field of the stator, the stationary brushes come into contact with different sections of the rotating commutator reversing the direction of the current in each set of windings in the rotor armature. The commutator and brush-system form a set of electrical switches, each firing in sequence, such that electrical-power flows through the armature-coil closest to the stationary stator.

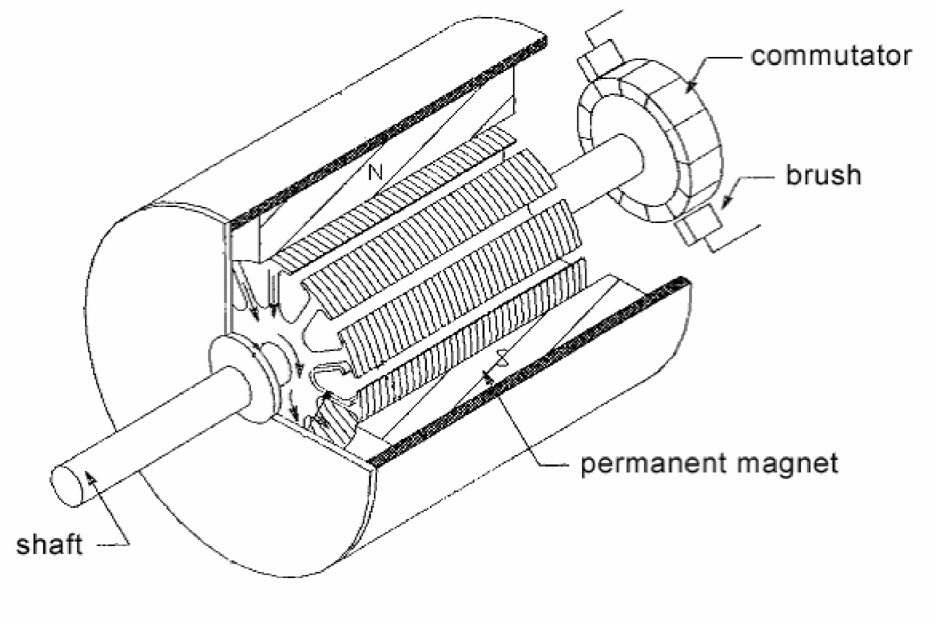

FIGURE 4.3: DC brushed motor

The general equivalent electrical circuit of a DC brushed motor and its physical construction is shown in Figure 4.4.

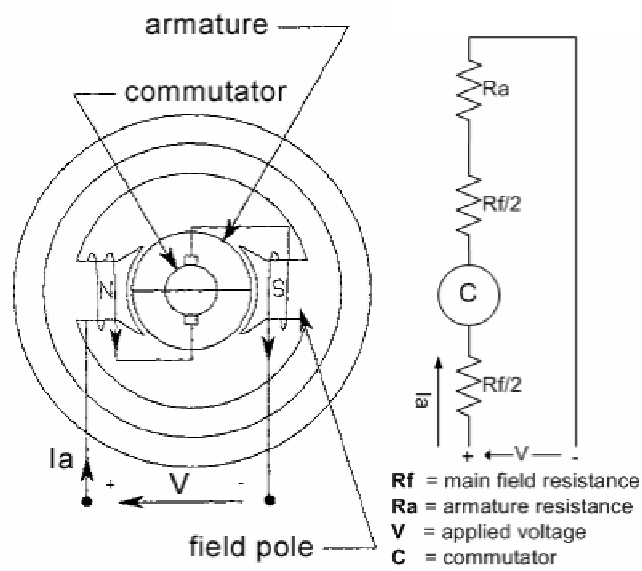

FIGURE 4.4: Physical construction and equivalent electric circuit of a DC brushed motor

Many of the limitations of the classic commutator DC motor are due to the need for brushes to press against the commutator:

- At higher speeds, brushes have increasing difficulty in maintaining contact.
- Brushes may bounce off the irregularities in the commutator surface, creating sparks, which limits the maximum speed of the machine.
- The current density per unit area of the brushes limits the output of the motor.
- The imperfect electric contact also causes electrical noise.
- Brushes eventually wear out and require replacement, and the commutator itself is subject to wear and maintenance.
- The commutator assembly on a large machine is a costly element, requiring precision assembly of many parts.

4.4. DC Brushless Motors

All problems of brushed technology are eliminated in DC brushless motors (also known as BLDC). In these motors, the brush-system/commutator assembly is replaced by an electronic controller. Magnets rotate and the current-carrying coils are stationary and energized sequentially to cause the rotor to turn. This introduces the need of an electronic drive controller to generate torque, which means more complex and sometimes expensive systems.

The controller can use position information of the rotor, plus the desired direction for the motor, to determine the next coil to which a current should be applied[2]. Some designs use Hall effect sensors to detect the position of the rotor and provide it to the controller. Others measure the back EMF in the undriven coils to infer the rotor position, eliminating the need for separate Hall effect sensors, and therefore are often called "sensorless" controllers.

There are basically two possible configurations for brushless DC motors according to their structure: Inner-Rotor Motors and Outer-Rotor Motors.

Their diagram construction is shown in Figure 4.5.

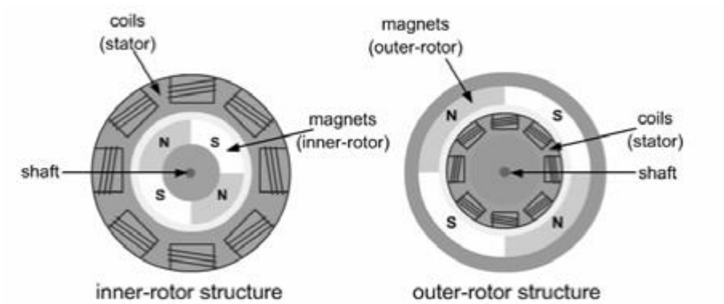

FIGURE 4.5: Inner and outer rotor assemblies for brushless motors

The outer motors have much more magnetic material than the inner ones. This means that they are capable of more flow when the same materials are used in both structures.

4.5. TECHNOLOGY COMPARISON

Due to brush wear, DC brushed motors need a higher maintenance and has a shorter life. Their voltage drop across commutator, and high motor friction, reduce the generated useful torque and efficiency. Their speed is also limited . However its reduced cost and simple control makes them suitable when parameters such as efficiency, reliability or long life are not critical.

TABLE 4.1: Brushed vs Brushless technology

The following table summarizes the comparison between both technologies: **Feature**	**Brushed**	**Brushless**
Commutation	Mechanical	Electronically
Maintenance	High	Low
Electrical Noise	High	Low
Life	Shorter	Longer
Speed/Torque Characteristics	Moderately flat	Flat. (Enables operation at all speeds)
Efficiency	Medium	High

Motor Size	Larger due to commutator and difficulty removing heat	Smaller
Speed ranges	Commutator limits speed	Can rotate high speeds
Audible noise	High at high speeds because of brushes	Low
However, because of its higher rotor diameter, outer motors offer higher rotor inertia and slower acceleration, which sometimes can benefit the system performance in some applications, such as computer disk drives or cooling fans. **Drive Complexity**	Simple and inexpensive	Complex and expensive
Control Requirements	No controller is required for fixed speed	A controller is always required to keep the motor running

Besides the advantages shown in the table, brushless motor's commutation control can also easily be separated and integrated into other required electronics, thereby improving the effective power-to-weight and/or power-to-volume ratio.

Brushless motors should then be used be when simplicity or cost effective solution is not a requirement, but it is high performance, small size or good efficiency.

4.6. MARKET TRENDS

Electric motor market trend indicates that the use of brushless DC has prevailed over brushed during last 20 years. Figure 4.6 shows the market evolution for DC brushless motor and its forecast.

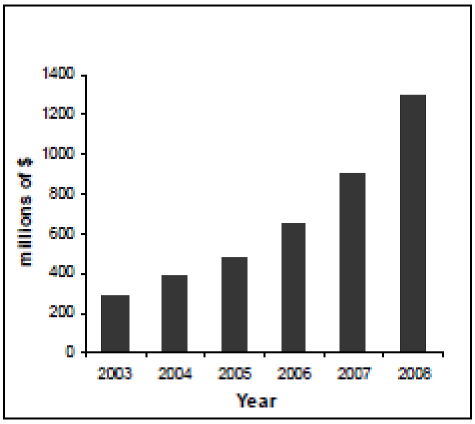

FIGURE 4.6: DC Brushless Market Growth

This growth is not only because of the best performance and efficiency offered by brushless technology , but also because of the growth of markets such as packaging machinery, CNC machinery or robotics (see Figure 4.7, Figure 4.8 and Figure 4.9) which demands for electric motors offering high precision and performance at high velocities, only achievable with brushless technology.

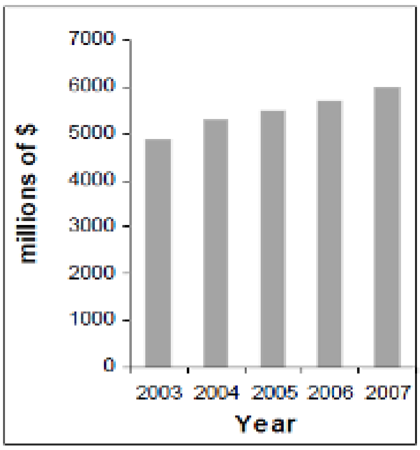

FIGURE 4.7: Packaging machines market growth

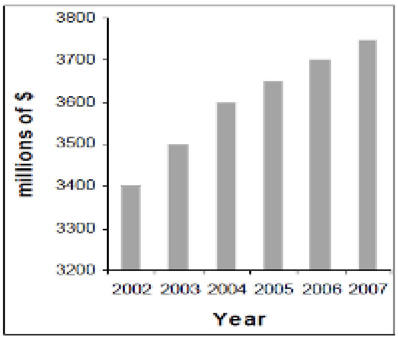

FIGURE 4.8: CNC machines market growth

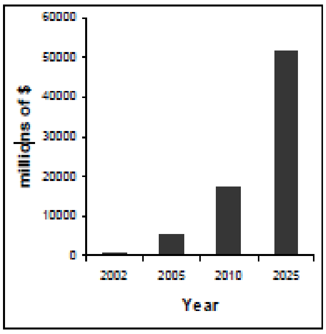

FIGURE 4.9: Personal and service robotics market growth

As a result of brushless DC expansion, some other markets have recently appeared and growth very fast, such as motion control market.

4.7 Conclusions

Brushed motors have been the most used DC technology over last 100 years. However, during last 10-20 years, brushless motors usage has increased strongly. This technology offers higher performance and efficiency, but needs a complex and sometimes expensive electronic control. The development of new machines and robots that need high degrees of precision and performance is only achievable with this technology, and this has driven the growth of brushless market and its motor control market.

CHAPTER 5

Lithium polymer battery

A lithium polymer battery is a rechargeable battery of lithium-ion technology in a pouch format. LiPos come in a soft package or pouch, which makes them lighter but also less rigid. The label "lithium polymer" has caused distraction among battery users. It may be interpreted in two ways. Originally, "lithium polymer" stood for a developing technology using a polymer electrolyte instead of the more common liquid electrolyte. The result is a "plastic" cell, which theoretically could be thin, flexible, and manufactured in different shapes, without risk of electrolyte leakage. These batteries are available[1] although the technology has not been fully developed and commercialized, and research is ongoing. The second meaning appeared when some manufacturers started applying the "polymer" label to lithium-ion cells in pouch format. This is the most extended use nowadays, where "polymer" went from showing a "polymer electrolyte" to mean a "polymer casing", that is, the soft, external pouch. While the design is usually flat, and lightweight, it is not a true polymer cell, as the electrolyte is still in liquid form, albeit it may be "plasticized" or "gelled" through a polymer additive. These cells are sometimes known as "LiPo", however, from the technological side, they are the same as the ones marketed simply as "Li-ion", as the underlying electrochemistry is the same. The name "lithium polymer" (LiPo) is more widespread among users of radio-controlled models, where it may indicate a single cell or a battery pack with cells connected in series or parallel. The more general term "lithium-ion" (Li-ion) is used almost everywhere else, including consumer electronics such as mobile phones and notebook computers, and battery-powered electric vehicles.

5.1.History

LiPo cells follow the history of lithium-ion and lithium-metal cells which underwent significant research during the 1980s, reaching a significant milestone with Sony's first commercial cylindrical Li-ion cell in 1991. After that, other packaging techniques evolved, including the pouch format now also called "LiPo".

5.2 Design origin and terminology

The first kind of cell named "lithium polymer" has technologically evolved from lithium-ion and lithium-metal batteries. The primary difference is that instead of using a lithium-salt electrolyte held in an organic solvent , the battery uses a solid polymer electrolyte. The solid electrolyte can be typically classified as one of three types: dry SPE, gelled SPE and porous SPE. The dry SPE was the first used in prototype batteries, around 1978 by Michel Armand, Domain University,[8][9] and 1985 by ANVAR and Elf V Acquitaine of France, and Hydro Quebec of Canada.[2] From 1990 several organisations like Mead and Valence in the United States and GS Yuasa in Japan developed batteries using gelled SPEs.[2] In 1996, Bellcore in the United States announced a rechargeable lithium polymer cell using porous SPE, but without success in commercialization.[2] In parallel to the development of these "polymer electrolyte" batteries, the term "lithium polymer" started being used for liquid electrolyte Li-ion cells in pouch format. These cells started appearing in consumer electronics around 1995,[*citation needed*] eventually becoming known as "LiPo" for some applications. The confusion in the names may stem from the construction of the basic lithium-ion cell. A typical cell has four main components: positive electrode, negative electrode, separator and electrolyte. The separator itself may be a polymer, such as a microporous film of polyethylene (PE) or polypropylene (PP); thus, even when the cell has a liquid electrolyte, it will still contain a "polymer" component. In addition to this, the positive electrode can be further decomposed in three parts: the lithium-transition-metal-oxide (such as $LiCoO_2$ or $LiMn_2O_4$), a conductive additive, and a polymer binder of poly(vinylidene fluoride) (PVdF).[10][11] The negative electrode material may have the same three parts, only with carbon replacing the lithium-metal-oxide.[10][11] Therefore, even if a bare, unfinished cell lacks a polymer separator, or any liquid or solid electrolyte, it may still have a "polymer" component in the active materials of the electrodes. This polymer, however, is just a small fraction, typically less than 5% by weight, and does not participate in the electrochemical reactions, being only useful for binding the active particles together to maintain good conductivity, and help make the slurry mix adhere well to the copper and aluminium foils that compose the current collectors of the battery cell.[11]

5.3.Working principle

Just as with other lithium-ion cells, LiPos work on the principle of injection and de-injection of lithium ions from a positive electrode material and a negative electrode material with the liquid electrolyte providing a conductive medium. To prevent the electrodes from touching each other directly, a micro separator is in between them, which allows only the ions to drift from one side to the other.

5.4.Charging

Just as with other kinds of lithium-ion cells, the voltage of a LiPo cell depends on its chemistry and varies from about 2.7-3.0 V (discharged) to about 4.20-4.35 V (fully charged), for cells based on lithium-metal-oxides (such as $LiCoO_2$), and around 1.8-2.0 V (discharged) to 3.6-3.8 V (charged) for those based on lithium-iron-phosphate ($LiFePO_4$). The exact voltage ratings should be specified in product data sheets, with the understanding that the cells should be protected by an electronic circuit that won't allow them to overcharge nor over-discharge under use. For LiPo battery packs with cells connected in series, a specialised charger may monitor the charge on a per-cell basis so that all cells are brought to the same state of charge (SOC).

5.5 Applying pressure on LiPo cells

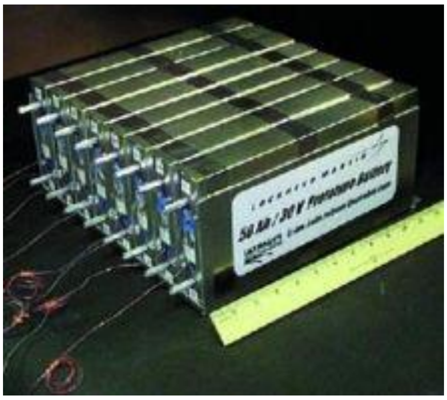

IMAGE 5.1: An experimental lithium-ion polymer battery made by Lockheed-Martin for NASA

Unlike lithium-ion cylindrical and prismatic cells, which have a rigid metal case, LiPo cells have a flexible, foil-type (polymer laminate) case, so they are relatively unconstrained. By themselves the cells are over 20% lighter than equivalent cylindrical cells of the same capacity. Being lightweight is an advantage when the application requires minimum weight, such as in the case of radio controlled models. However, it has been investigated that moderate pressure on the stack of layers that compose the cell results in increased capacity retention, because the contact between the components is maximised and delamination and deformation is prevented, which is associated with increase of cell impedance and degradation.

5.6. Applications

Six edge shaped Lithium-Polymer-Battery for Underwater Vehicles made by Custom Cells Itzehoe GmbH LiPo cells provide manufacturers with compelling advantages. They can easily produce batteries of almost any desired shape. For example, the space and weight requirements of mobile phones and notebook computers can be completely satisfied. Also, they have low-self discharge rate, which is about 1%.

5.7 Radio controlled equipment and Airsoft

IMAGE 5.2: LiPo battery for RC-models

LiPo batteries have just about taken over in the world of radio-controlled aircraft, radio-controlled cars and large scale model trains, where the advantages of lower weight and increased capacity and power delivery justify the price. As of the beginning of 2013, LiPo packs of 1.3 Ah exist, providing 45C continuous discharge, and short-time 90C bursts. Bigger packs of 4.5 Ah may feature discharge rates of 70C, with 140C bursts. LiPo packs also see widespread use in airsoft, where their higher discharge currents and better energy density compared to more traditional Nimh batteries has very noticeable performance gain (higher rate of fire). The high discharge currents do damage the switch contacts due to arcing (causing the contacts to oxidize and often deposit carbon), so it is advised to either use a solid-state MOSFET switch or clean the trigger contacts regularly.

5.8 Personal electronics

LiPo batteries are pervasive in mobile phones, tablet computers, very thin laptop computers, portable media players, wireless controllers for video game consoles, electronic cigarettes, and other applications where small form factors are sought and the high energy density outweighs cost considerations.

5.9 Electric vehicles

Lithium-ion cells in pouch format are being investigated to power battery electric vehicles. While it is possible to use a large number of cells of small capacity to obtain required levels of power and energy to drive a vehicle, some manufacturers and research centres are looking into large-format lithium-ion cells of capacities exceeding 50 Ah for this purpose. With higher energy content per cell, the number of cells and electrical connections in a battery pack would certainly decrease but the danger associated with individual cells of such high capacity might be greater. Hyundai Motor Company uses this type of battery in some of their hybrid vehicles,as well as Kia Motors in their battery electric Kia Soul. The Bolloré Bluecar, which is used in car sharing schemes in several cities, also uses this type of battery.

5.10 Safety

Main article: Lithium-ion battery Safety

IMAGE 5.3: Apple I Phone 3GS's Lithium-ion polymer battery, which has expanded due to a short circuit failure.

LiPo cells are affected by the same problems as other lithium-ion cells. This means that overcharge, over-discharge, over-temperature, short circuit, crush and nail penetration may all result in a catastrophic failure, including the pouch rupturing, the electrolyte leaking, and fire. All Li-ion cells expand at high levels of state of charge (SOC) or over-charge, due to slight vaporisation of the electrolyte. This may result in delamination, and thus bad contact of the internal layers of the cell, which in turn brings diminished reliability and overall cycle life of the cell. This is very noticeable for LiPos, which can visibly inflate due to lack of a hard case to contain their expansion. Compared to cylindrical Li-ion cells, LiPos lack integrated safety devices such as a current interrupting device (CID) or a positive temperature coefficient (PTC) material that is able to protect against an over-current or an over-temperature.

CHAPTER 6

Mobile broadband modem

A mobile broadband modem, also known as a *connect card* or *data card*, is a type of modem that allows a laptop, a personal computer or a router to receive Internet access via a mobile broadband connection instead of using telephone or cable television lines. A mobile Internet user can connect using a wireless modem to a wireless Internet Service Provider (ISP) to get Internet access.

6.1 History

While some analogue mobile phones provided a standard RJ11 telephone socket into which a normal landline modem could be plugged, this only provided slow dial-up connections, usually 2.4 kilobit per second (kbit/s) or less. The next generation of phones, known as 2G (for 'second generation'), were digital, and offered faster dial-up speeds of 9.6kbit/s or 14.4kbit/s without the need for a separate modem. A further evolution called HSCSD used multiple GSM channels (two or three in each direction) to support up to 43.2kbit/s. All of these technologies still required their users to have a dial-up ISP to connect to and provide the Internet access - it was not provided by the mobile phone network itself. The release of 2.5G phones with support for packet data changed this. The 2.5G networks break both digital voice and data into small chunks, and mix both onto the network simultaneously in a process called packet switching. This allows the phone to have a voice connection and a data connection at the same time, rather than a single channel that has to be used for one or the other. The network can link the data connection into a company network, but for most users the connection is to the Internet. This allows web browsing on the phone, but a PC can also tap into this service if it connects to the phone. The PC needs to send a special telephone number to the phone to get access to the packet data connection. From the PC's viewpoint, the connection still looks like a normal PPP dial-up link, but it is all terminating on the phone, which then handles the exchange of data with the network. Speeds on 2.5G networks are usually in the 30–50kbit/s range.

IMAGE 6.1: 3G wireless modem

Huawei CDMA2000 Evolution-Data Optimized USB wireless modem 3G networks have taken this approach to a higher level, using different underlying technology but the same principles. They routinely provide speeds over 300kbit/s. Due to the now increased internet speed, internet connection sharing via WLAN has become a workable reality. Devices which allow internet connection sharing or other types of routing on cellular networks are called also cellular routers. A further evolution is the 3.5G technology HSDPA, which provides speeds of multiple Megabits per second. Several of the mobile network operators that provide 3G or faster wireless internet access offer plans and wireless modems that enable computers to connect to and access the internet. These wireless modems are typically in the form of a small USB based device or a small, portable mobile hotspot that acts as a WiFi access point (hotspot) to enable multiple devices to connect to the internet. WiMAX based services that provide high speed wireless internet access are available in some countries and also rely on wireless modems that connect to the provider's wireless network. Wireless USB Modems are nicknamed as "Dongles". Early 3G mobile broadband modems used the PCMCIA or ExpressCard ports, commonly found on legacy laptops. The expression "connect card" (instead of connection card) had been registered and used the first time by Vodafone as brand for its products but now is become a brandnomer or genericized trademark used in colloquial or commercial speech for similar product, made by different manufacturers, too. Major producers are Huawei, Option N.V., Novatel Wireless. More recently, the expression "connect card" is also used to identify internet USB keys. Vodafone brands this type of device as a Vodem.

Often a mobile network operator will supply a 'locked' modem or other wireless device that can only be used on their network. It is possible to use online unlocking services that will remove the 'lock' so the device accepts SIM cards from any network.

6.2. Variants

IMAGE 6.2: HSDPA cellular router

6.3. Standalone

Standalone mobile broadband modems are designed to be connected directly to one computer. In the past, these used the PCMCIA, ExpressCard and Compact Flash standards to connect to the computer. These standards have become deprecated by the end of the 2000s in favour of USB-based modems, which are compatible with a greater number of devices. Some models have a built-in GPS chip, while others do not.[4]

6.4.Integrated router

Many mobile broadband modems sold nowadays also have built-in routing capabilities. They provide traditional networking interfaces such as Ethernet, USB and Wi-Fi.[5] Models are available for both consumers and enterprises. Some require the use of an AC adapter, while others are portable and can also be powered by a USB connection or a built-in battery. An RJ11 registered jack is also present on a few of these modems, allowing the connection of a traditional home phone to make cellular calls.

6.5. Smartphones and Tethering

Numerous smartphones support the Hayes command set and therefore can be used as a mobile broadband modem, although several mobile network operators charge a fee for this feature. Other networks have an allowance for full speed mobile broadband access, which -- if exceeded -- can result in overage charges or slower speeds. An internet-accessing smartphone may have the same capabilities as a standalone modem, and -- when connected directly to a computer -- can serve as a standalone modem for the computer. Those smartphones with built-in Wi-Fi also typically include routing and wireless access point features. This method of connecting is commonly referred to as "tethering." An example of tethering is, for instance, a desktop computer connecting to the internet through a USB cable connection ("tether") that connects it ("tethers" it) to a smartphone which has (and provides to the computer) internet access. When computers are tetherered to a smartphone for internet access, some cellular service providers charge additional cellular broadband access fees or rates to the smartphone consumer.

6.6. Service providers

There are competing common carriers broadcasting signal in most nations of the earth. Technologies

- GPRS (2.5G)
- CDPD
- CDMA2000
- EDGE
- EVDO
- UMTS (3G)
- GPRS Core Network
- IP Multimedia Subsystem
- HSDPA (3.5G)
- HSPA+

- DC-HSPA+
- iBurst (pre-4G)
- HiperMAN (pre-4G)
- WiMAX (pre-4G)
- WiBro (pre-4G)
- LTE (4G)
- LTE Advanced (4G)

6.7. Device driver switching

Mobile broadband modems often use a virtual CD-ROM switching utility and have the device drivers on board. Those modems have two modes, a USB flash drive mode and in the other mode they are a modem.

CHAPTER 7

AutoCAD

AutoCAD is a commercial software application for 2D and 3D computer-aided design (CAD) and drafting — available since 1982 as a desktop application and since 2010 as a mobile web- and cloud-based app marketed as AutoCAD 360. Developed and marketed by Autodesk, AutoCAD was first released in December 1982, running on microcomputers with internal graphics controllers. Prior to the introduction of AutoCAD, most commercial CAD programs ran on mainframe computers or minicomputers, with each CAD operator (user) working at a separate graphics terminal. AutoCAD is used across a wide range of industries, by architects, project managers, engineers, graphic designers, and other professionals. It is supported by 750 training centers worldwide as of 1994. As Autodesk's flagship product, by March 1986 AutoCAD had become the most ubiquitous CAD program worldwide.

7.1 History

AutoCAD was derived from a program begun in 1977 and released in 1979 called Interact CAD, also referred to in early Autodesk documents as MicroCAD, which was written prior to Autodesk's (then Marinchip Software Partners) formation by Autodesk cofounder Mike Riddle. The first version by Autodesk was demonstrated at the 1982 Comdex and released that December. The 2016 release marked the 30th major release of AutoCAD for Windows. The 2014 release marked the fourth consecutive year of AutoCAD for Mac.

7.2 File formats and versions

The native file format of AutoCAD is dwg. This and, to a lesser extent, its interchange file format DXF, have become de facto, if proprietary, standards for CAD data interoperability, particularly for 2D drawing exchange. AutoCAD has included support for dwf, a format developed and promoted by Autodesk, for publishing CAD data. Autodesk's logo and, respectively, AutoCAD icons have changed for several versions through the years.

7.3 Compatibility with other software

ESRI ArcMap 10 permits export as AutoCAD drawing files. Civil 3D permits export as AutoCAD objects and as LandXML. Third-party file converters exist for specific formats such as Bentley MX GENIO Extension, PISTE Extension (France), ISYBAU (Germany), OKSTRA and Microdrainage (UK); also, conversion of .pdf files is feasible, however, the accuracy of the results may be unpredictable or distorted, as that of jagged edges.

7.4 Extensions

AutoCAD supports a number of APIs for customization and automation. These include AutoLISP, Visual LISP, VBA, .NET and ObjectARX. ObjectARX is a C++ class library, which was also the base for:

- a) products extending AutoCAD functionality to specific fields;
- b) creating products such as AutoCAD Architecture, AutoCAD Electrical, AutoCAD Civil 3D; or
- c) third-party AutoCAD-based application.

There are a large number of AutoCAD plugins (add-on applications) available on the application store Autodesk Exchange Apps . AutoCAD's DXF, drawing exchange file, allows importing and exporting drawing information.

7.5 Vertical integration

Autodesk has also developed a few vertical programs (AutoCAD Architecture, AutoCAD Civil 3D, AutoCAD Electrical, AutoCAD ecscad, AutoCAD Map 3D, AutoCAD Mechanical, AutoCAD MEP, AutoCAD Structural Detailing, AutoCAD Utility Design, AutoCAD P&ID and AutoCAD Plant 3D) for discipline-specific enhancements. For example, AutoCAD Architecture (formerly Architectural Desktop) permits architectural designers to draw 3D objects, such as walls, doors and windows, with more intelligent data associated with them rather than simple objects, such as lines and circles. The data can be programmed to represent specific architectural products sold in the construction industry, or extracted into a data file for pricing, materials estimation, and other values related to the objects represented. Additional tools generate standard 2D drawings, such as elevations and sections, from a 3D architectural model. Similarly, Civil Design, Civil Design 3D, and Civil Design Professional support data-specific objects, facilitating easy standard civil engineering calculations and representations. Civil 3D was originally developed as an AutoCAD add-on by a company in New Hampshire called Softdesk. Softdesk was acquired by Autodesk, and Civil 3D was further evolved.

7.6 AutoCAD LT

AutoCAD LT is the lower cost version of AutoCAD, with reduced capabilities, first released in November 1993. Autodesk developed AutoCAD LT to have an entry-level CAD package to compete in the lower price level. AutoCAD LT, priced at $495, became the first AutoCAD product priced below $1000. It is sold directly by Autodesk and can also be purchased at computer stores (unlike the full version of AutoCAD, which must be purchased from official Autodesk dealers). As of the 2011 release the AutoCAD LT MSRP has risen to $1200. While there are hundreds of small differences between the full AutoCAD package and AutoCAD LT, there are a few recognized major differences in the software's features:

- 3D Capabilities: AutoCAD LT lacks the ability to create, visualize and render 3D models as well as 3D printing.
- Network Licensing: AutoCAD LT cannot be used on multiple machines over a network.
- Customization: AutoCAD LT does not support customization with LISP, ARX, and VBA.
- Management and automation capabilities with Sheet Set Manager and Action Recorder.
- CAD standards management tools.

AutoCAD LT 2015 introduced Desktop Subscription from $360 per year

CHAPTER 8

Flow Design Virtual wind tunnel testing tools

Flow Design is a virtual wind tunnel for visualizing airflow around buildings, vehicles, buildings, consumer products, and other objects. Support for many CAD file types means that little geometry preparation is necessary. With rapid results, you can quickly gain insight while exploring different conditions.

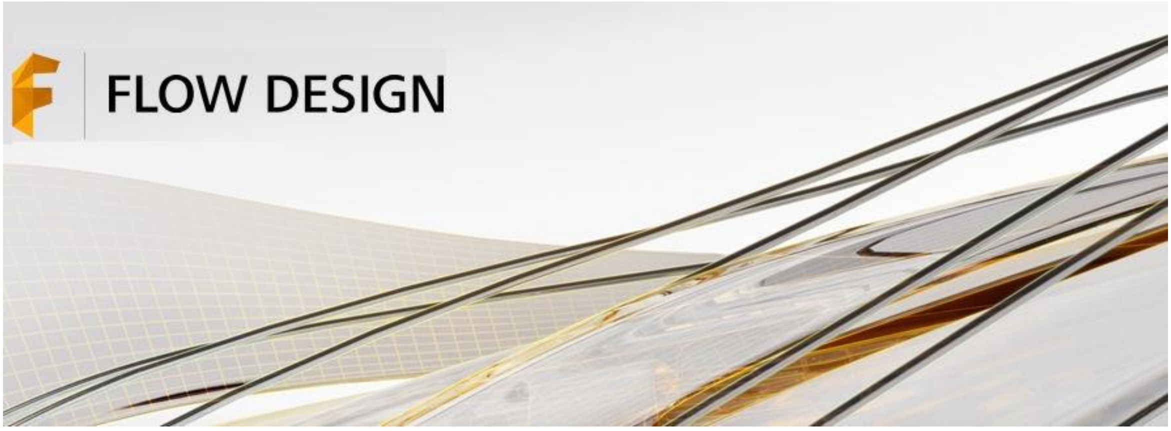

IMAGE 8.1: Flow design

8.1 The drag coefficient express the drag of an object in a moving fluid

Any object moving through a fluid experiences drag - the net force in the direction of flow due to pressure and shear stress forces on the surface of the object.

Drag force can be expressed as:

$F_d = c_d \, 1/2 \, \rho \, v^2 \, A$ *(1)*

where

F_d = drag force (N)

c_d = drag coefficient

ρ = density of fluid (1.2 kg/m^3 for air at NTP)

v = flow velocity

A = characteristic frontal area of the body

The drag coefficient is a function of several parameters like shape of the body, Reynolds Number for the flow, Froude number, Mach Number and Roughness of the Surface.

CHAPTER 9

Weaved server

The IoT Kit brings all the power of the Weaved Internet of Things fabric to Raspberry Pi in an easy to use solution, so that you can make your Pi application available remotely from any browser or smartphone. And with the free ios app, setting up your Pi to send you push notifications is a snap. Weaved is a start-up based in downtown Palo Alto, founded by serial entrepreneurs with a deep background in TCP/IP networking and cloud services. The Company is angel funded and backed by some of the top investors for both networking and cloud service companies. Weaved is committed to the vision of making it possible for anyone to create their own Internet of Things applications, to realize the Internet of Things for Everyone. Today, the Company offers a fully capable, software-only, hardware-agnostic platform along with drop-in services, to easily enable sophisticated users and developers to add Internet of Things capability to any already networked products. The founders' previous networking company was acquired by nVidia. Weaved is also a charter member of the AllSeen Alliance, a non-profit consortium dedicated to enabling the Internet of Everything through a universal development framework.

9.1 How it Works

The Weaved IoT kit brings the power of Software Defined Networking (SDN) to any networked device. The installer for Raspberry Pi and BeagleBone Black has presets for common services and the ability to configure Weaved for any TCP based service you want to make available remotely – securely and without port forwarding.

IMAGE 9.1: Weaved app

9.1.1 SSH

Whether on your computer or iOS/Android device, you probably have a favorite SSH client. The SSH option configures Weaved to connect to port 22. Once you've set up SSH, simply login to weaved.com and we'll give you an IP address:port combination that you can copy and paste to your SSH client to connect. Don't worry, that IP:port combination provides a secure, encrypted connection valid for a single session.

IMAGE 9.2: SSH login

9.1.2 Web (http) on port 80

If you have developed an application for your Raspberry Pi that uses a web browser for the user interface, then this option is ideal for you. It is also the option if you use an application like OpenSprinkler that uses a web-interface for the controls. This option is pre-configured for port 80, but don't worry, all Weaved based connections are secure even if not using SSL. The free iOS app also includes a built in web browser, so you can use that to connect as well.

9.1.3 WebIOPI (Raspberry Pi only)

This setting is for developers who wish to use WebIOPI, a popular customizable IoT Framework developed for Raspberry Pi by Eric Ptak. WebIOPi offers the ability to directly control your Raspberry Pi's GPIOs through a web interface, as well as support for a variety of popular sensors and other devices using i2c, SPI, or serial interfaces.

9.2 Custom TCP service

This last setting is intended for advanced users who would like to use the Weaved services for custom applications. Weaved can be set to work with any port & will work with any standard internet protocol. We'll soon also be releasing tools for other platforms, so developers will be able to build end-to-end custom Internet of Things applications, with the secure Weaved services.

9.3 Push Notifications to iOS Devices

Weaved also installs customizable scripts for sending push notifications to iOS devices. These scripts give you the flexibility to send custom messages from your own program running on the Raspberry Pi to your iPhone or iPad.

CHAPTER 10

The making of the autonomous surface vehicle

10.1 Design

The design of the vessel was on the basis of the reduced aerodynamic and hydrodynamic drag

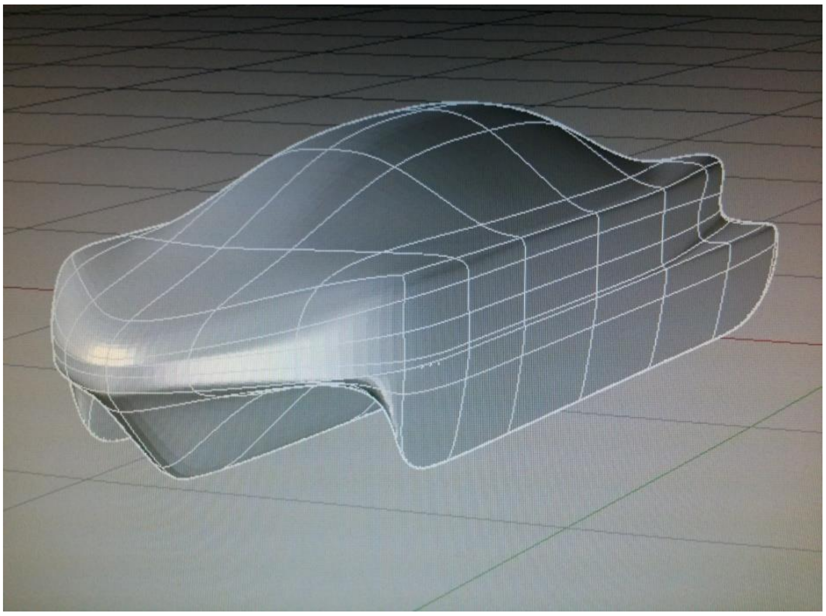

IMAGE 10.1: Vessel design

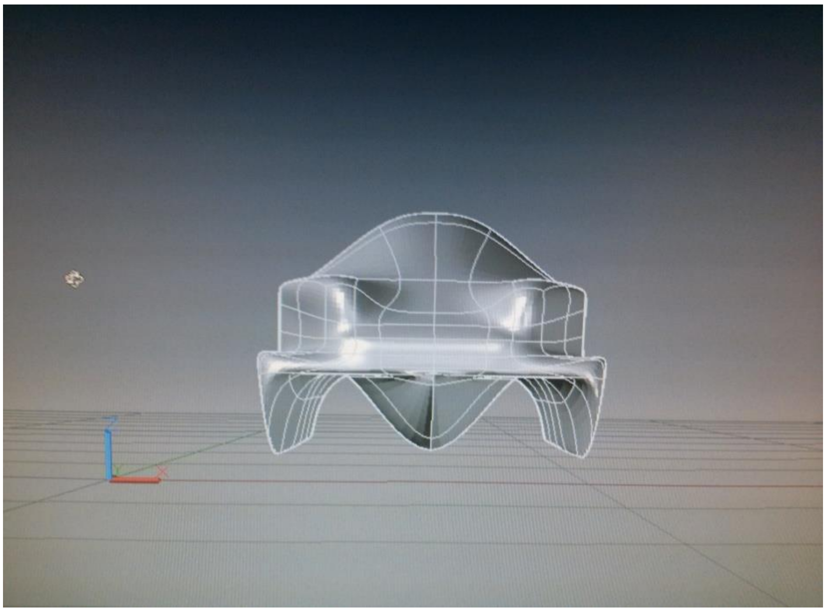

IMAGE 10.2: Vessel design rear view

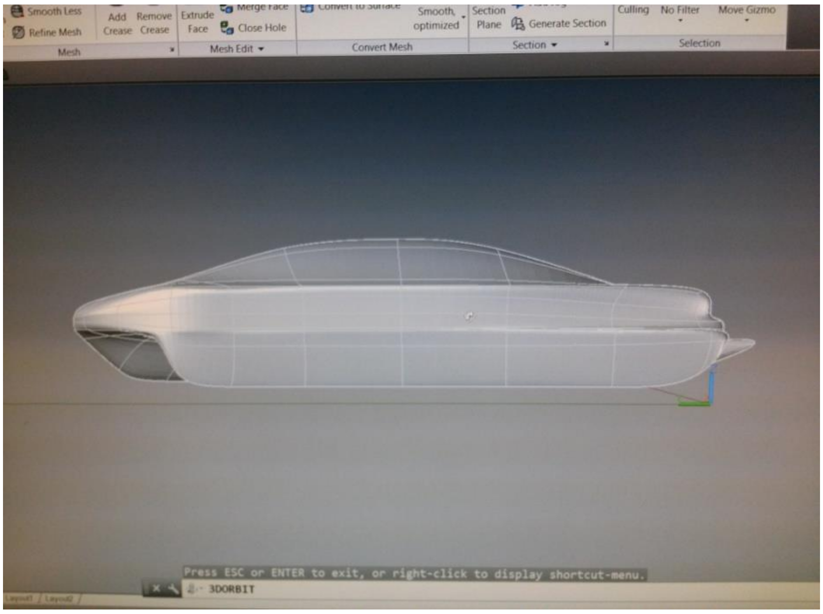

IMAGE 10.3: Vessel design side view

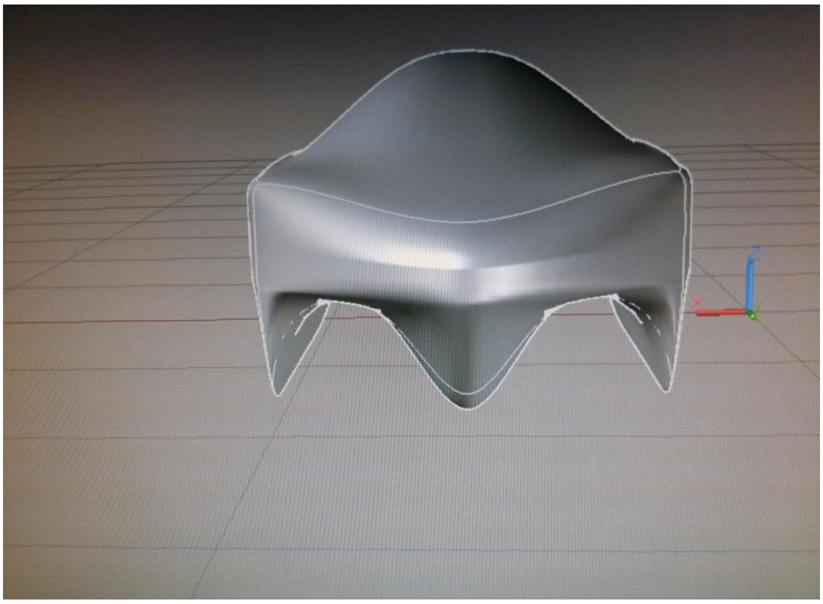

IMAGE 10.4: Vessel design front view

The design was implemented with the help of design software autocad and aerodynamic simulation program flow design

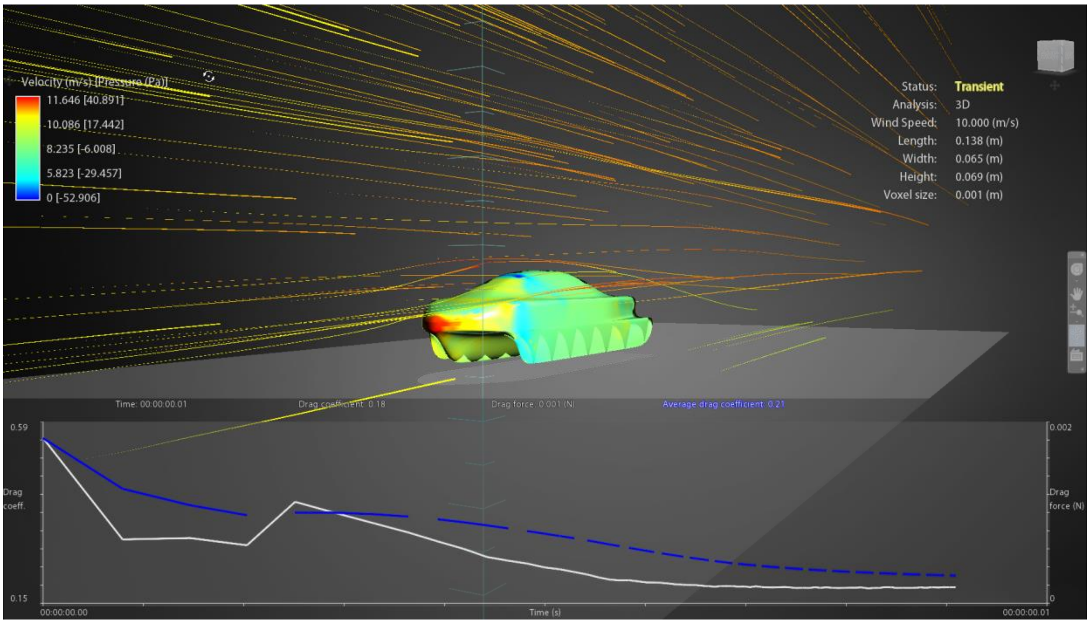

IMAGE 10.5: Aerodynamic simulation1

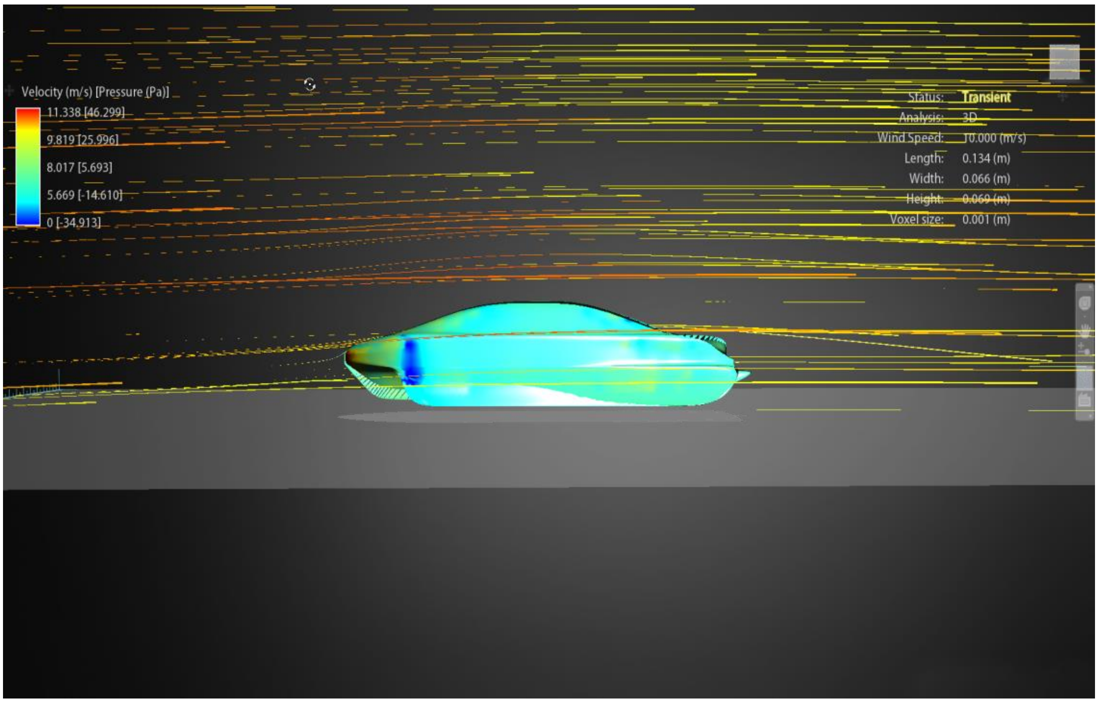

IMAGE 10.6: Aerodynamic simulation2

10.2 Wiring and electronic components properties

RHINO lipo motor battery:
Capacity : 1050mAh
Constant discharge: 20C
Burst rate: 30C (15sec)
Configuration : 3S 11.1v
Pack size: 73x18x35mm
Weight : 100.3g
Discharge plug: XT60

A2212 1000KV Brushless Motor:
-Model: A2212
-KV: 1000
-MAX Efficiency: 80%
-MAX Efficiency Current: 4-10A (>75%)
-Current Capacity: 12A / 60s
-No Load Current: 10 V : 0.5 A-Apply to the ESC: 30A.
-Apply to the Lipo: 2 - 3S.
-Apply to the NiCD / NiMH: 6 - 9S.
-Motor Dimension: 27.5 x 27mm
-Shaft Diameter: 3.17mm
-Weight: 50g approx

30A Brushless ESC:
-Output: Continuous 30A, burst 40A up to 10 Seconds.
-Input voltage: 2-4 cells Li-poly battery or 5-12 cells NiCd/NIMh battery
-BEC: 2A / 5V (Linear mode).
-Max speed: 210,000rpm for 2 poles BLM, 70,000rpm for 6 poles BLM, 35,000rpm for 12 poles BLM. (BLM: Brushless Motor)
-Size: 45 * 24 * 11mm / 1.8 * 0.9 * 0.4in

-Weight: 25g / 0.9oz

Vodafone(Huawei) K4203 - Unlocked 21Mbit/s USB Stick Modem Dongle K4203

- Type: USB Modem/Data Card(Unlocked)
- Processor: HiSilicon Balong 330
- 3G Bands: Dual Band, 900/2100MHz
- 2G Bands: Quad-band, 850/900/1800/1900
- Max 3G speed: WCDMA/UMTS 21.6Mbps DL, 5.76Mbps UL
- Max. Power consumption: 4.75V-5.25V / 500mA
- Weight: About 29g
- Size: 88.2x27.3x11.5mm

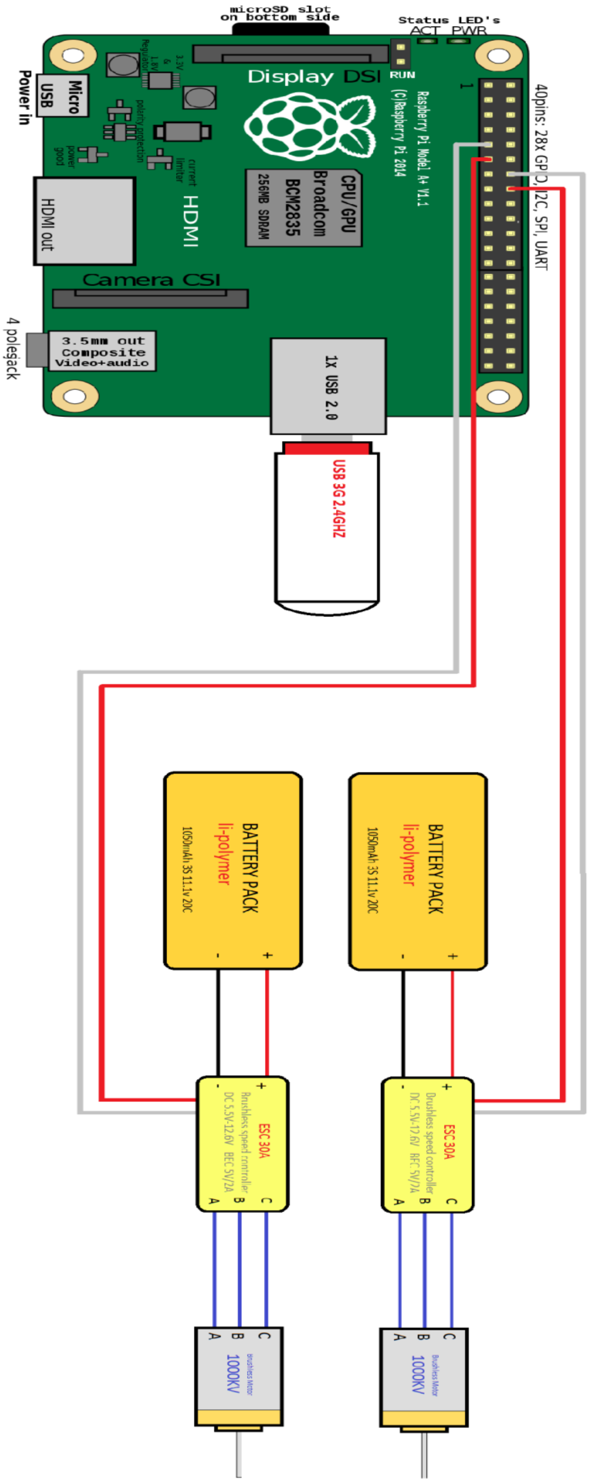

IMAGE 10.7: Wiring and electronic components diagram

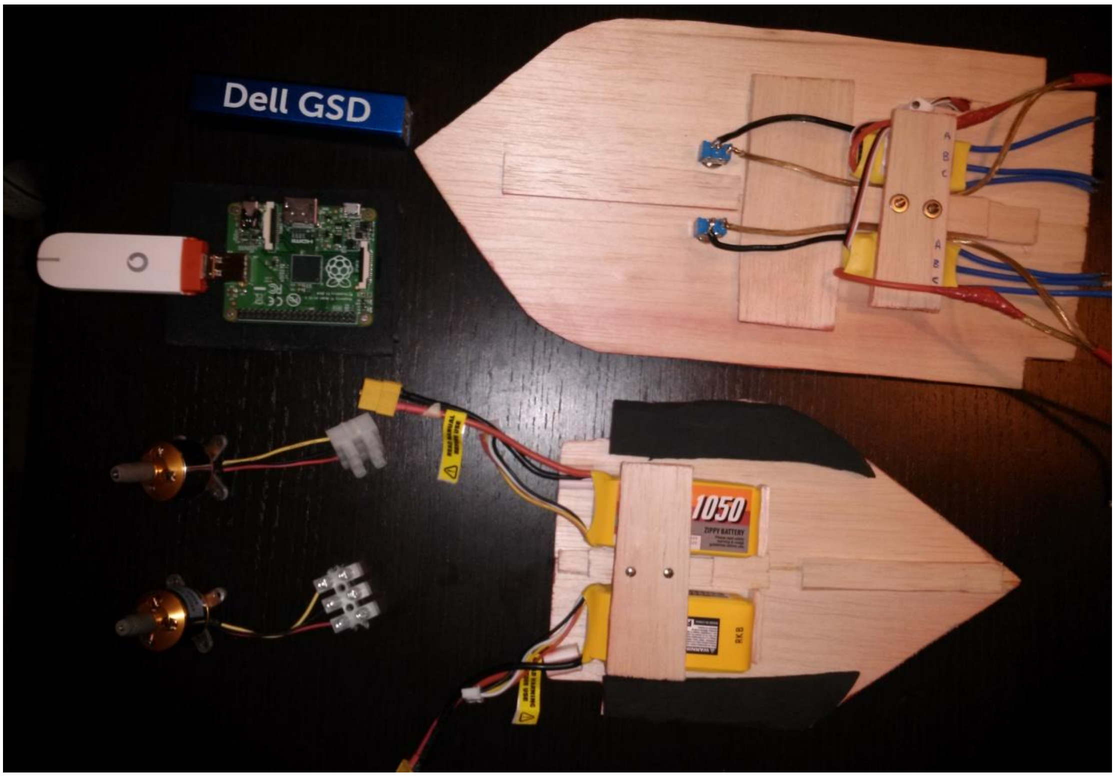

IMAGE 10.8: Electronic components

10.3 The construction of the main body

The first step was the creation of a prototype body made of polisterin based on our cad design.

IMAGE 10.9: prototype body made of polisterin

The protorype body used as a male mold for the construction of the final body. We used a combination of synthetic fibers and epoxy resin to make a lightweigh and strong Final vessel

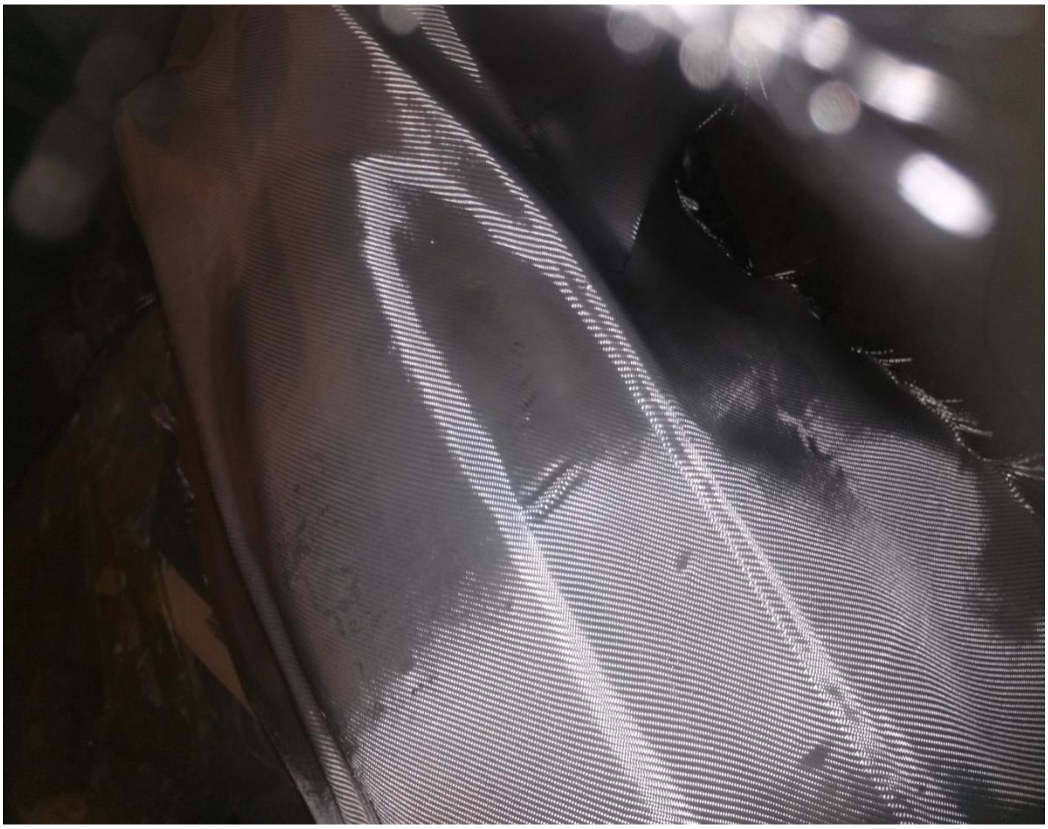

IMAGE 10.10: synthetic fibers mold wrap upper body

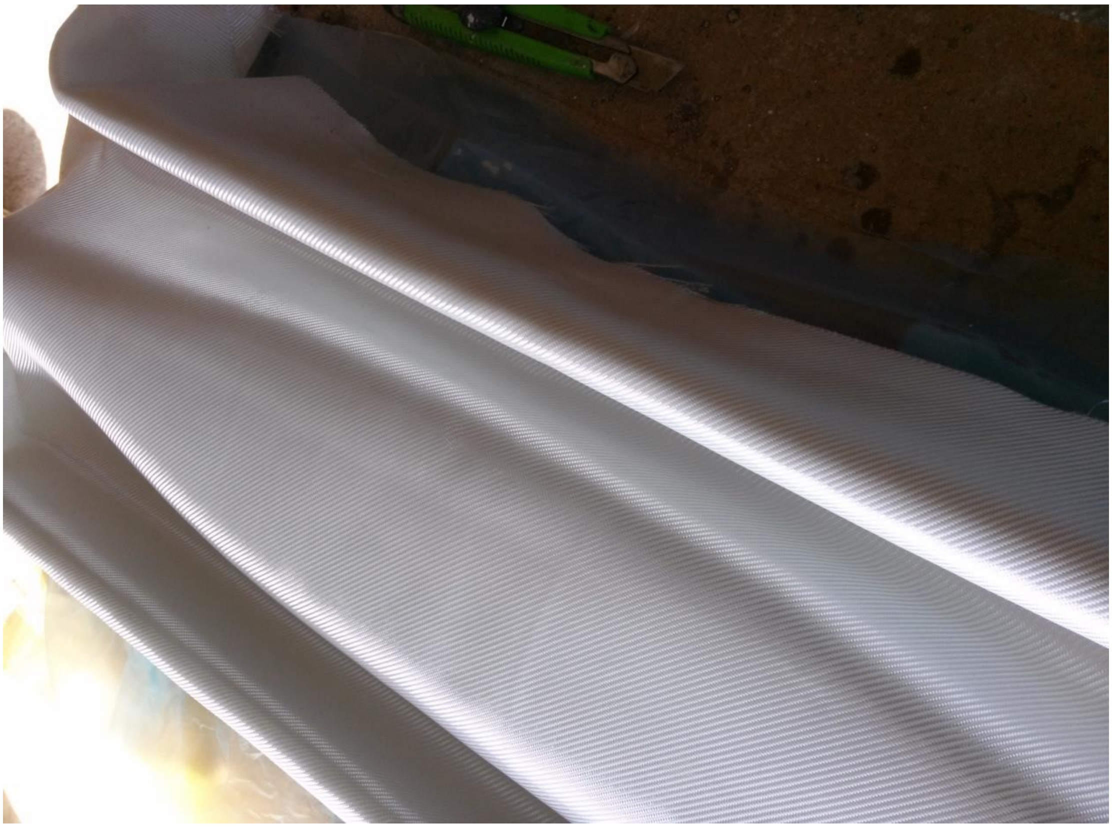

IMAGE 10.11: synthetic fibers mold wrap under keel

IMAGE 10.12: Red carbon fiber

We injected resin foam into the vessel in order to make it even stronger and stiffer

The top shell of the vessel painted in red with two stripes in racing spirit.

IMAGE 10.14: Top shell of the upper body

the next step is to place the drive shaft , the propeller and the internal components based of our electronic diagram.

IMAGE 10.15: Brushless motors location

IMAGE 10.16: Drive shaft angle

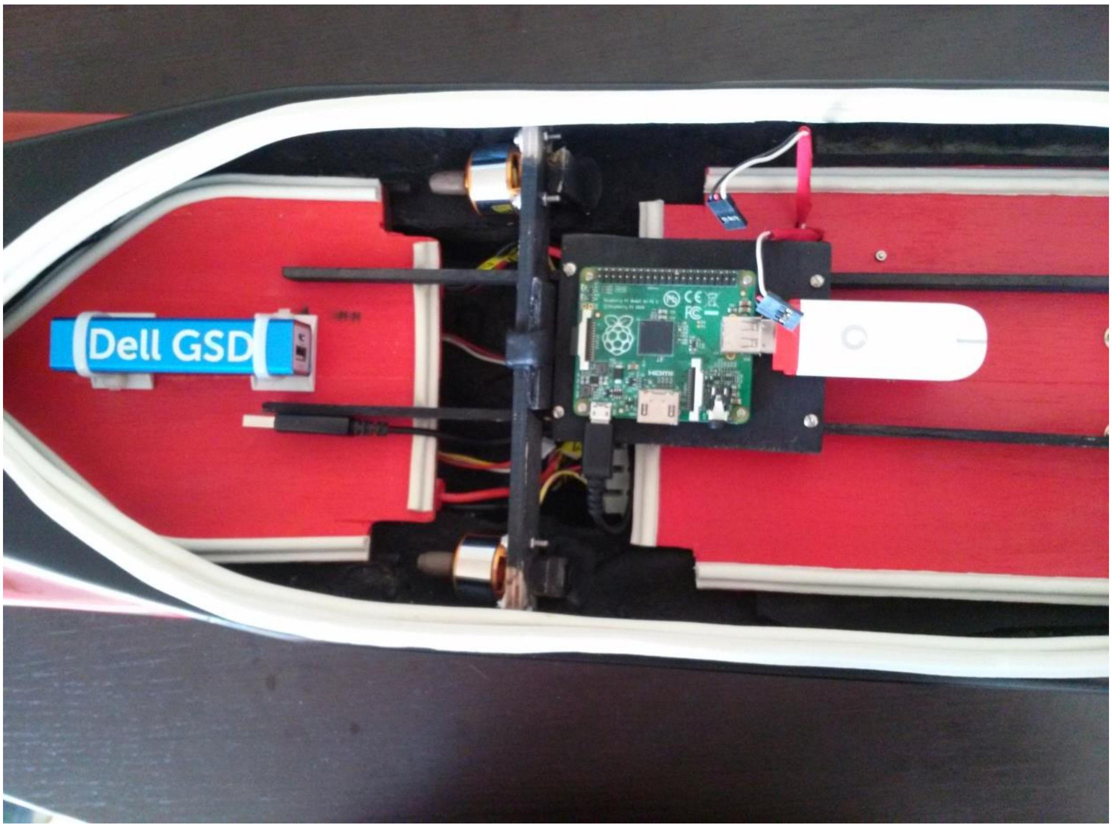

IMAGE 10.17: The internal parts placed base on their functionality

The final stage of construction board took the final painting and polishing

IMAGE 10.18: Final result1

IMAGE 10.19: Final result2

10.4 Technical characteristics

Dimensions: (75 x 21 x 16)cm

Weight: 2.725kgr(components included)

Battery Capacity: 1050mAh per battery

MAX Efficiency(motors): 80%

MAX Efficiency Current: 4-10A (>75%)

MAX Speed estimated: >43.19 nautical miles per hour

Speed at 20% load: 16.19 nautical miles per hour (ideal conditions)

Autonomy: 4h15m at 20% load

Drag coefficient: 0.18 c_d

vessel type: trimaran

10.5 Applications

- Scanning coasts for geological research
- Patrolling sea areas for protection
- Archaeological research
- Biological research
- Real-time sea life observation
- Research for rich fishing areas
- Sea or ocean exploration
- Autonomous delivery system on water surface
- Military applications
- Meteorological research

APPENDIX A

This annex contains the code handling the board .

RPIO\PWM__init__.py

```
# -*- coding: utf-8 -*-
#
# This file is part of RPIO.
#
# Copyright
#
#     Copyright (C) 2013 Chris Hager <chris@linuxuser.at>
#
# License
#
#     This program is free software: you can redistribute it and/or modify
#     it under the terms of the GNU Lesser General Public License as published
#     by the Free Software Foundation, either version 3 of the License, or
#     (at your option) any later version.
#
#     This program is distributed in the hope that it will be useful,
```

```
#     but WITHOUT ANY WARRANTY; without even the implied warranty of
#     MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
#     GNU Lesser General Public License for more details at
#     <http://www.gnu.org/licenses/lgpl-3.0-standalone.html>
#
# Documentation
#
#     http://pythonhosted.org/RPIO
#
"""
Flexible PWM via DMA for the Raspberry Pi. Supports pulse width granularities
of down to 1µs, multiple DMA channels, multiple GPIOs per channel, timing by
PWM (default) or PCM and more. RPIO.PWM is BETA; feedback highly appreciated.

You can directly access the low-level methods via PWM.init_channel(), etc. as
well as several helpers such as the PWM.Servo class. For more information take
a look at pythonhosted.org/RPIO as well as the source code at
https://github.com/metachris/RPIO/blob/master/source/c_pwm

Example of using `PWM.Servo`:

    servo = RPIO.PWM.Servo()

    # Set servo on GPIO17 to 1200µs (1.2ms)
```

#


```
    servo.set_servo(17, 1200)


    # Set servo on GPIO17 to 2000µs (2.0ms)

    servo.set_servo(17, 2000)


    # Clear servo on GPIO17

    servo.stop_servo(17)


Example of using the low-level methods:


    PWM.setup()

    PWM.init_channel(0)

    PWM.print_channel(0)

    PWM.add_channel_pulse(0, 17, 0, 50)

    ...

    PWM.clear_channel_gpio(0, 17)

    ...

    PWM.cleanup()
"""

from RPIO.PWM import _PWM


#

# Constants from pwm.c
```

```
#
DELAY_VIA_PWM = _PWM.DELAY_VIA_PWM
DELAY_VIA_PCM = _PWM.DELAY_VIA_PCM
LOG_LEVEL_DEBUG = _PWM.LOG_LEVEL_DEBUG
LOG_LEVEL_ERRORS = _PWM.LOG_LEVEL_ERRORS
SUBCYCLE_TIME_US_DEFAULT = _PWM.SUBCYCLE_TIME_US_DEFAULT
PULSE_WIDTH_INCREMENT_GRANULARITY_US_DEFAULT = \
        _PWM.PULSE_WIDTH_INCREMENT_GRANULARITY_US_DEFAULT
VERSION = _PWM.VERSION



#
# Methods from pwm.c
#
def setup(pulse_incr_us=PULSE_WIDTH_INCREMENT_GRANULARITY_US_DEFAULT, \
        delay_hw=DELAY_VIA_PWM):
    """
    Setup needs to be called once before working with any channels.

    Optional Parameters:
        pulse_incr_us: the pulse width increment granularity (deault=10us)
        delay_hw: either PWM.DELAY_VIA_PWM (default) or PWM.DELAY_VIA_PCM
    """
    return _PWM.setup(pulse_incr_us, delay_hw)
```

```
def cleanup():
    """ Stops all PWM and DMA actvity """
    return _PWM.cleanup()


def init_channel(channel, subcycle_time_us=SUBCYCLE_TIME_US_DEFAULT):
    """ Setup a channel with a specific subcycle time [us] """
    return _PWM.init_channel(channel, subcycle_time_us)


def clear_channel(channel):
    """ Clears a channel of all pulses """
    return _PWM.clear_channel(channel)


def clear_channel_gpio(channel, gpio):
    """ Clears one specific GPIO from this DMA channel """
    return _PWM.clear_channel_gpio(channel, gpio)


def add_channel_pulse(dma_channel, gpio, start, width):
```

```
    """
    Add a pulse for a specific GPIO to a dma channel subcycle. `start` and
    `width` are multiples of the pulse-width increment granularity.
    """
    return _PWM.add_channel_pulse(dma_channel, gpio, start, width)


def print_channel(channel):
    """ Print info about a specific channel to stdout """
    return _PWM.print_channel(channel)


def set_loglevel(level):
    """
    Sets the loglevel for the PWM module to either PWM.LOG_LEVEL_DEBUG for all
    messages, or to PWM.LOG_LEVEL_ERRORS for only fatal error messages.
    """
    return _PWM.set_loglevel(level)


def is_setup():
    """ Returns 1 if setup(..) has been called, else 0 """
    return _PWM.is_setup()
```

```
def is_channel_initialized(channel):
    """ Returns 1 if this channel has been initialized, else 0 """
    return _PWM.is_channel_initialized(channel)


def get_pulse_incr_us():
    """ Returns the currently set pulse width increment granularity in us """
    return _PWM.get_pulse_incr_us()


def get_channel_subcycle_time_us(channel):
    """ Returns this channels subcycle time in us """
    return _PWM.get_channel_subcycle_time_us(channel)


class Servo:
    """
    This class is a helper for using servos on any number of GPIOs.
    The subcycle time is set to the servo default of 20ms, but you can
    adjust this to your needs via the `Servo.__init__(..)` method.
```

```
    Example:

        servo = RPIO.PWM.Servo()

        # Set servo on GPIO17 to 1200µs (1.2ms)
        servo.set_servo(17, 1200)

        # Set servo on GPIO17 to 2000µs (2.0ms)
        servo.set_servo(17, 2000)

        # Clear servo on GPIO17
        servo.stop_servo(17)
    """
    _subcycle_time_us = None
    _dma_channel = None

    def __init__(self, dma_channel=0, subcycle_time_us=20000, \
            pulse_incr_us=10):
        """
        Makes sure PWM is setup with the correct increment granularity and
        subcycle time.
        """
        self._dma_channel = dma_channel
```

```
        self._subcycle_time_us = subcycle_time_us
        if _PWM.is_setup():
            _pw_inc = _PWM.get_pulse_incr_us()
            if not pulse_incr_us == _pw_inc:
                raise AttributeError(("Error: PWM is already setup with pulse-"
                        "width increment granularity of %sus instead of %sus")\
                         % (_pw_inc, self.pulse_incr_us))
        else:
            setup(pulse_incr_us=pulse_incr_us)


    def set_servo(self, gpio, pulse_width_us):
        """
        Sets a pulse-width on a gpio to repeat every subcycle
        (by default every 20ms).
        """
        # Make sure we can set the exact pulse_width_us
        _pulse_incr_us = _PWM.get_pulse_incr_us()
        if pulse_width_us % _pulse_incr_us:
            # No clean division possible
            raise AttributeError(("Pulse width increment granularity %sus "
                    "cannot divide a pulse-time of %sus") % (_pulse_incr_us,
                    pulse_width_us))


        # Initialize channel if not already done, else check subcycle time
```

```
        if _PWM.is_channel_initialized(self._dma_channel):
            _subcycle_us = _PWM.get_channel_subcycle_time_us(self._dma_channel)
            if _subcycle_us != self._subcycle_time_us:
                raise AttributeError(("Error: DMA channel %s is setup with a "
                        "subcycle_time of %sus (instead of %sus)") % \
                        (self._dma_channel, _subcycle_us,
                            self._subcycle_time_us))
        else:
            init_channel(self._dma_channel, self._subcycle_time_us)

        # Add pulse for this GPIO
        add_channel_pulse(self._dma_channel, gpio, 0, \
                int(pulse_width_us / _pulse_incr_us))

    def stop_servo(self, gpio):
        """ Stops servo activity for this gpio """
        clear_channel_gpio(self._dma_channel, gpio)
```

motor.py

```
from time import sleep

class motor(object):
    """Manages the currect Angular rotation W
        Implements the IO interface using the RPIO lib
        __init_(self, name, pin, kv=1000, WMin=1, WMax=100, debug=True, simulation=True):
        More info on RPIO in http://pythonhosted.org/RPIO/index.html"""

    def __init__(self, name, pin, kv=1000, WMin=0, WMax=100, debug=True, simulation=True):
        self.name = name
        self.powered = False
        self.simulation = simulation
        self.pin = pin
        self.debug=debug
        self.__WMin = 0
        self.__WMax = 100
        self.setWLimits(WMin, WMax)
```

```
        self.__W = self.__WMin

            self.kv = kv
                self.mass=0.050 #[kg]

                    try:
                        from RPIO import PWM
                            #here just check that library is available
                            self.PWM=PWM
                                except ImportError:
                                    self.simulation = True


def setWLimits(self, WMin, WMax):
    "set the pin for each motor"
        if WMin < 0:
            WMin = 0
    self.__WMin = WMin
        if WMax > 100:
            WMax = 100
self.__WMax = WMax
```

```
    def saveWh(self):
        "Save Wh = current W%"
        self.__Wh = self.__W


    def setWh(self):
        "Sets current W% =Wh"
        self.__W = self.__Wh
        self.setW(self.__W)


    def getWh(self):
        "returns current W% =Wh"
        return self.__Wh


    def start(self):
        "Run the procedure to init the PWM"
        if not self.simulation:
            try:
                from RPIO import PWM
                if not self.PWM.is_setup():
                    self.PWM.setup(pulse_incr_us=1)
                    self.PWM.set_loglevel(PWM.LOG_LEVEL_ERRORS)
                    self.PWM.init_channel(1,3000)
#self.servo = PWM.Servo(dma_channel=1, subcycle_time_us=5000,pulse_incr_us=1)
```

motor_test.py

```
import curses
from motor import motor
mymotor = motor('m1', 24, simulation=False)
mymotor2 = motor('m1', 27, simulation=False)
print('***Disconnect ESC power')
print('***then press ENTER')
res = raw_input()
mymotor.start()
mymotor.setW(100)
mymotor2.start()
mymotor2.setW(100)

print('***Connect ESC Power')
print('***Wait beep-beep')

print('***then press ENTER')
res = raw_input()
```

```
mymotor.setW(0)


mymotor2.setW(0)


print('***Wait N beeps - one for each battery cell')
print('***Wait beeeeeep for ready')
print('***then press ENTER')
res = raw_input()
print ('increase > a | decrease > z | save Wh > n | set Wh > h|quit > 9')
screen = curses.initscr()
cycling = True
try:
    while cycling:
        res = screen.getch()
        if res == ord('1'):
            mymotor.setW(6)
            mymotor2.setW(6)
        if res == ord('w'):
            mymotor.setW(mymotor.getW() + 2)
            mymotor2.setW(mymotor2.getW() + 2)
        if res == 's':
            mymotor.setW(mymotor.getW() - 2)
            mymotor2.setW(mymotor2.getW() - 2)
        if res == ord('a'):
```

```
            mymotor.setW(mymotor.getW() - 2)
            mymotor2.setW(mymotor2.getW() + 2)
        if res == ord('2'):
            mymotor.setW(0)
            mymotor2.setW(0)

        if res == ord('d'):
            mymotor.setW(mymotor.getW() + 2)
            mymotor2.setW(mymotor2.getW() - 2)
        if res == ord('9'):
            break
finally:
    # shut down cleanly
    mymotor.stop()
    mymotor2.stop()
    print ("well done!")
    curses.endwin()
```

BIBLIOGRAPHY

REFERENCES

- William H.Yeadon, Alan W.Yeadon, “HandBook on Small Electric Motors”, MCGraw Hill
- Ari Almqvist, “New approach for high performance motion control”, SICFP’03, May 7-9 2003.
- Edward Lee, “Large Brushless Drive Systems”
- Sun, Bing; Mindemark, Jonas; Edström, Kristina; Brandell, Daniel (1 September 2014). "Polycarbonate-based solid polymer electrolytes for Li-ion batteries". Solid State Ionics 262: 738–742. doi:10.1016/j.ssi.2013.08.014.
- Zhai, Wei; Zhu, Hua-jun; Wang, Long (1 July 2014). "Study of PVDF-HFP/PMMA blended micro-porous gel polymer electrolyte incorporating ionic liquid [BMIM]BF_4 for Lithium ion batteries". Electrochimica Acta 133: 623–630. doi:10.1016/j.electacta.2014.04.076.
- Brodd, Ralf J. (2002). "Chapter 9: Lithium-Ion cell production processes". In van Schalkwijk, Walter A.; Scrosati, Bruno. Advances in Lithium-ion batteries. Kluwer Academic Publishers. ISBN 0-306-47356-9.
- Yazami, Rachid (2009). "Chapter 5: Thermodynamics of Electrode Materials for Lithium-Ion Batteries". In Ozawa, Kazunori. Lithium ion rechargeable batteries. Wiley-Vch Verlag GmbH & Co. KGaA. ISBN 978-3-527-31983-1.
- "Lithium polymer battery". Retrieved 20 November 2015.

- Brown, Warren (3 November 2011). "2011 Hyundai Sonata Hybrid: Hi, tech. Bye, performance". Washington Post. Retrieved 25 November 2011.
- FAA Battery Incident Chart, includes incidents of Lithium-Polymer-Air ignition after puncturing. Ex: Entry for 11-Dec-2007
- Scrosati, Bruno (2002). "Chapter 8: Lithium polymer electrolytes". In van Schalkwijk, Walter A.; Scrosati, Bruno. Advances in Lithium-ion batteries. Kluwer Academic Publishers. ISBN 0-306-47356-9.
- Yoshio, Masaki; Brodd, Ralph J.; Kozawa, Akiya, eds. (2009). Lithium-ion batteries. Springer. doi:10.1007/978-0-387-34445-4. ISBN 978-0-387-34444-7.
- Nishi, Yoshio (2002). "Chapter 7: Lithium-Ion Secondary batteries with gelled polymer electrolytes". In van Schalkwijk, Walter A.; Scrosati, Bruno. Advances in Lithium-ion batteries. Kluwer Academic Publishers. ISBN 0-306-47356-9.
- Tarascon, Jean-Marie; Armand, Michele (2001). "Issues and challenges facing rechargeable lithium batteries". Nature 414: 359–367. doi:10.1038/35104644. PMID 11713543.
- Danny Briere; Pat Hurley; Edward Ferris (2008). Wireless Home Networking for Dummies (3 ed.). For Dummies. p. 265. ISBN 978-0-470-25889-7.
- "AutoCAD Civil 3D 2011 Drawing Compatibility" (PDF). AutoCAD Civil 3D 2011 User's Guide. Autodesk. April 2010. pp. 141–142. Retrieved January 29, 2013.

External links

- http://www.raspberrypi.org/archives/3195
- http://www.element14.com/community/docs/DOC-44828/l/raspberry-pi-safety-data-sheet
- https://wikipedia.org
- http://www.autodesk.com/products/flow-design/overview
- http://www.engineeringtoolbox.com/drag-coefficient-d_627.html
- https://www.weaved.com/raspberry-pi-remote-connection/