Design of a launch system for a scientific fix wing UAV without undercarriage

FINAL DEGREE PROJECT

Document:

Annex

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Degree:

Electrical + Mechanical engineering degree

Convocatory:

Spring

Annex Index

Annex 1. Bormatec Maja

Annex 1.1. Bormatec Maja Datasheet

BORMATEC .com
UNMANNED VEHICLES

Bauanleitung

MAJA

Trägersystem UAV / RPV / FPV

MADE IN GERMANY

Vorsicht! Dieses Modell ist kein Spielzeug! Geeignet für Personen ab 14 Jahren!

BORMATEC
unmanned vehicles

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Baukasteninhalt

- Rumpf, teilbar aus EPP und Coroplast
- Tragfläche dreiteilig aus EPP
- Leitwerke aus EPP
- Motorhalterung
- Rumpfarretierungen
- Randbögen
- Kleinzubehör
- Bauanleitung

Erforderliches Zubehör

- 2 Mini-Servos (9 – 20 gr.) für Seiten- und Höhenruder
- 2 Tragflächenservos (Standard 20 - 40 gr.) für Querruder
- RC-Anlage
- Brushless-Motor mit 400W-550W + 40A-50A Regler
- Luftschraube: 2-Blatt 12 x 6, bzw. 3-Blatt 10 x 7
- Akku z.B. 3S LiPo 8000mAh 11,1V

Erforderliches Werkzeug

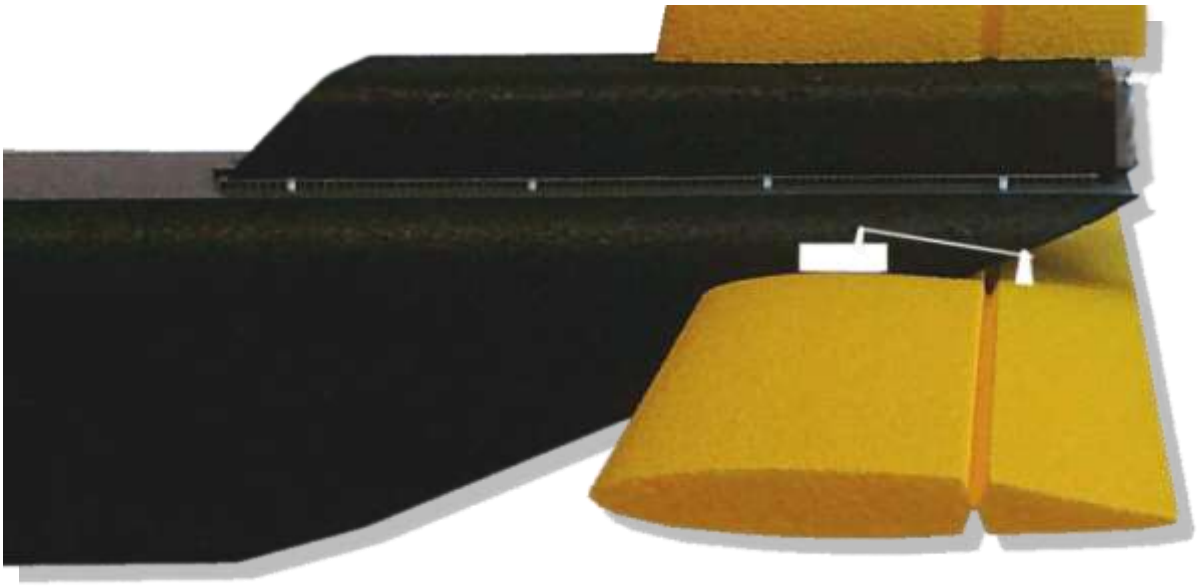
- Cutter (sehr scharfes Messer)
- Klebstoff (Heißkleber oder 5min-Epoxi)
- Schleifpapier

Technische Daten

Spannweite:	1800 / 2200 mm
Länge:	1200 mm
Leergewicht:	~1700 gr. (inkl. RC & Antrieb, ohne Akku)
RC-Funktionen:	Seite, Höhe, Quer, Motor

Höhenleitwerk

Höhenleitwerk im Ausschnitt am Heck mittig einkleben. Servoaussparung lt. Bild im Heckteil vornehmen. Servo in die Aussparung einkleben. Servokabel nach oben zum Rumpfoberteil führen.



Heckaufsatz / Motoraufnahme

Der Heckaufsatz vereint den Antrieb, die Seitenleitwerksauflage und den Kühlkanal für den Regler. Dieser ist so konzipiert, dass er mit 4 Stiften am Rumpf befestigt ist und abgenommen werden kann, um schnell und einfach an die einzelnen Komponenten zu gelangen.
Die zwei beiliegenden Motorspante zusammenkleben und die Seitenstreben mit dem Motorspant verkleben. Motor am Spant befestigen und im Heckteil des Aufsatzes einkleben. Der Regler wird im Innenteil des Heckaufsatzes verlegt.

Seitenruder

Die Arretierungsstifte des Heckaufsatzes herausziehen und den Aufsatz abnehmen. Die Servoaussparungen für das Seitenruderservo mit Hilfe eines Cutters vornehmen und das Servo einkleben. Seitenleitwerk mittig und nach hinten mit 2cm Abstand (siehe Bild) auf den Aufsatz aufkleben. Sämtliche Kabel durch die Öffnung auf der Rumpfoberseite einführen und in das Innere des Rumpfes ziehen. Heckaufsatz bündig mit der Vorderkante aufsetzen und mit den 4 Stiften arretieren.

Rumpf

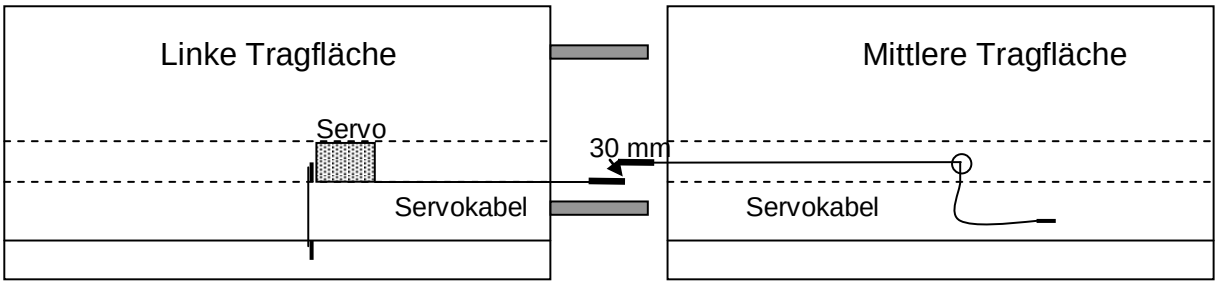
Um den Rumpf zusammen zu halten, werden Ober- und Unterteil mit den Arretierungen festgehalten. Diese müssen noch seitlich, **mit der Überlappung nach unten**, angeklebt werden. Achten Sie darauf, dass die Überlappung der Arretierung nicht verklebt wird. Den Abstand entnehmen Sie bitte dem folgenden Bild.

Winglets

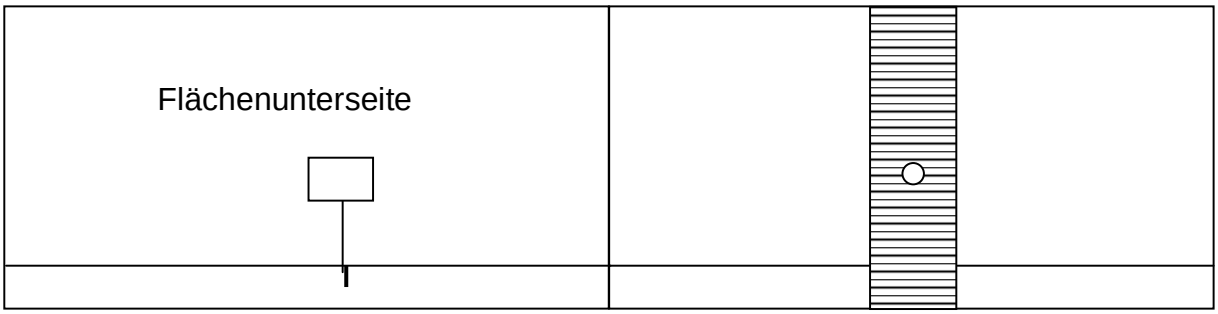
Die Winglets werden mit Epoxi an die äußeren Tragflächenenden geklebt.

Tragflächen

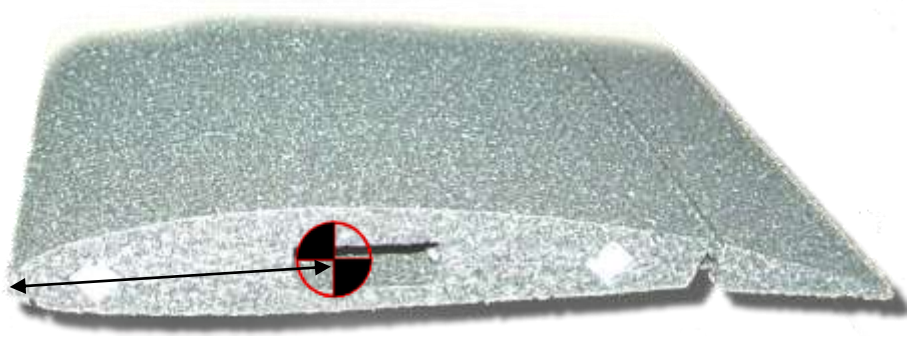
Die Tragflächenservos werden auf der Flügelunterseite verbaut. Die Flächen sind hierfür bereits mit einem Servoschacht versehen. Die Servos lt. Zeichnung positionieren.



Sind die Servos positioniert, werden die Aussparungen mit einem Cutter herausgeschnitten, die Servos eingebaut und mit den Querrudern verbunden. Die beiden Servoverlängerungskabel der mittleren Fläche werden später durch eine Öffnung im Rumpfoberteil in den Rumpf eingeführt.



Schwerpunkt



Der Schwerpunkt liegt **6 cm** hinter der Tragflächen-vorderkante.

Einfliegen

Sämtliche Ruder sollten ca. 15 – 20 mm auf jeder Seite ausschlagen!

Kontrollieren Sie nochmals den Schwerpunkt, alle Ruderfunktionen auf sinngemäß richtigen Ausschlag und führen Sie einen Reichweitentest durch.

Warten Sie nun für den Erstflug einen möglichst windstillen Tag ab. Überprüfen Sie generell vor jedem Flug alle Funktionen. Starten Sie das Fluggerät mit **Vollgas** und mit einem leichten Schwung nach oben. Vermeiden Sie ruckartige Gaswechsel, um ein Abkippen der Fluglage zu verhindern.

Trimmen Sie das Modell beim Erstflug so, dass es gerade fliegt. Korrigieren Sie nach der Landung alle Einstellungen, die Ihnen nicht gefallen haben.

Hinweis: MAJA nur im Temperaturbereich – 5 bis +50 ° C einsetzen.

Wir weisen ausdrücklich darauf hin, dass wir keinen Einfluss auf den Zusammenbau und den Betrieb der MAJA haben und daher auch keine Haftung für Schäden übernehmen, die beim Bau oder durch den Flugbetrieb entstehen.

Sicherheitshinweise

Bitte unbedingt die folgenden Sicherheitshinweise beachten.
Sofern das Modell an eine andere Person weitergegeben wird, müssen diese Sicherheitshinweise, sowie der Schnellbauplan unbedingt zur Beachtung weitergegeben werden.
Aus Sicherheitsgründen dürfen nur die im Bausatz enthaltenen Bauteile und Zubehörteile eingesetzt werden.

Wichtige Sicherheitshinweise
Haftungsausschluss
Sowohl die Einhaltung der Montage- und Betriebsanleitung in Zusammenhang mit dem Modell als auch die Bedienung und Methoden bei Installation, Betrieb, Verwendung und Wartung der Fernsteuerungsanlagen können von der Firma borjet/BORMATEC nicht überwacht werden. Daher übernimmt die Firma borjet/BORMATEC keinerlei Haftung für Verluste, Schäden oder Kosten, die sich aus der fehlerhaften Verwendung und Betrieb ergeben oder in irgendeiner Weise damit zusammenhängen.
Soweit vom Gesetzgeber nicht zwingend vorgeschrieben, ist die Verpflichtung der Firma borjet/BORMATEC zur Leistung von Schadensersatz, gleich aus welchem Rechtsgrund, begrenzt auf den Rechnungswert, der an dem schadenstiftenden Ereignis unmittelbar Beteiligten Warenmenge der Firma borjet/BORMATEC. Dies gilt nicht, soweit die Firma borjet/BORMATEC nach zwingenden gesetzlichen Vorschriften wegen Vorsatz oder grober Fahrlässigkeit unbeschränkt haftet.

Vor dem Versuch der ersten Inbetriebnahme muss die gesamte Betriebs- und Montageanleitung sorgfältig gelesen werden.
Sie alleine sind verantwortlich für den sicheren Betrieb Ihres RC-Flugmodells. Bei Jugendlichen muss der Bau und Betrieb von einem Erwachsenen, der mit den Gegebenheiten und möglichen Gefahren eines RC-Flugmodells vertraut ist, verantwortlich überwacht werden. Diese Bedienungsanleitung muss sorgfältig aufbewahrt und im Falle einer Weitergabe dem nachfolgenden Benutzer unbedingt mit ausgehändigt werden. Fragen, die die Sicherheit beim Betrieb des RC-Flugmodells betreffen, werden Ihnen vom Fachhandel oder von unserer Seite gerne beantwortet.
Fernsteuer-Flugmodelle sind sehr anspruchsvolle und gefährliche Gegenstände und erfordern vom Betreiber einen hohen Sachverstand, Können und Verantwortungsbewusstsein.
Rechtlich gesehen ist ein Flugmodell ein Luftfahrzeug und unterliegt entsprechenden Gesetzen, die unbedingt eingehalten werden müssen. Die Broschüre "Modellflugrecht" stellt eine Zusammenfassung dieser Gesetze dar; sie kann auch beim Fachhandel eingesehen werden. Ferner müssen postalische Auflagen, die die Fernlenkanlage betreffen, beachtet werden.
Entsprechende Hinweise finden Sie in der Bedienungsanleitung Ihrer Fernsteueranlage.

Es dürfen nur die dem Bausatz enthaltenen Teile, sowie die ausdrücklich von uns empfohlenen Original-borjet/BORMATEC-Zubehör- und Ersatzteile verwendet werden. Wird auch nur eine Komponente der Antriebseinheit geändert, ist ein sicherer Betrieb nicht mehr gewährleistet und es erlischt jeglicher etwaiger Garantieanspruch.

Verwenden Sie immer nur passende, verpolungssichere Steckverbindungen. Alle stromführenden Leitungen, Steckverbindungen, sowie die Antriebsbatterie, bei Selbstkonfektionierung, kurzschlusssicher isolieren. Kombinieren Sie niemals unterschiedliche, z. B. Blech- und Goldkontakte, da hier keine sichere Funktion gewährleistet ist.

Durch die hohe Energie der Batterien besteht Explosions- und Brandgefahr. Ein RC-Flugmodell kann nur funktionsfähig sein und den Erwartungen entsprechen, wenn es im Sinne der Bauanleitung sorgfältigst gebaut wurde. Nur ein vorsichtiger und überlegter Umgang beim Betrieb schützt vor Personen- und Sachschäden.

Allgemeine Hinweise

Der Hersteller hat keine Möglichkeit, den Bau und den Betrieb eines RC-Flugmodells zu beeinflussen. Deshalb wird hiermit auf die Gefahren nachdrücklich hingewiesen und jede Haftung dafür abgelehnt.
Bitte wenden Sie sich dazu an erfahrene Modellflieger, an Vereine oder Modellflugschulen. Ferner sei auf den Fachhandel und die einschlägige Fachpresse verwiesen. Am besten als Club-Mitglied auf zugelassenem Modellflugplatz fliegen.

Klebstoffe enthalten Inhaltsstoffe, die unter Umständen gesundheitsschädlich sein können. Beachten Sie daher unbedingt auch die entsprechenden Hinweise und Warnungen der Hersteller.
Der Betreiber muss im Besitz seiner vollen körperlichen und geistigen Fähigkeiten sein. Wie beim Autofahren, ist der Betrieb des Flugmodells unter Alkohol oder Drogeneinwirkung nicht erlaubt.
Informieren Sie alle Passanten und Zuschauer vor der Inbetriebnahme über alle möglichen Gefahren, die von Ihrem Modell ausgehen und ermahnen diese, sich in ausreichendem Schutzabstand, wenigstens 5 m hinter der Luftschraubenebene, aufzuhalten. Stets mit dem notwendigen Sicherheitsabstand zu Personen oder Gegenständen fliegen; nie Personen in niedriger Höhe überfliegen oder auf sie zufliegen!
Modellflug darf nur bei Außentemperaturen - 5º C bis + 35º C betrieben werden.
Extremere Temperaturen können zu Veränderungen von z. B. Akku-Kapazität, Werkstoffeigenschaften und mangelhafte Klebeverbindungen führen.

Jeder Modellflieger hat sich so zu verhalten, dass die öffentliche Sicherheit und Ordnung, insbesondere andere Personen und Sachen, sowie die Ordnung des Modellflugbetriebs nicht gefährdet oder gestört wird.
Das Flugmodell niemals in der Nähe von Hochspannungsleitungen, Industriegelände, in Wohngebieten, öffentlichen Straßen, Plätzen, Schulhöfen und Spielplätzen usw. fliegen lassen.

Überprüfung vor dem Start

Vor jedem Einsatz korrekte Funktion überprüfen. Dazu den Sender einschalten, ebenso den Empfänger. Senderantenne ausziehen, kontrollieren, ob alle Ruder einwandfrei funktionieren und in der richtigen Richtung ausschlagen. Diese Überprüfung bei laufendem Motor wiederholen, während ein Helfer das Modell festhält. Beim erstmaligen Steuern eines Flugmodells ist es von Vorteil, wenn ein erfahrener Helfer bei der Überprüfung und den ersten Flügen zur Seite steht.
Warnungen müssen unbedingt beachtet werden. Sie beziehen sich auf Dinge und Vorgänge, die bei einer Nichtbeachtung zu schweren - in Extremfällen tödlichen Verletzungen oder bleibenden Schäden führen können. Luftschrauben, die durch einen Motor angetrieben werden, stellen eine ständige Verletzungsgefahr dar. Sie dürfen mit keinem Körperteil berührt werden! Eine schnell drehende Luftschraube kann z. B. einen Finger einschneiden!
Sich niemals in oder vor der Drehebene von Luftschrauben aufhalten! Es könnte sich doch einmal ein Teil davon oder die komplette Luftschraube lösen und mit hoher Geschwindigkeit und viel Energie wegfliegen und Sie oder Dritte treffen. Darauf achten, dass kein sonstiger Gegenstand mit einer laufenden Luftschraube in Berührung kommt! Die Blockierung der Luftschraube, durch irgendwelche Teile, muss ausgeschlossen sein.
Vorsicht bei losen Kleidungsstücken wie Schals, weiten Hemden usw.: sie werden vom Propellerstrahl angesaugt und können in den Luftschraubenkreis gelangen.
Steht ein Modell mit drehender Luftschraube z. B. auf sandigem Grund, so werden Sand oder Schmutzpartikel angesaugt und herumgewirbelt, die u. U. Augenschäden hervorrufen können. Nötigenfalls Schutzbrille tragen.
Überprüfen Sie vor jeder Inbetriebnahme das Modell und alle an ihm gekoppelten Teile (z. B. Luftschrauben, Getriebe, RC-Teile usw.) auf festen Sitz und mögliche Beschädigungen. Das Modell darf erst nach Beseitigung aller Mängel in Betrieb genommen werden. Auf gute Standfestigkeit achten, wenn Sie das Modell in der Hand halten. Passendes Schuhwerk, z. B. Sportschuhe tragen.

Sicherheitshinweise beim Modellflug

Vergewissern sie sich, dass die verwendete Frequenz frei ist. Erst dann einschalten!
Funkstörungen, verursacht durch Unbekannte, können stets ohne Vorwarnung auftreten! Das Modell ist dann steuerlos und unberechenbar! Fernlenkanlage nicht unbeaufsichtigt lassen, um ein Betätigen durch Dritte zu verhindern.
Elektromotor nur einschalten, wenn nichts im Drehbereich der Luftschraube ist. Nicht versuchen, die laufende Luftschraube anzuhalten. Elektromotor mit Luftschraube nur im fest eingebauten Zustand laufen lassen.
Die Fluglage des Modells muss während des gesamten Fluges immer eindeutig erkennbar sein, um immer ein sicheres Steuern und Ausweichen zu gewährleisten. Machen sich während des Fluges Funktionsbeeinträchtigungen/Störungen bemerkbar, muss aus Sicherheitsgründen sofort die Landung eingeleitet werden. Sie haben anderen Luftfahrzeugen stets auszuweichen.
Start- und Landeflächen müssen frei von Personen und sonstigen Hindernissen sein.
Immer auf vollgeladene Akkus achten, da sonst keine einwandfreie Funktion der RC-Anlage gewährleistet ist.
Niemals heiß gewordene (über 50° C), defekte oder beschädigte Batterien verwenden. Es sind stets die Gebrauchsvorschriften des Batterieherstellers zu beachten.
Vor jedem Flug eine Überprüfung der kompletten RC-Anlage, sowie des Flugmodells, auf volle Funktionstüchtigkeit und Reichweite durchführen.
Dabei ist zu beachten, dass bei der Inbetriebnahme die Motorsteuerfunktion am Sender immer zuerst in AUS-Stellung gebracht wird. Danach Sender und dann erst Empfangsanlage einschalten, um ein unkontrolliertes Anlaufen des Elektromotors zu vermeiden. Gleichfalls gilt immer zuerst Empfangsanlage ausschalten, danach erst den Sender.
Überprüfen Sie, dass die Ruder sich entsprechend der Steuerknüppelbetätigung bewegen.
Nach Gebrauch alle Batterien aus dem Modell nehmen und nur im entladenen Zustand für Kinder unzugänglich, bei ca. + 5º bis + 25º C aufbewahren.

Mit diesen Hinweisen soll auf die vielfältigen Gefahren hingewiesen werden, die durch unsachgemäße und verantwortungslose Handhabung entstehen können.
Richtig und gewissenhaft betrieben ist Modellflug eine kreative, lehrreiche und erholsame Freizeitgestaltung.

ACHTUNG
In manchen Ländern ist es vorgeschrieben für den Betrieb eines Modells eine spezielle Modellhalterhaftpflichtversicherung abzuschließen. Informationen hierzu bekommen Sie bei den Modellsportverbänden oder bei einer Versicherung.

HINWEIS BEI VIDEOFLUG
Bei Verwendung einer Videokamera beim Modellflug beachten Sie bitte die gesetzlichen Bestimmungen Ihres Landes.

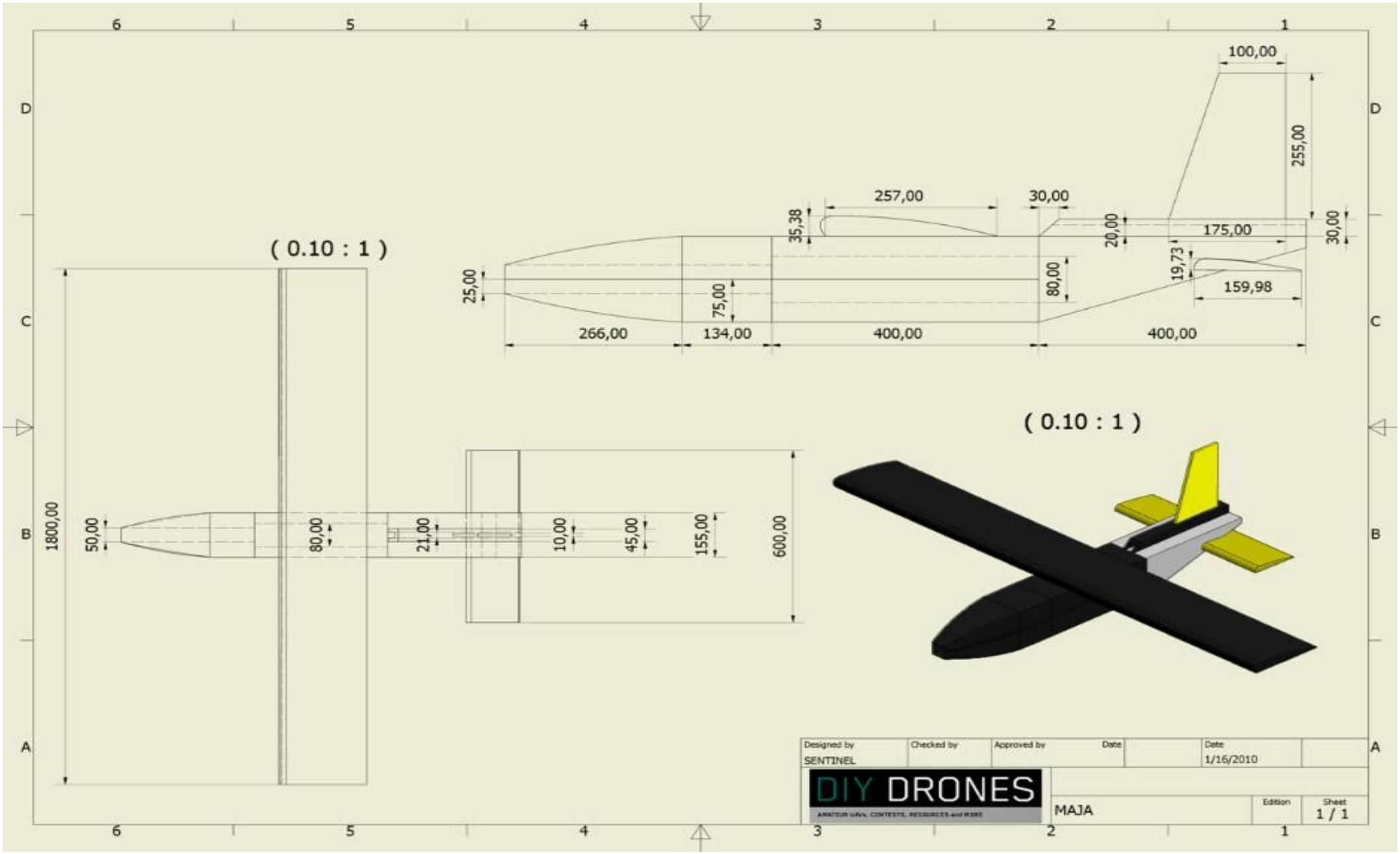
Ersatzteile MAJA

B_141001		Rumpf fertig zusammengeklebt		
		Fuselage EPP and Coroplast		
B_141002		Aufsatz Heck inkl. Spant		
		Rear top part with motor mount		
B_141003		Seitenleitwerk		
		Vertical tail		
B_141004		Höhenleitwerk		
		Elevator		
B_141005		3-teilige Fläche 180 cm		
		Wing 3 parts 180 cm		
B_141470				
		3-teilige Fläche 220 cm		
		Wing 3 parts 220 cm		
B_141006		Rumpf/Flächenarretierung 2 St.		
		Interlock 2x		

Zubehör MAJA

B_141050		Fahrwerk Landing gear		
B_141030		Power-Set MAJA: - Brushless 2820/6 (550 W) - Controller 50-A - Prop (12x6)		
B_141040		Servo-Set: 4 x MG Digital-Servo + cable		
B_141090		Equipment-Board		
B_141060		Pan/Tilt		
~~B_170100~~		~~Katapult Aluminium, 3m~~ ~~Launching ramp, aluminium~~		

Annex 1.2. Bormatec Maja 2D Drawings



Annex 3. Chassis Material

Annex 3.1. Aluminum 6063 T16 Datasheet

Technical datasheet - Extruded products
Alloy EN AW-6063 [AlMg0.7Si]

Alloy 6063, historically one of the most popular alloys in the 6000 series, provides good strength, very good corrosion resistance and is suitable for decorative anodising. Increasingly replaced by alloy 6060 with equal strength but improved surface finish. Used primarily for structures requiring good strength, good surface finish and good anodising response, such as profiles for windows, doors, entrance lots, ceilings and furniture. This is also a commonly used alloy for thermal applications such as heat sinks.

Typical Applications

- Architectural and building products
- Door and window frames
- Electrical components and conduit
- Heat sinks
- Railings and furniture
- Pipe and tube for irrigation systems
- Truck and trailer flooring
- Ladders

Chemical Composition [1]

Si		Fe		Cu		Mn		Mg		Cr		Zn		Ti		Pb		Bi	Sn	Others	
Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max	Max	Each	Tot
0.20	0.60		0.35		0.10		0.10	0.45	0.90		0.10		0.10		0.10					0.05	0.15

[1] Chemical composition in weight-% according to EN-573-3:2013, Hydro internal limits are tighter - different variants to fulfill T6 and T66 properties

Mechanical Properties [2,3]

Temper	Wall thickness t [mm]	$R_{p0,2}$ [MPa]	R_m [MPa]	A [%]	A_{50mm} [%]	HBW [c] TYPICAL VALUE	Vickers [c] TYPICAL VALUE
T4[a]	t ≤ 25	65	130	14	12	50	56
T5	t ≤ 10	130	175	8	6	65	74
	10 < t ≤ 25	110	160	7	5	65	74
T6[a]	t ≤ 10	170	215	8	6	75	86
	10 < t ≤ 25	160	195	8	6	75	86
T64[a b]	t ≤ 15	120	180	12	10	65	74
T66[a]	t ≤ 10	200	245	8	6	80	92
	10 < t ≤ 25	180	225	8	6	80	92

[2] Properties according to EN 755-2:2016 for extruded profile, minimum values unless else specified

[3] If a profile cross section comprises different thickness which fall in more than one set of specified mechanical property values, the lowest specified value shall be considered as valid for the whole profile section

[a] Properties may be obtained by press quenching

[b] Bending quality

[c] Brinell hardness values for information only. Vickers converted from Brinell value and should be considered approximate

Temper Designations [4]

T4	Solution heat treated and naturally aged
T5	Cooled from an elevated temperature shaping process and then artificially aged
T6	Solution heat treated and then artificially aged
T64	Solution heat treated and then artificially aged in underageing conditions (between T6 and T61) to improve formability
T66	Solution heat treated and then artificially aged – mechanical property level higher than T6 achieved through special control of the process

[4] Temper designations according to EN 515:1993

Technical datasheet - Extruded products
Alloy EN AW-6063 [AlMg0.7Si]

Physical Properties [5]

Temper	Modulus of Elasticity [GPa]	Modulus of Rigidity [GPa]	Melting Range [°C]	Density [g/cm^3]	Thermal Conductivity [W/m·K]	Specific Heat Capacity [J/kg·K]	Electrical Resistivity [nΩm]	Coefficient of linear expansion [10^{-6}K^{-1}]
	69	26	615 - 655	2.70		901		23.5
T6					201		35	

[5] Reference: MNC Handbok nr 12, version 2, SIS, 1989. Typical properties at room temperature 20°C

Comparative Characteristics of Related Alloys [6]

Property	6060	6063	6005	6005A	6082
Tensile strength	1	2	3	3	4
Impact strength	2	2	1	3	4
Surface finish	5	4	3	3	2
Suitability for decorative anodizing	5	5	4	3	2
Corrosion resistance	5	5	4	4	4
Machinability	2	3	4	4	5
Coldforming	5	5	4	4	3
Weldability	5	5	5	5	4

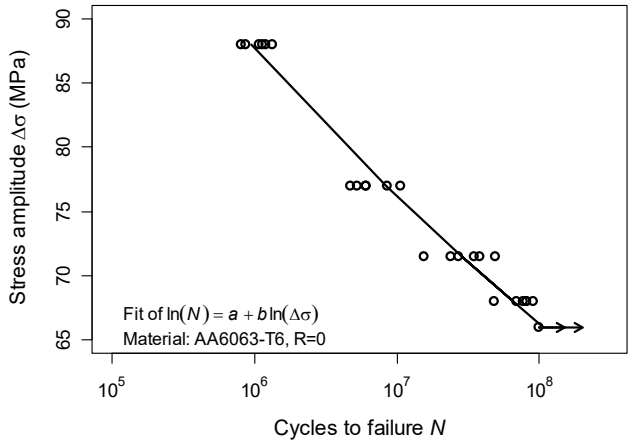
[6] Relative grading, 5 = top grade

Fatigue Properties

Example of fatigue properties for 6063 in temper T6. Provided for informational purposes only, not to be considered as guaranteed properties. Results are valid for the investigated specimens taken from a specific sample.

Tests performed at 20 ± 2 °C on 7 mm diameter cylindrical specimens parallel to the extrusion direction by Hydro Innovation & Technology, Finspång, Sweden.

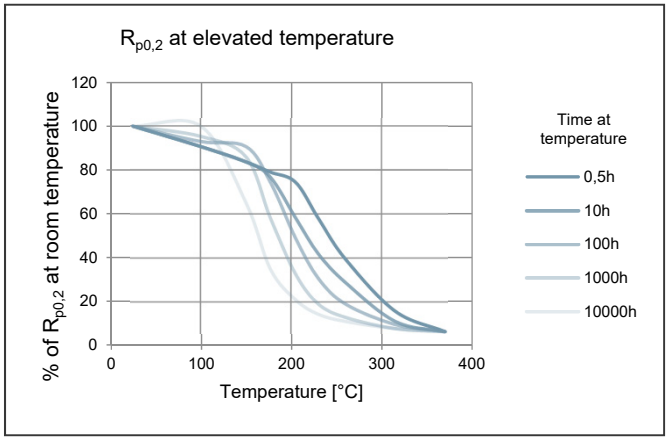
Axial testing, constant amplitude, sine wave loading at around 100 Hz test frequency. Load ratio (min. stress / max. stress) R = 0. Runouts after 10^8 cycles are indicated by the arrows.

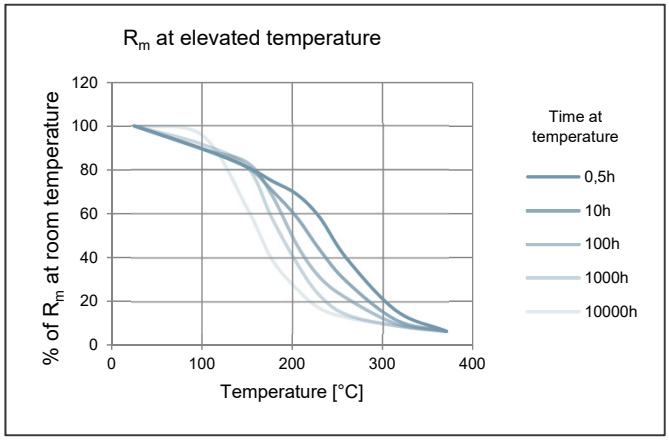


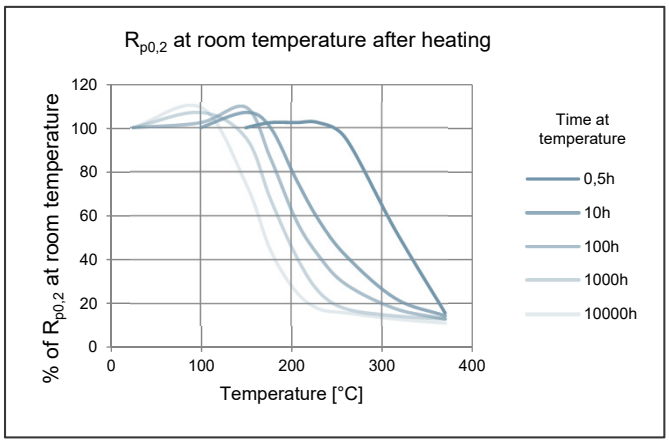
Technical datasheet - Extruded products
Alloy EN AW-6063 [AlMg0.7Si]

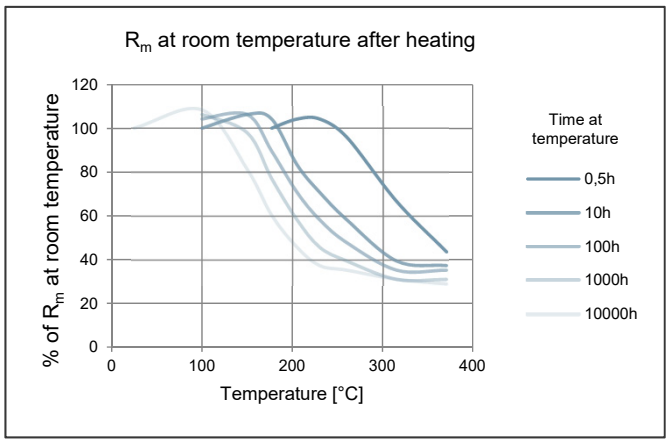
Tensile Data at Elevated Temperature [7]

Provided for informational purposes only, not to be considered as guaranteed properties.







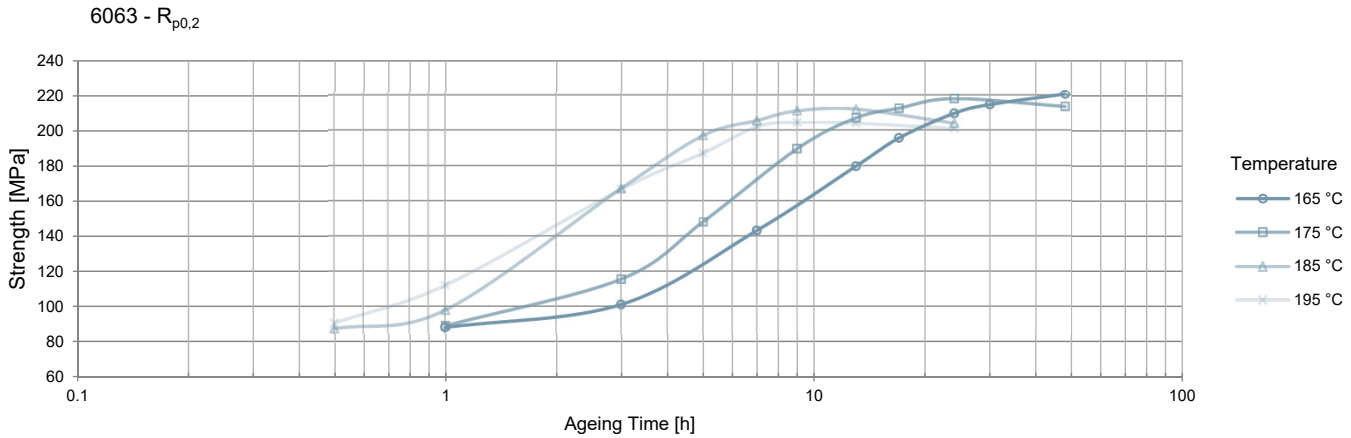


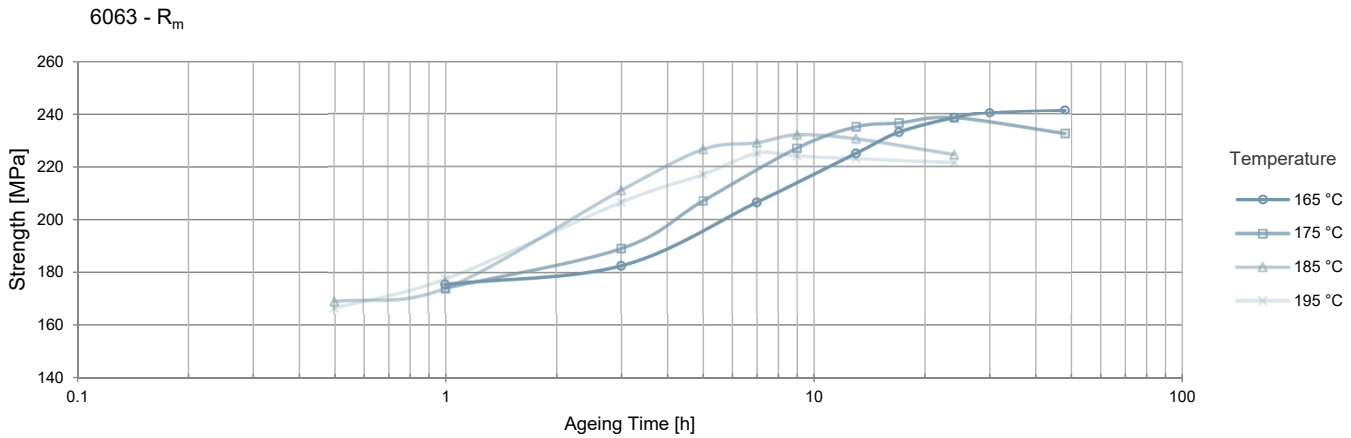
[7] Reference: J. Kaufman, Properties of Aluminium alloys -tensile, creep, and fatigue data at high and low temperatures, pp 176, ASM 1999

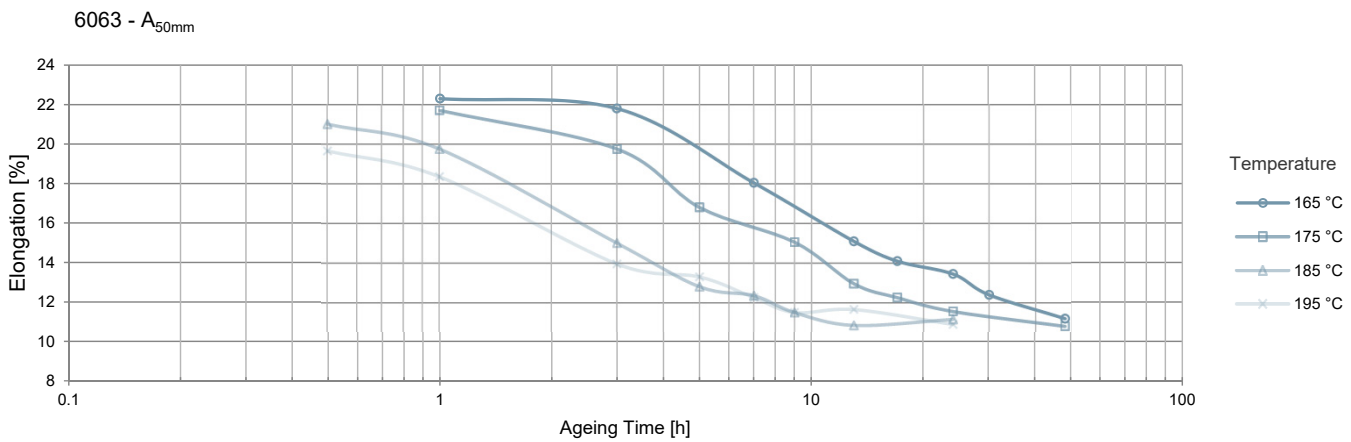
Technical datasheet - Extruded products
Alloy EN AW-6063 [AlMg0.7Si]

Heat Treatment Response [8]

Example of heat treatment response for alloy 6063-T6.







[8] *Solid profile, 200 x 3 mm, air quenched after extrusion, 24 h natural ageing prior to artificial ageing, properties in extrusion direction*

Annex 3.2. Carbon Fiber Datasheet

Cytec Thornel® Mat VMA Carbon Fiber

Category : Carbon , Carbon Fiber , Other Engineering Material , Composite Fibers

Material Notes:

Data provided by the manufacturer, Amoco Performance Products, Inc.Composed of high strength, high modulus carbon filaments in a random-layered orientation. The fine diameter filaments are up to three inches long and are mechanically bonded to form a continuous web of materials ~1 inch thick, 20.5 inches wide that is supplied in rolls 60-80 feet long.98% carbon assay, 13 µm filament diameterThornel® products were sold by Amoco and are now owned by Cytec.

Order this product through the following link:
http://www.lookpolymers.com/polymer_Cytec-Thornel-Mat-VMA-Carbon-Fiber.php

Physical Properties	Metric	English	Comments
Density	2.00 g/cc	0.0723 lb/in³	Filament Property.
Apparent Bulk Density	0.0360 g/cc	0.00130 lb/in³	
Specific Surface Area	0.40 m²/g	0.40 m²/g	Filament Property

Mechanical Properties	Metric	English	Comments
Tensile Strength, Ultimate	1400 MPa	203000 psi	Filament Property. Mat strength is 120 N/m
Modulus of Elasticity	170 GPa	24700 ksi	Filament property, in tension

Thermal Properties	Metric	English	Comments
Thermal Conductivity	0.410 W/m-K	2.85 BTU-in/hr-ft²-°F	across thickness of mat

Electrical Properties	Metric	English	Comments
Electrical Resistivity	0.00120 ohm-cm	0.00120 ohm-cm	Filament
	0.700 ohm-cm	0.700 ohm-cm	Mat

Contact Songhan Plastic Technology Co.,Ltd.

Website : www.lookpolymers.com
Email : sales@lookpolymers.com
Tel : +86 021-51131842
Mobile : +86 13061808058
Skype : lookpolymers
Address : United North Road 215,Fengxian District, Shanghai City,China

Annex 3.3 AISI 304 Datasheet

Stainless Steel - Grade 304

Chemical Formula

Fe, <0.08% C, 17.5-20% Cr, 8-11% Ni, <2% Mn, <1% Si, <0.045% P, <0.03% S

Topics Covered

Background

Grade 304 is the standard "18/8" stainless; it is the most versatile and most widely used stainless steel, available in a wider range of products, forms and finishes than any other. It has excellent forming and welding characteristics. The balanced austenitic structure of Grade 304 enables it to be severely deep drawn without intermediate annealing, which has made this grade dominant in the manufacture of drawn stainless parts such as sinks, hollow-ware and saucepans. For these applications it is common to use special "304DDQ" (Deep Drawing Quality) variants. Grade 304 is readily brake or roll formed into a variety of components for applications in the industrial, architectural, and transportation fields. Grade 304 also has outstanding welding characteristics. Post-weld annealing is not required when welding thin sections.

Grade 304L, the low carbon version of 304, does not require post-weld annealing and so is extensively used in heavy gauge components (over about 6mm). Grade 304H with its higher carbon content finds application at elevated temperatures. The austenitic structure also gives these grades excellent toughness, even down to cryogenic temperatures.

Key Properties

These properties are specified for flat rolled product (plate, sheet and coil) in ASTM A240/A240M. Similar but not necessarily identical properties are specified for other products such as pipe and bar in their respective specifications.

Composition

Typical compositional ranges for grade 304 stainless steels are given in table 1.

Table 1. Composition ranges for 304 grade stainless steel

Grade		C	Mn	Si	P	S	Cr	Mo	Ni	N
304	min.	-	-	-	-	-	18.0	-	8.0	-
	max.	0.08	2.0	0.75	0.045	0.030	20.0		10.5	0.10
304L	min.	-	-	-	-	-	18.0	-	8.0	-
	max.	0.030	2.0	0.75	0.045	0.030	20.0		12.0	0.10
304H	min.	0.04	-	-	-0.045	-	18.0	-	8.0	-
	max.	0.10	2.0	0.75		0.030	20.0		10.5	

Mechanical Properties

Typical mechanical properties for grade 304 stainless steels are given in table 2.

Table 2. Mechanical properties of 304 grade stainless steel

Grade	Tensile Strength (MPa) min	Yield Strength 0.2% Proof (MPa) min	Elongation (% in 50mm) min	Hardness	
				Rockwell B (HR B) max	Brinell (HB) max
304	515	205	40	92	201
304L	485	170	40	92	201
304H	515	205	40	92	201
304H also has a requirement for a grain size of ASTM No 7 or coarser.					

Physical Properties

Typical physical properties for annealed grade 304 stainless steels are given in table 3.

Table 3. Physical properties of 304 grade stainless steel in the annealed condition

Grade	Density (kg/m^3)	Elastic Modulus (GPa)	Mean Coefficient of Thermal Expansion (µm/m/°C)			Thermal Conductivity (W/m.K)		Specific Heat 0-100°C (J/kg.K)	Electrical Resistivity (nΩ.m)
			0-100°C	0-315°C	0-538°C	at 100°C	at 500°C		
304/L/H	8000	193	17.2	17.8	18.4	16.2	21.5	500	720

Grade Specification Comparison

Approximate grade comparisons for 304 stainless steels are given in table 4.

Table 4. Grade specifications for 304 grade stainless steel

Grade	UNS No	Old British		Euronorm		Swedish	Japanese JIS
		BS	En	No	Name	SS	
304	S30400	304S31	58E	1.4301	X5CrNi18-10	2332	SUS 304
304L	S30403	304S11	-	1.4306	X2CrNi19-11	2352	SUS 304L
304H	S30409	304S51	-	1.4948	X6CrNi18-11	-	-
These comparisons are approximate only. The list is intended as a comparison of functionally similar materials **not** as a schedule of contractual equivalents. If exact equivalents are needed original specifications must be consulted.							

Possible Alternative Grades

Possible alternative grades to grade 304 stainless steels are given in table 5.

Table 5. Possible alternative grades to 304 grade stainless steel

Grade	Why it might be chosen instead of 304
301L	A higher work hardening rate grade is required for certain roll formed or stretch formed components.
302HQ	Lower work hardening rate is needed for cold forging of screws, bolts and rivets.
303	Higher machinability needed, and the lower corrosion resistance, formability and weldability are acceptable.
316	Higher resistance to pitting and crevice corrosion is required, in chloride environments
321	Better resistance to temperatures of around 600-900°C is needed…321 has higher hot strength.
3CR12	A lower cost is required, and the reduced corrosion resistance and resulting discolouration are acceptable.
430	A lower cost is required, and the reduced corrosion resistance and fabrication characteristics are acceptable.

Corrosion Resistance

Excellent in a wide range of atmospheric environments and many corrosive media. Subject to pitting and crevice corrosion in warm chloride environments, and to stress corrosion cracking above about 60°C. Considered resistant to potable water with up to about 200mg/L chlorides at ambient temperatures, reducing to about 150mg/L at 60°C.

Heat Resistance

Good oxidation resistance in intermittent service to 870°C and in continuous service to 925°C. Continuous use of 304 in the 425-860°C range is not recommended if subsequent aqueous corrosion resistance is important. Grade 304L is more resistant to carbide precipitation and can be heated into the above temperature range.

Grade 304H has higher strength at elevated temperatures so is often used for structural and pressure-containing applications at temperatures above about 500°C and up to about 800°C. 304H will become sensitised in the temperature range of 425-860°C; this is not a problem for high temperature applications, but will result in reduced aqueous corrosion resistance.

Heat Treatment

Solution Treatment (Annealing) - Heat to 1010-1120°C and cool rapidly. These grades cannot be hardened by thermal treatment.

Welding

Excellent weldability by all standard fusion methods, both with and without filler metals. AS 1554.6 pre-qualifies welding of 304 with Grade 308 and 304L with 308L rods or electrodes (and with their high silicon equivalents). Heavy welded sections in Grade 304 may require post-weld annealing for maximum corrosion resistance. This is not required for Grade 304L. Grade 321 may also be used as an alternative to 304 if heavy section welding is required and post-weld heat treatment is not possible.

Machining

A "Ugima" improved machinability version of grade 304 is available in bar products. "Ugima" machines significantly better than standard 304 or 304L, giving higher machining rates and lower tool wear in many operations.

Dual Certification

It is common for 304 and 304L to be stocked in "Dual Certified" form, particularly in plate and pipe. These items have chemical and mechanical properties complying with both 304 and 304L specifications. Such dual certified product does not meet 304H specifications and may be unacceptable for high temperature applications.

Applications

Typical applications include:

- Food processing equipment, particularly in beer brewing, milk processing & wine making.
- Kitchen benches, sinks, troughs, equipment and appliances
- Architectural panelling, railings & trim
- Chemical containers, including for transport
- Heat Exchangers
- Woven or welded screens for mining, quarrying & water filtration
- Threaded fasteners
- Springs

Source: Atlas Steels Australia

Annex 4. Joint Material

Annex 4.1. PETG Datasheet

TECHNICAL DATA SHEET

Prusament PETG by Prusa Polymers

PETG is one of the most commonly used filaments. It is an excellent choice for printing mechanically stressed parts. Compared to PLA, it is more heat resistant, more flexible and less brittle.

APPLICATIONS: The typical use of PETG is printing functional and mechanical parts. Thanks to good layer adhesion it is also suitable for waterproof prints.

NOT SUITABLE FOR: Not suitable for tiny parts

POST-PROCESSING: When post-processing PETG, it's possible to use both dry and wet sanding.

IDENTIFICATION:

Trade name	Prusament PETG
Chemical name	Copolyester
Usage	FDM 3D printing
Diameter	1.75 ± 0.02 mm
Manufacturer	Prusa Polymers, Prague, Czech Republic

RECOMMENDED PRINT SETTINGS:

Nozzle Temperature [°C]	250 ± 10
Heatbed Temperature [°C]	80 ± 10
Print Speed [mm/s]	up to 200

TYPICAL MATERIAL PROPERTIES:

Physical Properties	Typical Value	Method
Specific Gravity [g/cm3]	1.27	ISO 1183
Moisture Absorption 24 hours [%](1)	0.2	Prusa Polymers
Moisture Absorption 7 days [%](1)	0.3	Prusa Polymers
Moisture Absorption 4 weeks [%](1)	0.3	Prusa Polymers
Heat Deflection Temperature (0,45 MPa) [°C]	68	ISO 75
Tensile Yield Strength Filament [MPa]	46 ± 1	ISO 527

MECHANICAL PROPERTIES OF PRINTED TESTING SPECIMENS(2):

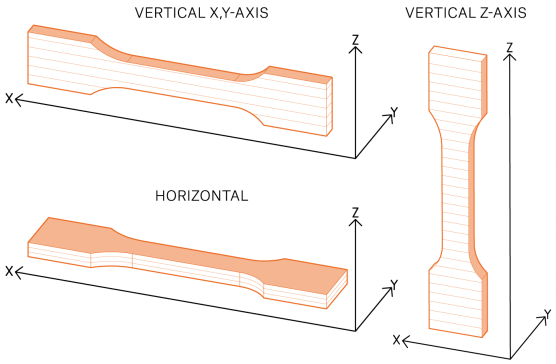
Property / print direction	Horizontal	Vertical X,Y-Axis	Vertical Z-Axis	Method
Tensile Yield Strength [MPa]	47 ± 2	50 ± 1	30 ± 5	ISO 527-1
Tensile Modulus [GPa]	1.5 ± 0.1	1.5 ± 0.1	1.4 ± 0.1	ISO 527-1
Elongation at Yield Point [%]	5.1 ± 0.1	5.1 ± 0.1	2.5 ± 0.5	ISO 527-1
Impact Strength Charpy(3) [kJ/m2]	NB(C)(4)	NB(4)	5 ± 1	ISO 179-1

(1) 30 °C; humidity 30 %

(2) Original Prusa i3 MK3 3D printer was used to make testing specimens. Slic3r Prusa Edition 1.40.0 was used to create G-codes with following settings:Prusa PETG Filament; Print settings 0,20mm FAST (layers 0,2mm); solid layers Top:0 Bottom:0; Infill 100% Rectilinear, infill print speed 100mm/s; extrusion multiplier 1.07; extruder temperature 260°C all layers; bed temperature 90°C all layers; other parameters set default

(3) Charpy unnotched - Edgewise direction of blow according to ISO 179-1

(4) NB (no break); C (complete break) in brackets second most frequent type of failure > 1/3



Dislamer

The results presented in this data sheet are just for your information and comparison. Values are significantly dependent on print settings, operators experiences and surrounding conditions. Everyone have to consider suitability and possible consequences of printed parts usage. Prusa Polymers can not carry any responsibility for injures or any loss caused by using of Prusa Polymers material.

Annex 4.2. PLA Datasheet

PLA Filament 1.75 mm

PLA (Polylactic acid) is the best material for getting started with your 3D printer, as it:

– Hardens quickly
– Has minimal thermal tension
– Has minimal deformation
– Does not require Kapton tape
– Does not require heated bed
–Acetone-resistant

BQ PLA filament is made from 100% PLA.
PLA is a biodegradable product obtained from plant-derived sugars.

Filament Diameter: 1.75 mm
Thickness: 1.24 g/cm³ (ASTM D792)
Weight: 1 kg
Spool Size: 195 mm x 73 mm
Spool axle diameter: 52 mm

Compatible with: any printer that uses 1.75 mm filament

SKU: F000097
8 435439 881425
Coral

SKU: F000098
8 435439 881432
Turquoise

SKU: F000099
8 435439 881449
Violet

SKU: F000100
8 435439 881456
Sulphur yellow

SKU: F000101
8 435439 881463
Topaz blue

SKU: 05BQFIL023
8 436545 513651
Aubergine

SKU: 05BQFIL024
8 436545 513668
Magenta

SKU: 05BQFIL025
8 436545 513743
Sky blue

SKU: 05BQFIL026
8 436545 513682
Coal black

SKU: 05BQFIL027
8 436545 513699
Pure white

SKU: 05BQFIL028
8 436545 513705
Vitamine orange

SKU: 05BQFIL029
8 436545 513712
Ruby red

SKU: 05BQFIL030
8 436545 513729
Grass green

SKU: 05BQFIL031
8 436545 513736
Bottle green

SKU: 05BQFIL032
8 436545 513750
Ash grey

SKU: 05BQFIL033
8 436545 513767
Transparent

SKU: 05BQFIL034
8 436545 513774
Sunshine yellow

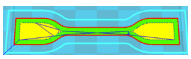
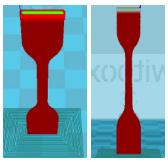
PLA filament: technical datasheet

PROPERTY	VALUE	UNITS	TEST METHOD
General properties			
Specific gravity	1.24	g/cm^3	ASTM D792
Mechanical properties			
Flexural elastic modulus	3600	MPa	ISO 178
Flexural Strength	108	MPa	ISO 178
Hardness, Sh D	85	Sh D	ASTM D2240
Thermal properties			
Heat distortion temperature HDT B (0,45MPa)	56	°C	ISO 75/2B
Melting temperature	145-160	°C	ASTM D3418
Glass Transition Temperature	56-64	°C	ASTM D3418

In addition to the described properties, we have performed tensile tests on tensile specimen printed with our PLA and on injection moulded tensile specimen in order to ascertain the mechanical properties of the final printed object. The following table contains the results:

Mechanical properties	Injection moulded tensile specimen	Printed tensile specimen[a]	Printed tensile specimen[b]	Units	Test method
Tensile strength at break	52	50	39	MPa	ISO 527
Tensile elongation at break	5	9	4	%	ISO 527
Tensile modulus	1320	1230	1120	MPa	ISO 527

[a] Stretch-direction is parallel to the layers.
[b] Stretch-direction is perpendicular to the layers.

Tensile specimen	Layer height (mm)	Shell thickness (mm)	Bottom/top thickness (mm)	Fill density (%)	Print design
Tensile specimen print-direction is parallel to the layers	0.2	2	0.2	100	
Tensile specimen print-direction is perpendicular to the layers	0.3	1	0.3	100	

Annex 4.3. ABS Datasheet

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1621	1622	1623	1624	1626
1627	1629	1630	1641	1628

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Technical data sheet ABS

Ultimaker

Chemical Name	Acrylonitrile butadiene styrene
Description	Used by an array of industries worldwide, ABS is known for its exceptional mechanical properties. Our ABS is specifically formulated to minimize warping and ensure consistent interlayer adhesion.
Key features	Excellent mechanical properties and interlayer adhesion (especially when using the front door add-on), nice aesthetics, minimal warping and reliable bed adhesion.
Applications	Visual and functional prototyping and short run manufacturing.
Non suitable for	Food contact and in-vivo applications. Long term UV exposure can negatively affect properties of an ABS print. Applications where the printed part is exposed to temperatures higher than 85 ˚C.

Filament specifications	Value	Method
Diameter	2.85±0.10 mm	-
Max roundness deviation	0.10 mm	-
Net filament weight	750 g	-

Color information	Color	Color code
	ABS Black	RAL 9017
	ABS White	RAL 9003
	ABS Red	RAL 3020
	ABS Blue	RAL 5002
	ABS Silver	RAL 9006
	ABS Pearl Gold	RAL 1036
	ABS Green	RAL 6018
	ABS Orange	RAL 2008
	ABS Yellow	RAL 1023
	ABS Gray	RAL 7011

Mechanical properties (*)	Injection molding		3D printing	
	Typical value	**Test method**	**Typical value**	**Test method**
Tensile modulus	2030 MPa	ISO 527 (1 mm/min)	1681.5 MPa	ISO 527 (1 mm/min)
Tensile stress at yield	43.6 MPa	ISO 527 (50 mm/min)	39.0 MPa	ISO 527 (50 mm/min)
Tensile stress at break	-	-	33.9 MPa	ISO 527 (50 mm/min)
Elongation at yield	4.8 %	ISO 527 (50 mm/min)	3.5 %	ISO 527 (50 mm/min)
Elongation at break	34 %	ISO 527 (50 mm/min)	4.8 %	ISO 527 (50 mm/min)
Flexural strength	-	-	70.5 MPa	ISO 178
Flexural modulus	-	-	2070.0 MPa	ISO 178
Izod impact strength, notched (at 23˚C)	-	-	10.5 kJ/m^2	ISO 180
Charpy impact strength (at 23˚C)	58 kJ/m^2	ISO 179	-	-
Hardness	97 (Shore A)	-	-	-

Thermal properties	Typical value	Test method
Melt mass-flow rate (MFR)	41 g/10 min	ISO 1133 (260 ˚C, 5 kg)
Heat deflection (HDT) at 0.455 MPa	-	-
Heat deflection (HDT) at 1.82 MPa	-	-
Glass transition	97 ˚C	ISO 306
Coefficient of thermal expansion (flow)	-	-
Coefficient of thermal expansion (xflow)	-	-
Melting temperature	225-245 ˚C	ISO 294
Thermal shrinkage	-	-

Other properties	Typical value	Test method
Specific gravity	1.10	ISO 1183
Flame classification	-	-

(*) See notes.

Notes

Properties reported here are average of a typical batch. The 3D printed test specimens were printed in the XY plane, using the normal quality profile in Cura 2.1, an UM2+, a 0.4 mm nozzle, 90% infill, 250 ˚C nozzle temperature and 80 ˚C build plate temperature. The values are the average of 5 white and 5 black tensile bars. Ultimaker is constantly working on extending the TDS data.

Disclaimer

Version Version 3.006

Date 28/02/2017

Ultimaker Filaments

Item Code	Filament	Colour
1621	ABS - M2560 Black 750 - 206127	Black
1624	ABS - M2560 Blue 750 - 206127	Blue
1630	ABS - M2560 Grey 750 - 206127	Grey
1627	ABS - M2560 Green 750 - 206127	Green
1628	ABS - M2560 Orange 750 - 206127	Orange
1626	ABS - M2560 Pearl Gold 750 - 206127	Pearl Gold
1623	ABS - M2560 Red 750 - 206127	Red
1625	ABS - M2560 Silver 750 - 206127	Silver
1622	ABS - M2560 White 750 - 206127	White
1629	ABS - M2560 Yellow 750 - 206127	Yellow
1631	CPE - M0188 Black 750 - 201273	Black
1636	CPE - M0188 Blue 750 - 201273	Blue
1634	CPE - M0188 Dark Grey 750 - 201273	Dark Grey
1638	CPE - M0188 Green 750 - 201273	Green
1633	CPE - M0188 Light Grey 750 - 201273	Light Grey
1635	CPE - M0188 Red 750 - 201273	Red
1639	CPE - M0188 Transparent 750 - 201273	Transparent
1632	CPE - M0188 White 750 - 201273	White
1637	CPE - M0188 Yellow 750 - 201273	Yellow
1646	PAX - M2085 Black 750 215158	Black
1647	PAX - M2085 Transparent 750 - 215158	Transparent
1609	PLA - M0751 Black 750 - 211399	Black
1616	PLA - M0751 Blue 750 - 211399	Blue
1608	PLA - M0751 Green 750 - 211399	Green
1620	PLA - M0751 Pearl White 750 - 211399	Pearl White
1618	PLA - M0751 Red 750 - 211399	Red
1612	PLA - M0751 Silver Metallic 750 - 211399	Silver Metallic
1614	PLA - M0751 Transparent 750 - 211399	Transparent
1613	PLA - M0751 White 750 - 211399	White
1619	PLA - M0751 Yellow 750 - 211399	Yellow
9023	PLA - M0751 Magenta 750 - 211399	Magenta
9021	PLA - M0751 Magenta 750 - 211399	Orange
9732	PVA - M0952 Natural 350 - 206127	Natural
9731	PVA - M0952 Natural 750 - 206127	Natural

Ultimaker Filaments

9715	PCA - Transparent 750 - 212674	Transparent
9716	PCA - Black 750 - 212674	Black
9717	PCA - White 750 - 212674	White
9720	TPU - White 750 - 215194	White
9725	CPE-TR - Transparent 700 - 210592	Transparent
9726	CPE-TR - Black 700 - 210592	Black
9727	CPE-TR White 700 - 210592	White

9703

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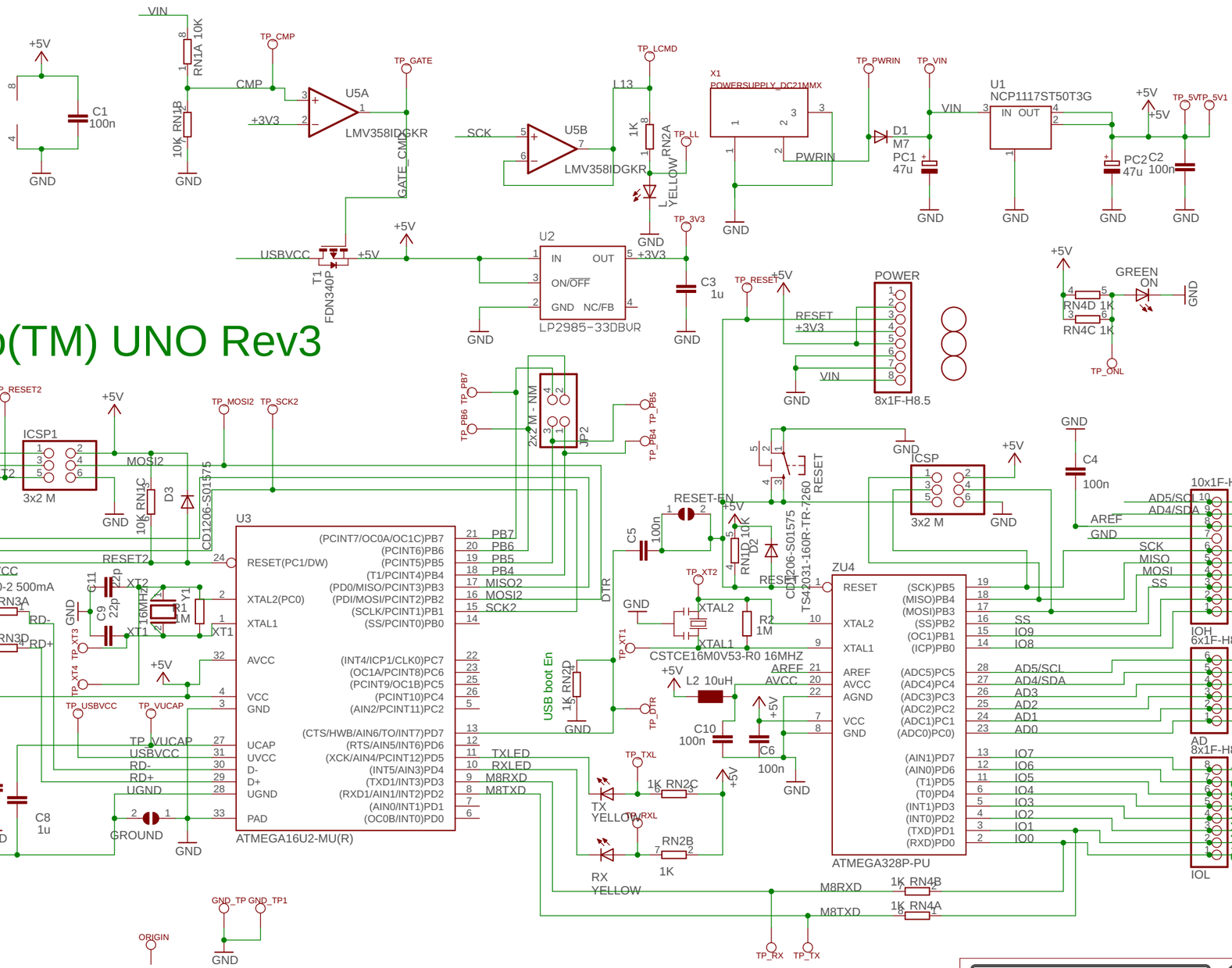
Annex 5. Dolly Componenets

Annex 5.1. Arduino UNO Datasheet

Arduino(TM) UNO Rev3



ARDUINO

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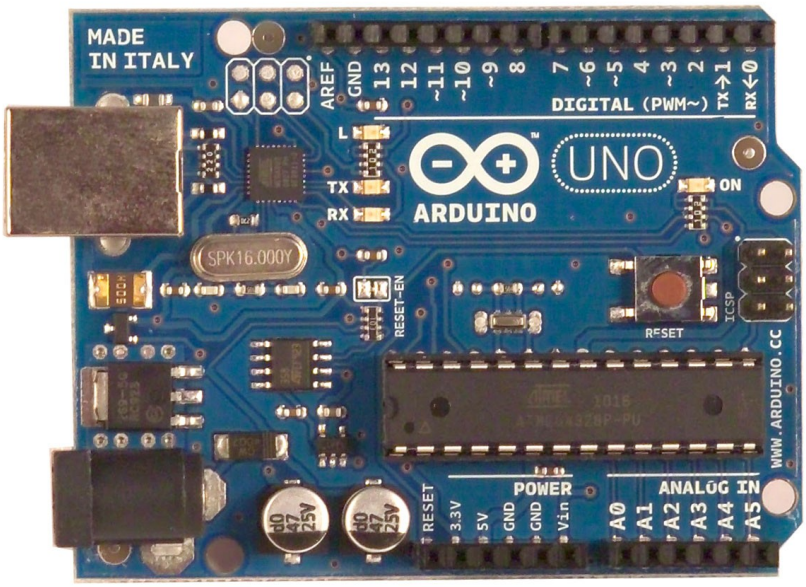
Arduino UNO



Product Overview

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduno, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

Index

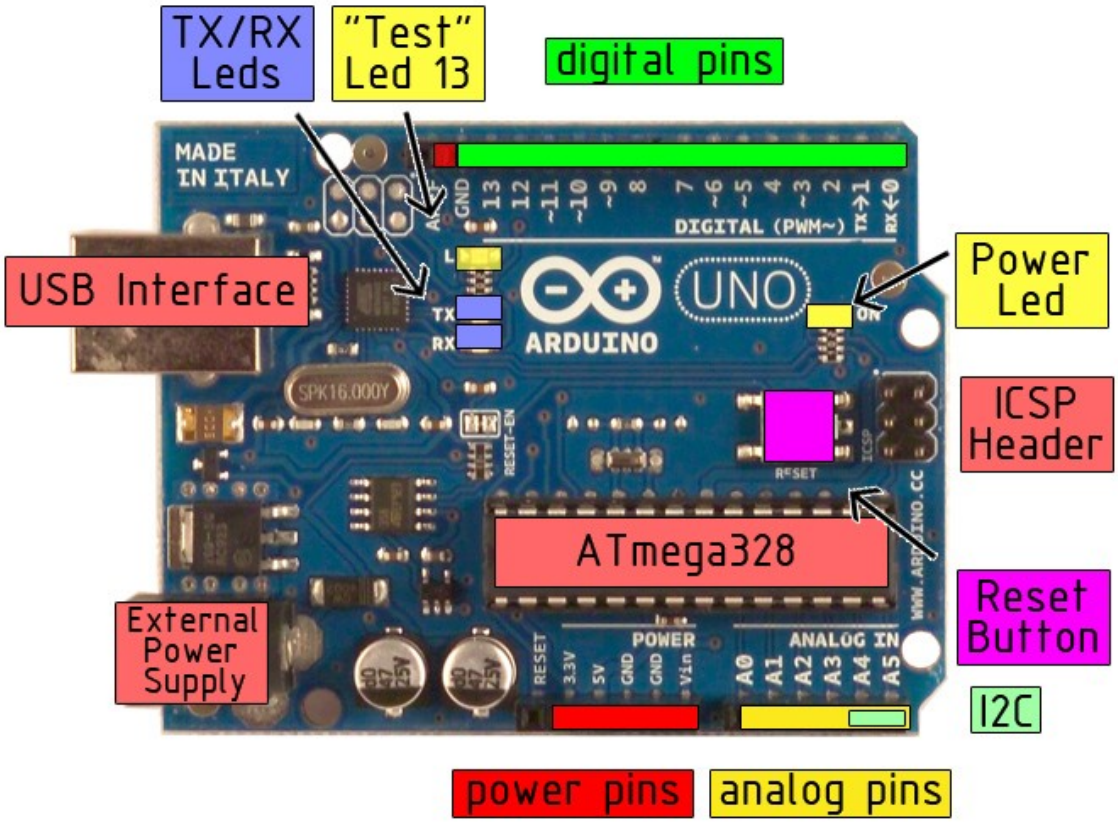
Technical Specification

EAGLE files: arduino-duemilanove-uno-design.zip Schematic: arduino-uno-schematic.pdf

Summary

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB of which 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

the board



Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V.** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins.

Memory

The Atmega328 has 32 KB of flash memory for storing code (of which 0,5 KB is used for the bootloader); It has also 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. TThese pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip .
- **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- **PWM: 3, 5, 6, 9, 10, and 11.** Provide 8-bit PWM output with the analogWrite() function.
- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.

- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analogReference() function. Additionally, some pins have specialized functionality:

- **I²C: 4 (SDA) and 5 (SCL).** Support I²C (TWI) communication using the Wire library.

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analogReference().
- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

See also the mapping between Arduino pins and Atmega328 ports.

Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega8U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '8U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an *.inf file is required..

The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A SoftwareSerial library allows for serial communication on any of the Uno's digital pins.

The ATmega328 also support I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. To use the SPI communication, please see the ATmega328 datasheet.

Programming

The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno w/ ATmega328" from the **Tools > Board** menu (according to the microcontroller on your board). For details, see the reference and tutorials.

The ATmega328 on the Arduino Uno comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).

You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.

The ATmega8U2 firmware source code is available . The ATmega8U2 is loaded with a DFU bootloader, which can be activated by connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2. You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU bootloader).

Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Uno. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.

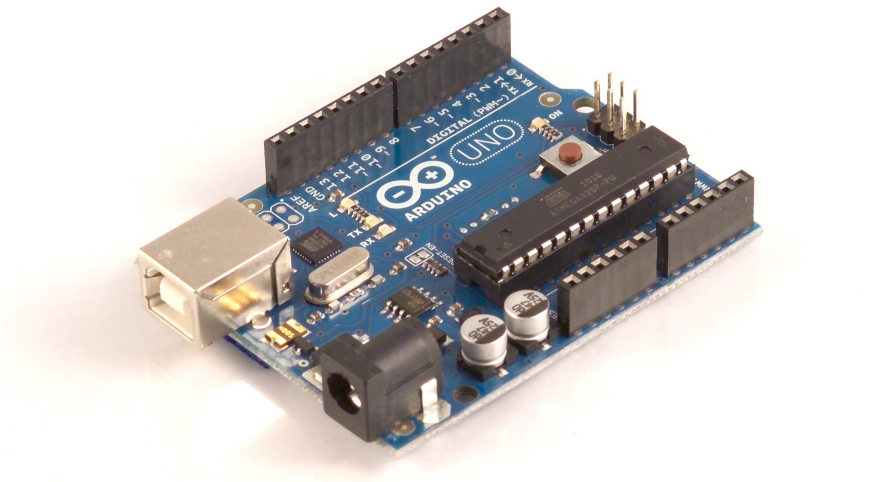
The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

USB Overcurrent Protection

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.



How to use Arduino

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, MaxMSP).

Arduino is a cross-platoform program. You'll have to follow different instructions for your personal OS. Check on the Arduino site for the latest instructions. *http://arduino.cc/en/Guide/HomePage*

Linux Install Windows Install Mac Install

Once you have downloaded/unzipped the arduino IDE, you can Plug the Arduino to your PC via USB cable.

Blink led

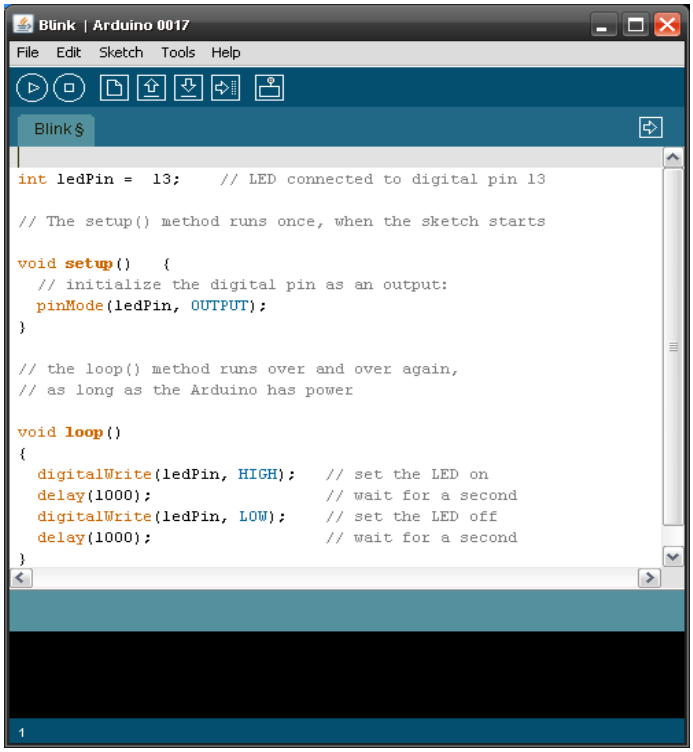
Now you're actually ready to "burn" your first program on the arduino board. To select "blink led", the physical translation of the well known programming "hello world", select

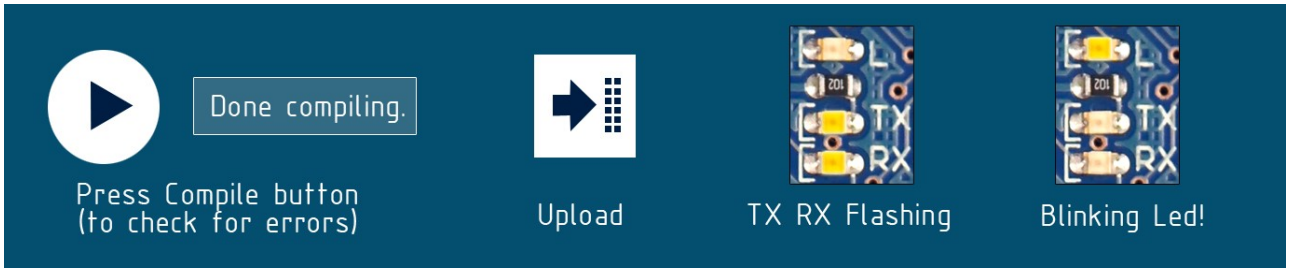
File>Sketchbook>
Arduino-0017>Examples>
Digital>Blink

Once you have your skecth you'll see something very close to the screenshot on the right.

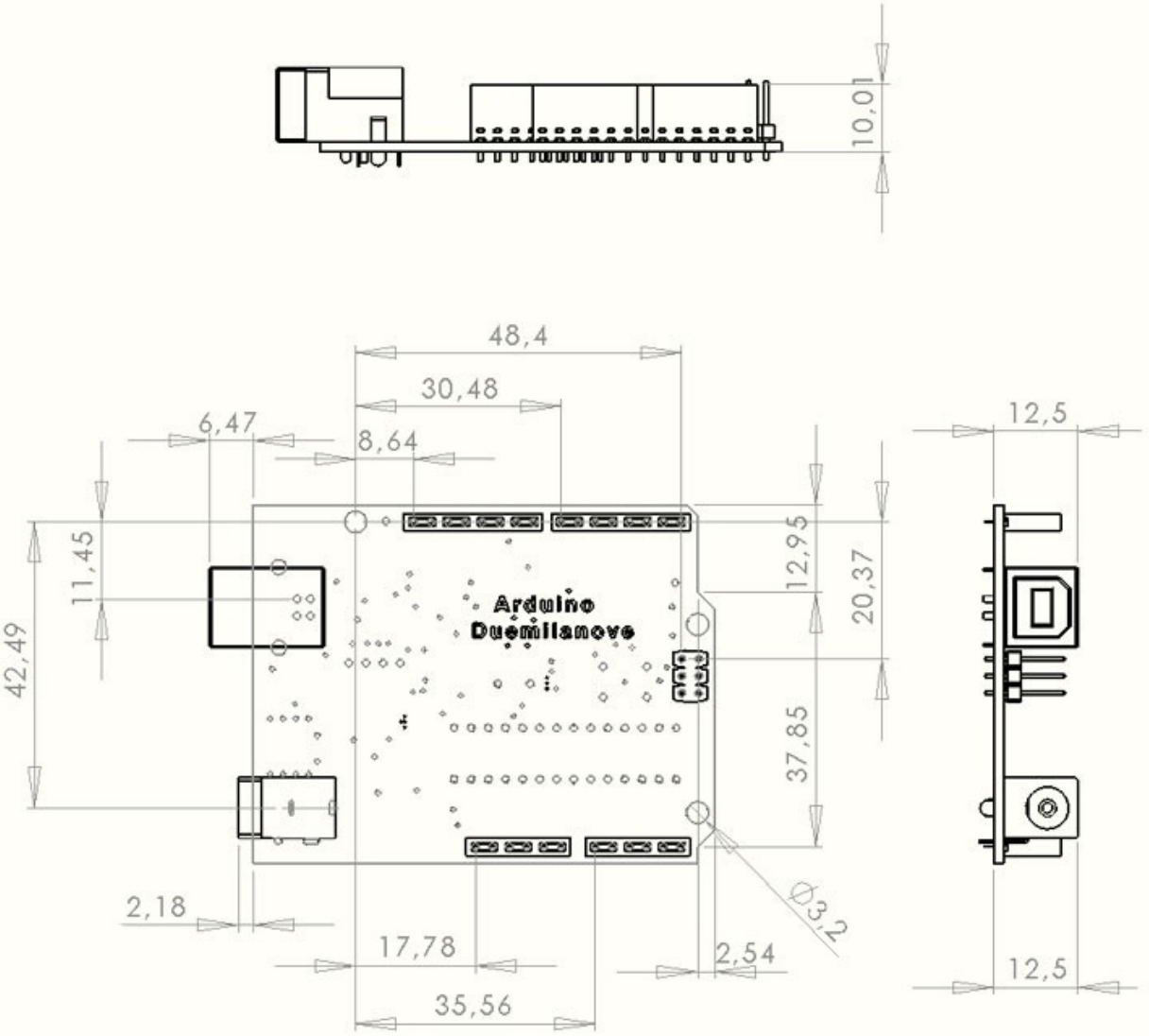
In **Tools>Board** select

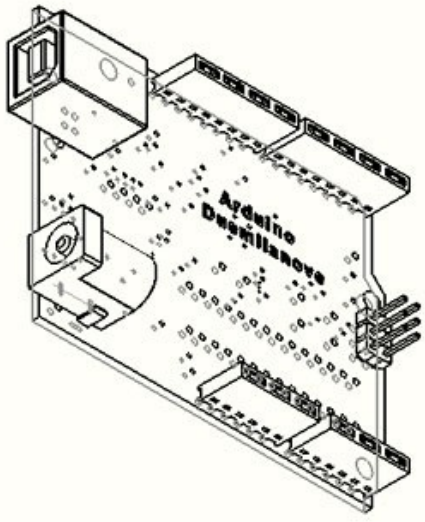
Now you have to go to
Tools>SerialPort
and select the right serial port, the one arduino is attached to.





Dimensioned Drawing





Terms & Conditions

1. Warranties

1.1 The producer warrants that its products will conform to the Specifications. This warranty lasts for one (1) years from the date of the sale. The producer shall not be liable for any defects that are caused by neglect, misuse or mistreatment by the Customer, including improper installation or testing, or for any products that have been altered or modified in any way by a Customer. Moreover, The producer shall not be liable for any defects that result from Customer's design, specifications or instructions for such products. Testing and other quality control techniques are used to the extent the producer deems necessary.

1.2 If any products fail to conform to the warranty set forth above, the producer's sole liability shall be to replace such products. The producer's liability shall be limited to products that are determined by the producer not to conform to such warranty. If the producer elects to replace such products, the producer shall have a reasonable time to replacements. Replaced products shall be warranted for a new full warranty period.

1.3 EXCEPT AS SET FORTH ABOVE, PRODUCTS ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." THE PRODUCER DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING PRODUCTS, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE

1.4 Customer agrees that prior to using any systems that include the producer products, Customer will test such systems and the functionality of the products as used in such systems. The producer may provide technical, applications or design advice, quality characterization, reliability data or other services. Customer acknowledges and agrees that providing these services shall not expand or otherwise alter the producer's warranties, as set forth above, and no additional obligations or liabilities shall arise from the producer providing such services.

1.5 The Arduino™ products are not authorized for use in safety-critical applications where a failure of the product would reasonably be expected to cause severe personal injury or death. Safety-Critical Applications include, without limitation, life support devices and systems, equipment or systems for the operation of nuclear facilities and weapons systems. Arduino™ products are neither designed nor intended for use in military or aerospace applications or environments and for automotive applications or environment. Customer acknowledges and agrees that any such use of Arduino™ products which is solely at the Customer's risk, and that Customer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

1.6 Customer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products and any use of Arduino™ products in Customer's applications, notwithstanding any applications-related information or support that may be provided by the producer.

2. Indemnification

The Customer acknowledges and agrees to defend, indemnify and hold harmless the producer from and against any and all third-party losses, damages, liabilities and expenses it incurs to the extent directly caused by: (i) an actual breach by a Customer of the representation and warranties made under this terms and conditions or (ii) the gross negligence or willful misconduct by the Customer.

3. Consequential Damages Waiver

In no event the producer shall be liable to the Customer or any third parties for any special, collateral, indirect, punitive, incidental, consequential or exemplary damages in connection with or arising out of the products provided hereunder, regardless of whether the producer has been advised of the possibility of such damages. This section will survive the termination of the warranty period.

4. Changes to specifications

The producer may make changes to specifications and product descriptions at any time, without notice. The Customer must not rely on the absence or characteristics of any features or instructions marked "reserved" or "undefined." The producer reserves these for future definition and shall have no responsibility whatsoever for conflicts or incompatibilities arising from future changes to them. The product information on the Web Site or Materials is subject to change without notice. Do not finalize a design with this information.

Enviromental Policies

The producer of Arduino™ has joined the Impatto Zero® policy of LifeGate.it. For each Arduino board produced is created / looked after half squared Km of Costa Rica's forest's.

Annex 5.2. LSM303DLHC Datasheet

LSM303DLHC

Ultra compact high performance e-compass 3D accelerometer and 3D magnetometer module

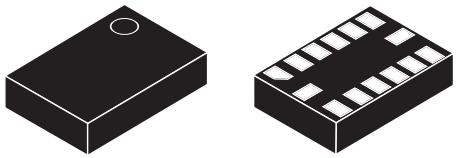
Preliminary data

Features

- 3 magnetic field channels and 3 acceleration channels
- From ±1.3 to ±8.1 gauss magnetic field full-scale
- ±2g/±4g/±8g/±16g selectable full-scale
- 16 bit data output
- I^2C serial interface
- Analog supply voltage 2.16 V to 3.6 V
- Power-down mode/ low-power mode
- 2 independent programmable interrupt generators for free-fall and motion detection
- Embedded temperature sensor
- Embedded FIFO
- 6D/4D orientation detection
- ECOPACK® RoHS and “Green” compliant

Applications

- Compensated compass
- Map rotation
- Position detection
- Motion-activated functions
- Free-fall detection
- Click/double click recognition
- Pedometer
- Intelligent power-saving for handheld devices
- Display orientation
- Gaming and virtual reality input devices
- Impact recognition and logging
- Vibration monitoring and compensation



LGA-14 (3x5x1mm)

Description

The LSM303DLHC is a system-in-package featuring a 3D digital linear acceleration sensor and a 3D digital magnetic sensor.

LSM303DLHC has linear acceleration full-scales of ±2*g* / ±4*g* / ±8*g* / ±16*g* and a magnetic field full-scale of ±1.3 / ±1.9 / ±2.5 / ±4.0 / ±4.7 / ±5.6 / ±8.1 gauss. All full-scales available are fully selectable by the user.

LSM303DLHC includes an I^2C serial bus interface that supports standard and fast mode 100 kHz and 400kHz. The system can be configured to generate interrupt signals by inertial wake-up/free-fall events as well as by the position of the device itself. Thresholds and timing of interrupt generators are programmable by the end user on the fly. Magnetic and accelerometer parts can be enabled or put into power-down mode separately.

The LSM303DLHC is available in a plastic land grid array package (LGA) and is guaranteed to operate over an extended temperature range from -40 °C to +85 °C.

Table 1. Device summary

Part number	Temperature range [°C]	Package	Packing
LSM303DLHC	-40 to +85	LGA-14	Tray
LSM303DLHCTR	-40 to +85	LGA-14	Tape and reel

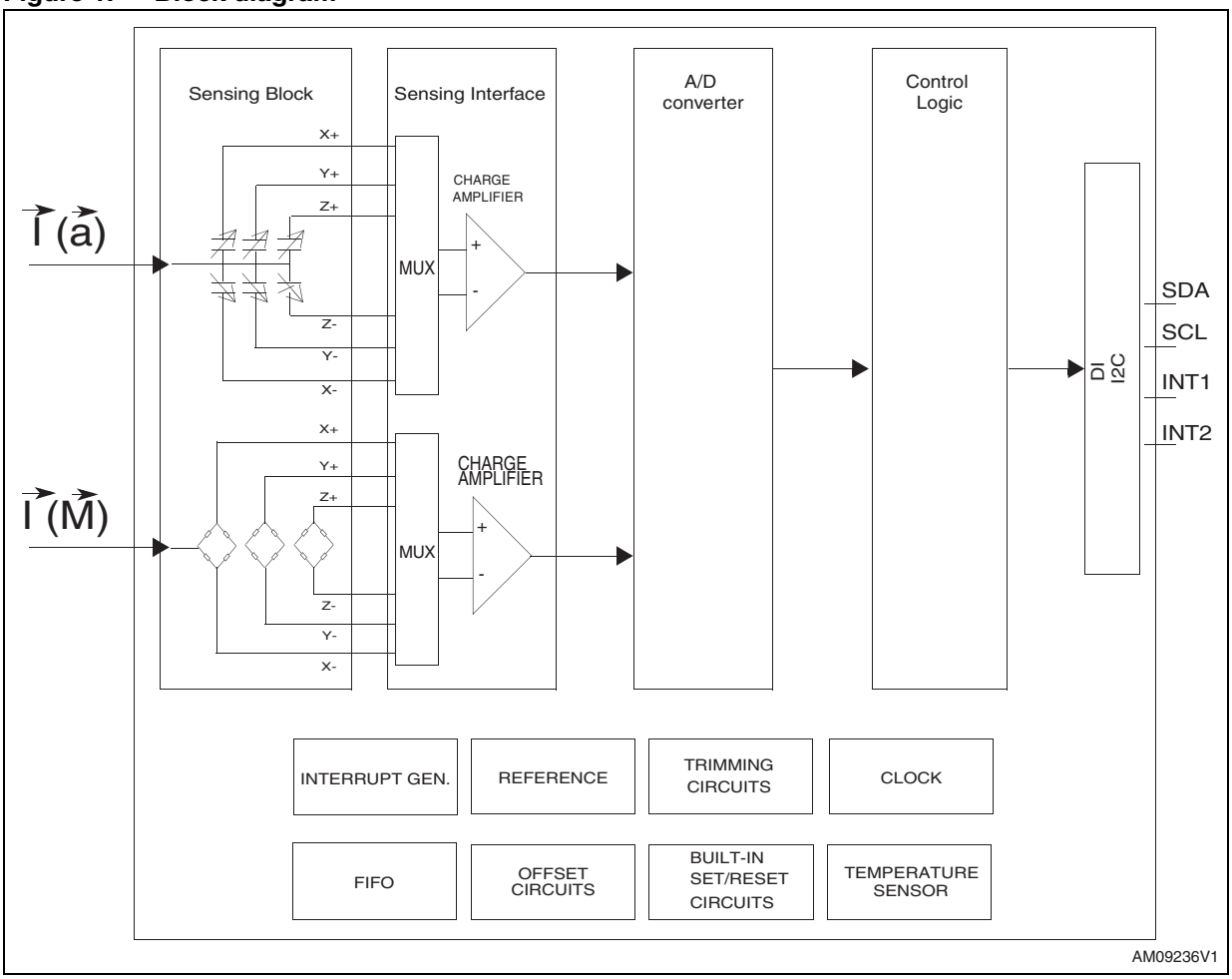
Contents

List of tables

1 Block diagram and pin description

1.1 Block diagram

Figure 1. Block diagram



1.2 Pin description

Figure 2. Pin connection

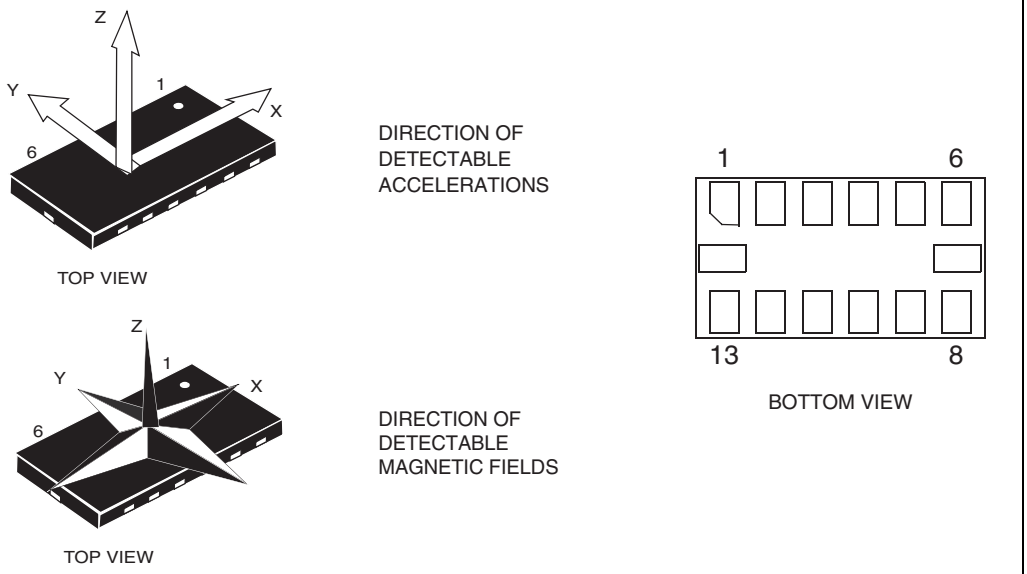


Table 2. Pin description

Pin#	Name	Function
1	Vdd_IO	Power supply for I/O pins
2	SCL	Signal interface I^2C serial clock (SCL)
3	SDA	Signal interface I^2C serial data (SDA)
4	INT2	Inertial Interrupt 2
5	INT1	Inertial Interrupt 1
6	C1	Reserved capacitor connection (C1)
7	GND	0 V supply
8	Reserved	Leave unconnected
9	DRDY	Data ready
10	Reserved	Connect to GND
11	Reserved	Connect to GND
12	SETP	S/R capacitor connection (C2)
13	SETC	S/R capacitor connection (C2)
14	Vdd	Power supply

2 Module specifications

2.1 Sensor characteristics

@ Vdd = 2.5 V, T = 25 °C unless otherwise noted[a].

Table 3. Sensor characteristics

Symbol	Parameter	Test conditions	Min.	Typ.[1]	Max.	Unit
LA_FS	Linear acceleration measurement range[2]	FS bit set to 00		±2		*g*
		FS bit set to 01		±4		
		FS bit set to 10		±8		
		FS bit set to 11		±16		
M_FS	Magnetic measurement range	GN bits set to 001		±1.3		gauss
		GN bits set to 010		±1.9		
		GN bits set to 011		±2.5		
		GN bits set to 100		±4.0		
		GN bits set to 101		±4.7		
		GN bits set to 110		±5.6		
		GN bits set to 111		±8.1		
LA_So	Linear acceleration sensitivity	FS bit set to 00		1		mg/LSB
		FS bit set to 01		2		
		FS bit set to 10		4		
		FS bit set to 11		12		
M_GN	Magnetic gain setting	GN bits set to 001 (X,Y)		1100		LSB/ gauss
		GN bits set to 001 (Z)		980		
		GN bits set to 010 (X,Y)		855		
		GN bits set to 010 (Z)		760		
		GN bits set to 011 (X,Y)		670		
		GN bits set to 011 (Z)		600		
		GN bits set to 100 (X,Y)		450		
		GN bits set to 100 (Z)		400		
		GN bits set to 101 (X,Y)		400		
		GN bits set to 101 (Z)		355		
		GN bits set to 110 (X,Y)		330		
		GN bits set to 110 (Z)		295		
		GN bits set to 111[2] (X,Y)		230		
		GN bits set to 111[2] (Z)		205		

a. The product is factory calibrated at 2.5 V. The operational power supply range is from 2.16 V to 3.6 V.

Table 3. Sensor characteristics (continued)

Symbol	Parameter	Test conditions	Min.	Typ.(1)	Max.	Unit
LA_TCSo	Linear acceleration sensitivity change vs. temperature	FS bit set to 00		±0.01		%/°C
LA_TyOff	Linear acceleration typical Zero-*g* level offset accuracy(3),(4)	FS bit set to 00		±60		m*g*
LA_TCOff	Linear acceleration Zero-*g* level change vs. temperature	Max. delta from 25 °C		±0.5		m*g*/°C
LA_An	Acceleration noise density	FS bit set to 00, normal mode(*Table 8.*), ODR bit set to 1001		220		ug/ sqrt(Hz)
M_R	Magnetic resolution			2		mgauss
M_CAS	Magnetic cross-axis sensitivity	Cross field =.0.5 gauss H applied = ±3 gauss		±1		%FS/ gauss
M_EF	Maximum exposed field	No permitting effect on zero reading			10000	gauss
M_DF	Disturbing field	Sensitivity starts to degrade. Use S/R pulse to restore sensitivity			20	gauss
Top	Operating temperature range		-40		+85	°C

1. Typical specifications are not guaranteed.
2. Verified by wafer level test and measurement of initial offset and sensitivity.
3. Typical Zero-*g* level offset value after MSL3 preconditioning.
4. Offset can be eliminated by enabling the built-in high pass filter.

2.2 Temperature sensor characteristics

@ Vdd = 2.5 V, T = 25 °C unless otherwise noted [b].

Table 4. Temperature sensor characteristics

Symbol	Parameter	Test condition	Min.	Typ.(1)	Max.	Unit
TSDr	Temperature sensor output change vs. temperature	-		8		LSB/°C(2)
TODR	Temperature refresh rate			ODR(3)		Hz
Top	Operating temperature range		-40		+85	°C

1. Typical specifications are not guaranteed.
2. 12-bit resolution.
3. For ODR configuration refer to *Table 72*.

b. The product is factory calibrated at 2.5 V.

2.3 Electrical characteristics

@ Vdd = 2.5 V, T = 25 °C unless otherwise noted.

Table 5. Electrical characteristics

Symbol	Parameter	Test conditions	Min.	Typ.(1)	Max.	Unit
Vdd	Supply voltage	-	2.16		3.6	V
Vdd_IO	Module power supply for I/O		1.71	1.8	Vdd+0.1	
Idd	Current consumption in normal mode(2)			110		µA
IddSL	Current consumption in sleep-mode(3)			1		µA
Top	Operating temperature range		-40		+85	°C

1. Typical specifications are not guaranteed.
2. Magnetic sensor setting ODR = 7.5 Hz, Accelerometer sensor ODR = 50 Hz.
3. Linear accelerometer in sleep-mode and magnetic sensor in power-down mode.

2.4 Communication interfaces characteristics

External pull-up resistors are required to support I²C standard and fast speed modes.

2.4.1 Sensor I²C - inter IC control interface

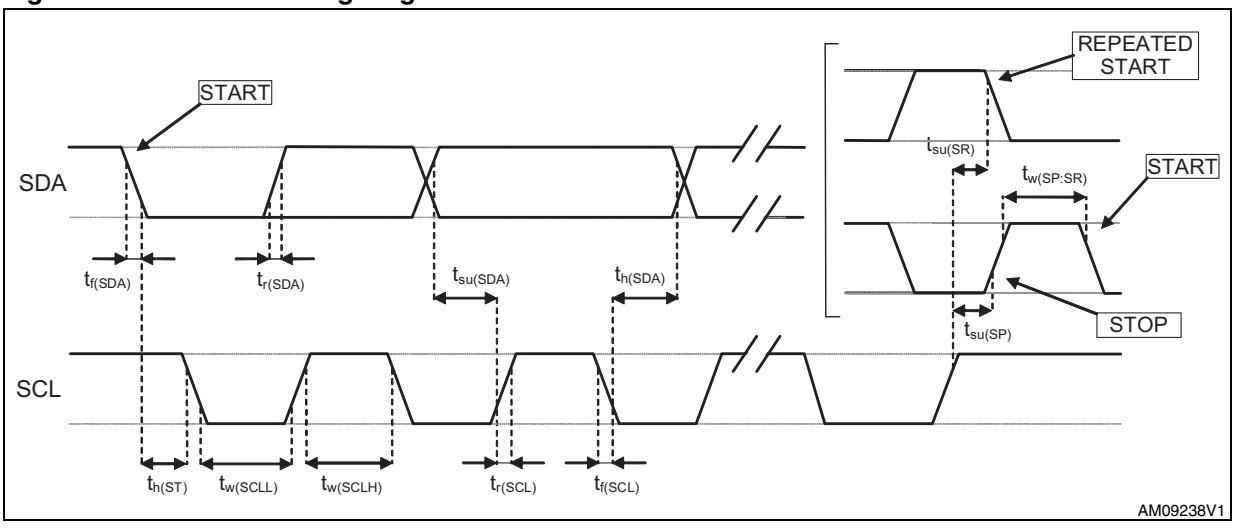
Subject to general operating conditions for Vdd and Top.

Table 6. I²C slave timing values

Symbol	Parameter	I²C standard mode (1)		I²C fast mode (1)		Unit
		Min.	Max.	Min.	Max.	
$f_{(SCL)}$	SCL clock frequency	0	100	0	400	KHz
$t_{w(SCLL)}$	SCL clock low time	4.7		1.3		µs
$t_{w(SCLH)}$	SCL clock high time	4.0		0.6		
$t_{su(SDA)}$	SDA setup time	250		100		ns
$t_{h(SDA)}$	SDA data hold time	0.01	3.45	0.01	0.9	µs
$t_{r(SDA)}$ $t_{r(SCL)}$	SDA and SCL rise time		1000	$20 + 0.1C_b$ (2)	300	ns
$t_{f(SDA)}$ $t_{f(SCL)}$	SDA and SCL fall time		300	$20 + 0.1C_b$ (2)	300	
$t_{h(ST)}$	START condition hold time	4		0.6		µs
$t_{su(SR)}$	Repeated START condition setup time	4.7		0.6		
$t_{su(SP)}$	STOP condition setup time	4		0.6		
$t_{w(SP:SR)}$	Bus free time between STOP and START condition	4.7		1.3		

1. Data based on standard I²C protocol requirement, not tested in production.
2. Cb = total capacitance of one bus line, in pF.

Figure 3. I²C slave timing diagram (c)



2.5 Absolute maximum ratings

Stresses above those listed as “absolute maximum ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device under these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Table 7. Absolute maximum ratings

Symbol	Ratings	Maximum value	Unit
Vdd	Supply voltage	-0.3 to 4.8	V
Vdd_IO	I/O pins supply voltage	-0.3 to 4.8	V
Vin	Input voltage on any control pin (SCL, SDA)	-0.3 to Vdd_IO +0.3	V
A_{POW}	Acceleration (any axis, powered, Vdd = 2.5 V)	3,000 for 0.5 ms	*g*
		10,000 for 0.1 ms	*g*
A_{UNP}	Acceleration (any axis, unpowered)	3,000 for 0.5 ms	*g*
		10,000 for 0.1 ms	*g*
T_{OP}	Operating temperature range	-40 to +85	°C
T_{STG}	Storage temperature range	-40 to +125	°C

This is a mechanical shock sensitive device, improper handling can cause permanent damage to the part.

This is an ESD sensitive device, improper handling can cause permanent damage to the part.

c. Measurement points are done at 0.2·Vdd_IO and 0.8·Vdd_IO, for both ports.

2.6 Terminology

2.6.1 Linear acceleration sensitivity

Linear acceleration sensitivity describes the gain of the accelerometer sensor and can be determined by applying 1 *g* acceleration to it. As the sensor can measure DC accelerations, this can be done easily by pointing the axis of interest towards the center of the Earth, noting the output value, rotating the sensor by 180 degrees (pointing to the sky) and noting the output value again. By doing so, ±1 *g* acceleration is applied to the sensor. Subtracting the larger output value from the smaller one, and dividing the result by 2, leads to the actual sensitivity of the sensor. This value changes very little over temperature and also very little over time. The sensitivity tolerance describes the range of sensitivities of a large population of sensors.

2.6.2 Zero-g level

Zero-*g* level offset (TyOff) describes the deviation of an actual output signal from the ideal output signal if no acceleration is present. A sensor in a steady-state on a horizontal surface measures 0 *g* in the X axis and 0 *g* in the Y axis whereas the Z axis measures 1 *g*. The output is ideally in the middle of the dynamic range of the sensor (content of OUT registers 00h, data expressed as 2's complement number). A deviation from the ideal value in this case is called Zero-*g* offset. Offset is, to some extent, a result of stress to the MEMS sensor and therefore the offset can slightly change after mounting the sensor onto a printed circuit board or exposing it to extensive mechanical stress. Offset changes little over temperature, see "Zero-*g* level change vs. temperature". The Zero-*g* level tolerance (TyOff) describes the standard deviation of the range of Zero-*g* levels of a population of sensors.

3 Functionality

The LSM303DLHC is a system-in-package featuring a 3D digital linear acceleration and 3D digital magnetic field detection sensor.

The system includes specific sensing elements and an IC interface capable of measuring both the linear acceleration and magnetic field applied on it and to provide a signal to the external world through an I^2C serial interface with separated digital output.

The sensing system is manufactured using specialized micromachining processes, while the IC interfaces are realized using a CMOS technology that allows to design a dedicated circuit which is trimmed to better match the sensing element characteristics.

The LSM303DLHC features two data-ready signals (RDY) which indicate when a new set of measured acceleration data and magnetic data are available, therefore simplifying data synchronization in the digital system that uses the device.

The LSM303DLHC may also be configured to generate a free-fall interrupt signal according to a programmed acceleration event along the enabled axes.

Linear acceleration operating mode

LSM303DLHC provides two different acceleration operating modes, respectively reported as “normal mode” and “low-power mode”. While normal mode guarantees high resolution, low-power mode reduces further the current consumption.

Table 8 summarizes how to select the operating mode.

Table 8. Accelerometer operating mode selection

Operating mode	CTRL_REG1[3] (LPen bit)	CTRL_REG4[3] (HR bit)	BW [Hz]	Turn-on time [ms]
Low-power mode	1	0	ODR/2	1
Normal mode	0	1	ODR/9	7/ODR

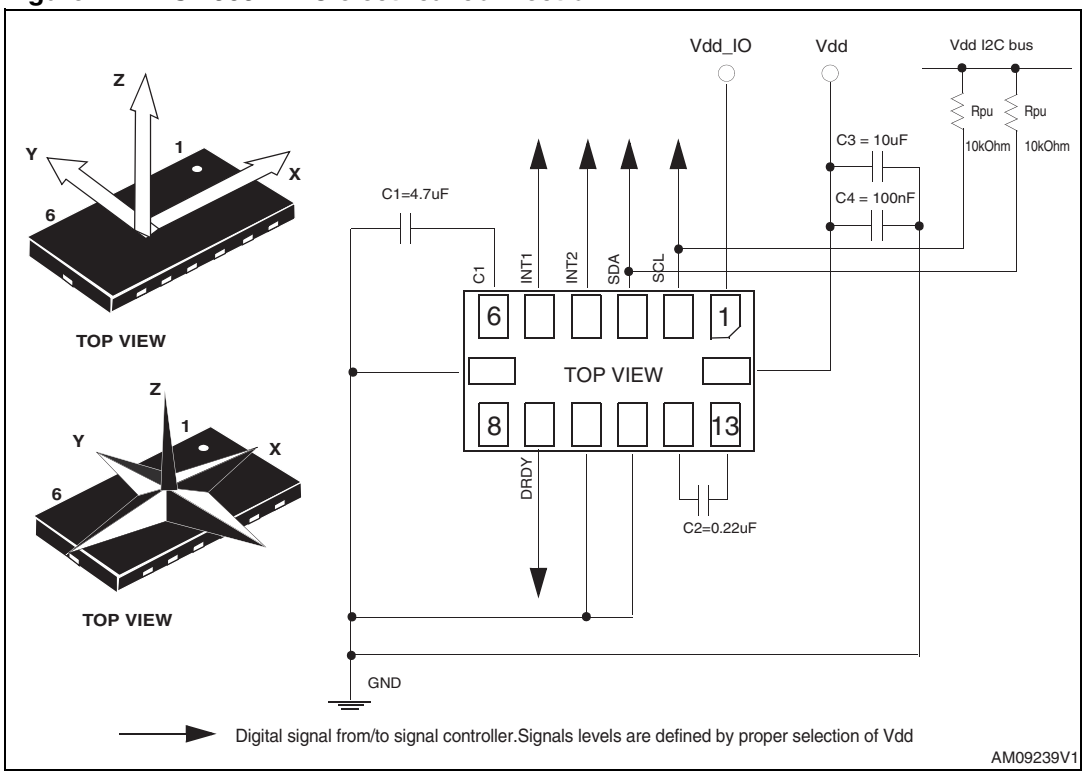
3.1 Factory calibration

The IC interface is factory calibrated for linear acceleration sensitivity (LA_So), and linear acceleration Zero-g level (LA_TyOff).

The trimming values are stored inside the device by a non-volatile memory. Any time the device is turned on, the trimming parameters are downloaded into the registers to be used during the normal operation. This allows the user to use the device without further calibration.

4 Application hints

Figure 4. LSM303DLHC electrical connection



4.1 capacitors

The C1 and C2 external capacitors should be low SR value ceramic type constructions (typ. suggested value 200 mOhm). Reservoir capacitor C1 is nominally 4.7 µF in capacitance, with the set/reset capacitor C2 nominally 0.22 µF in capacitance.

The device core is supplied through the Vdd line. Power supply decoupling capacitors (C4=100 nF ceramic, C3=10 µF Al) should be placed as near as possible to the supply pin of the device (common design practice). All the voltage and ground supplies must be present at the same time to have proper behavior of the IC (refer to *Figure 4*).

The functionality of the device and the measured acceleration/magnetic field data is selectable and accessible through the I^2C interface.

The functions, the threshold, and the timing of the two interrupt pins (INT 1 and INT 2) can be completely programmed by the user through the I^2C interface.

4.2 Pull-up resistors

Pull-up resistors (suggested value 10 kOhm) are placed on the two I^2C bus lines.

4.3 Digital interface power supply

This digital interface, dedicated to the linear acceleration and to the magnetic field signal, is capable of operating with a standard power supply (Vdd) or using a dedicated power supply (Vdd_IO).

4.4 Soldering information

The LGA package is compliant with the ECOPACK®, RoHS, and “Green” standard.
It is qualified for soldering heat resistance according to JEDEC J-STD-020.

Leave “Pin 1 Indicator” unconnected during soldering.

Land pattern and soldering recommendations are available at www.st.com/mems.

4.5 High current wiring effects

High current in the wiring and printed circuit trace can be culprits in causing errors in magnetic field measurements for compassing.

Conductor generated magnetic fields add to the Earth’s magnetic field, causing errors in compass heading computation.

Keep currents higher than 10 mA a few millimeters further away from the sensor IC.

5 Digital interfaces

The registers embedded inside the LSM303DLHC are accessible through two separate I^2C serial interfaces, one for the accelerometer core and one for the magnetometer core.

Table 9. Serial interface pin description

PIN Name	PIN Description
SCL	I^2C serial clock (SCL)
SDA	I^2C serial data (SDA)

5.1 I^2C serial interface

The LSM303DLHC I^2C is a bus slave. The I^2C is employed to write the data into the registers whon also be read back.

The relevant I^2C terminology is given in the table below.

Table 10. Serial interface pin description

Term	Description
Transmitter	The device which sends data to the bus
Receiver	The device which receives data from the bus
Master	The device which initiates a transfer, generates clock signals, and terminates a transfer
Slave	The device addressed by the master

There are two signals associated with the I^2C bus, the serial clock line (SCL) and the serial data line (SDA). The latter is a bidirectional line used for sending and receiving the data to/from the interface.

5.1.1 I²C operation

The transaction on the bus is started through a START (ST) signal. A START condition is defined as a HIGH to LOW transition on the data line while the SCL line is held HIGH. After this has been transmitted by the master, the bus is considered busy. The next byte of data transmitted after the start condition contains the address of the slave in the first 7 bits and bit 8 tells whether the master is receiving data from the slave or transmitting data to the slave. When an address is sent, each device in the system compares the first seven bits after a start condition with its address. If they match, the device considers itself addressed by the master.

Data transfer with acknowledge is mandatory. The transmitter must release the SDA line during the acknowledge pulse. The receiver must then pull the data line LOW so that it remains stable low during the HIGH period of the acknowledge clock pulse. A receiver which has been addressed is obliged to generate an acknowledge after each byte of data received.

The I²C embedded inside the LSM303DLHC behaves like a slave device and the following protocol must be adhered to. After the start condition (ST) a slave address is sent, once a slave acknowledge (SAK) has been returned, an 8-bit sub-address (SUB) is transmitted; the 7 LSBs represent the actual register address while the MSB enables address auto-increment. If the MSB of the SUB field is '1', the SUB (register address) is automatically increased to allow multiple data Read/Write.

Table 11. Transfer when master is writing one byte to slave

Master	ST	SAD + W		SUB		DATA		SP
Slave			SAK		SAK		SAK	

Table 12. Transfer when master is writing multiple bytes to slave:

Master	ST	SAD + W		SUB		DATA		DATA		SP
Slave			SAK		SAK		SAK		SAK	

Table 13. Transfer when master is receiving (reading) one byte of data from slave:

Master	ST	SAD + W		SUB		SR	SAD + R			NMAK	SP
Slave			SAK		SAK			SAK	DATA		

Data are transmitted in byte format (DATA). Each data transfer contains 8 bits. The number of bytes transferred per transfer is unlimited. Data is transferred with the most significant bit (MSB) first. If a receiver can't receive another complete byte of data until it has performed some other function, it can hold the clock line SCL LOW to force the transmitter into a wait state. Data transfer only continues when the receiver is ready for another byte and releases the data line. If a slave receiver doesn't acknowledge the slave address (i.e. it is not able to receive because it is performing some real-time function) the data line must be left HIGH by the slave. The master can then abort the transfer. A LOW to HIGH transition on the SDA line while the SCL line is HIGH is defined as a STOP condition. Each data transfer must be terminated by the generation of a STOP (SP) condition.

5.1.2 Linear acceleration digital interface

For linear acceleration the default (factory) 7-bit slave address is 0011001b.

The slave address is completed with a Read/Write bit. If the bit is '1' (read), a repeated START (SR) condition must be issued after the two sub-address bytes; if the bit is '0' (write) the master transmits to the slave with the direction unchanged. *Table 14* explains how the ead/write bit pattern is composed, listing all the possible configurations.

Table 14. SAD+Read/Write patterns

Command	SAD[7:1]	R/W	SAD+R/W
Read	0011001	1	00110011 (33h)
Write	0011001	0	00110010 (32h)

In order to read multiple bytes, it is necessary to assert the most significant bit of the sub-address field. In other words, SUB(7) must be equal to 1 while SUB(6-0) represents the address of the first register to be read.

In the presented communication format, MAK is master acknowledge and NMAK is no master acknowledge.

Table 15. Transfer when master is receiving (reading) multiple bytes of data from slave

Master	ST	SAD +W		SUB		SR	SAD +R			MAK		MAK		NMAK	SP
Slave			SAK		SAK			SAK	DATA		DATA		DATA		

5.1.3 Magnetic field digital interface

For magnetic sensors the default (factory) 7-bit slave address is 0011110xb.

The slave address is completed with a Read/Write bit. If the bit is '1' (read), a repeated START (SR) condition must be issued after the two sub-address bytes; if the bit is '0' (write) the master transmits to the slave with the direction unchanged. *Table 16* explains how the SAD is composed.

Table 16. SAD

Command	SAD[6:0]	R/W	SAD+R/W
Read	0011110	1	00111101 (3Dh)
Write	0011110	0	00111100 (3Ch)

Magnetic signal interface reading/writing

The interface uses an address pointer to indicate which register location is to be read from or written to. These pointer locations are sent from the master to this slave device and succeed the 7-bit address plus 1 bit Read/Write identifier.

To minimize the communication between the master and magnetic digital interface of LSM303DLHC, the address pointer updates automatically without master intervention.

This automatic address pointer update has two additional features. First, when address 12 or higher is accessed, the pointer updates to address 00, and secondly, when address 08 is reached, the pointer rolls back to address 03. Logically, the address pointer operation functions as shown below.

If (address pointer = 08) then the address pointer = 03

Or else, if (address pointer >= 12) then the address pointer = 0

Or else, (address pointer) = (address pointer) + 1

The address pointer value itself cannot be read via the I^2C bus.

Any attempt to read an invalid address location returns 0, and any write to an invalid address location, or an undefined bit within a valid address location, is ignored by this device.

6 Register mapping

Table 17 provides a listing of the 8-bit registers embedded in the device and the related addresses:

Table 17. Register address map

Name	Slave address	Type	Register address		Default	Comment
			Hex	Binary		
Reserved (do not modify)	*Table 14*		00 - 1F	--	--	Reserved
CTRL_REG1_A	*Table 14*	rw	20	010 0000	00000111	
CTRL_REG2_A	*Table 14*	rw	21	010 0001	00000000	
CTRL_REG3_A	*Table 14*	rw	22	010 0010	00000000	
CTRL_REG4_A	*Table 14*	rw	23	010 0011	00000000	
CTRL_REG5_A	*Table 14*	rw	24	010 0100	00000000	
CTRL_REG6_A	*Table 14*	rw	25	010 0101	00000000	
REFERENCE_A	*Table 14*	rw	26	010 0110	00000000	
STATUS_REG_A	*Table 14*	r	27	010 0111	00000000	
OUT_X_L_A	*Table 14*	r	28	010 1000	output	
OUT_X_H_A	*Table 14*	r	29	010 1001	output	
OUT_Y_L_A	*Table 14*	r	2A	010 1010	output	
OUT_Y_H_A	*Table 14*	r	2B	010 1011	output	
OUT_Z_L_A	*Table 14*	r	2C	010 1100	output	
OUT_Z_H_A	*Table 14*	r	2D	010 1101	output	
FIFO_CTRL_REG_A	*Table 14*	rw	2E	010 1110	00000000	
FIFO_SRC_REG_A	*Table 14*	r	2F	010 1111		
INT1_CFG_A	*Table 14*	rw	30	011 0000	00000000	
INT1_SOURCE_A	*Table 14*	r	31	011 0001	00000000	
INT1_THS_A	*Table 14*	rw	32	011 0010	00000000	
INT1_DURATION_A	*Table 14*	rw	33	011 0011	00000000	
INT2_CFG_A	*Table 14*	rw	34	011 0100	00000000	
INT2_SOURCE_A	*Table 14*	r	35	011 0101	00000000	
INT2_THS_A	*Table 14*	rw	36	011 0110	00000000	
INT2_DURATION_A	*Table 14*	rw	37	011 0111	00000000	
CLICK_CFG_A	*Table 14*	rw	38	011 1000	00000000	
CLICK_SRC_A	*Table 14*	rw	39	011 1001	00000000	
CLICK_THS_A	*Table 14*	rw	3A	011 1010	00000000	
TIME_LIMIT_A	*Table 14*	rw	3B	011 1011	00000000	

Table 17. Register address map (continued)

Name	Slave address	Type	Register address		Default	Comment
			Hex	Binary		
TIME_LATENCY_A	*Table 14*	rw	3C	011 1100	00000000	
TIME_WINDOW_A	*Table 14*	rw	3D	011 1101	00000000	
Reserved (do not modify)	*Table 14*		3E-3F	--	--	Reserved
CRA_REG_M	*Table 16*	rw	00	00000000	0001000	
CRB_REG_M	*Table 16*	rw	01	00000001	0010000	
MR_REG_M	*Table 16*	rw	02	00000010	00000011	
OUT_X_H_M	*Table 16*	r	03	00000011	output	
OUT_X_L_M	*Table 16*	r	04	00000100	output	
OUT_Z_H_M	*Table 16*	r	05	00000101	output	
OUT_Z_L_M	*Table 16*	r	06	00000110	output	
OUT_Y_H_M	*Table 16*	r	07	00000111	output	
OUT_Y_L_M	*Table 16*	r	08	00001000	output	
SR_REG_Mg	*Table 16*	r	09	00001001	00000000	
IRA_REG_M	*Table 16*	r	0A	00001010	01001000	
IRB_REG_M	*Table 16*	r	0B	00001011	00110100	
IRC_REG_M	*Table 16*	r	0C	00001100	00110011	
Reserved (do not modify)	*Table 16*		0D-30	--	--	Reserved
TEMP_OUT_H_M	*Table 16*		31	00000000	output	
TEMP_OUT_L_M	*Table 16*		32	00000000	output	
Reserved (do not modify)	*Table 16*		33-3A	--	--	Reserved

Registers marked as “reserved” must not be changed. The writing to these registers may cause permanent damage to the device.

The content of the registers that are loaded at boot should not be changed. They contain the factory calibrated values. Their content is automatically restored when the device is powered up.

7 Register description

The device contains a set of registers which are used to control its behavior and to retrieve acceleration data. The register address, made up of 7 bits, is used to identify them and to write the data through the serial interface.

7.1 Linear acceleration register description

7.1.1 CTRL_REG1_A (20h)

Table 18. CTRL_REG1_A register

ODR3	ODR2	ODR1	ODR0	LPen	Zen	Yen	Xen

Table 19. CTRL_REG1_A description

ODR3-0	Data rate selection. Default value: 0 (0000: power-down, others: refer to *Table 20*.)
LPen	Low-power mode enable. Default value: 0 (0: normal mode, 1: low-power mode)
Zen	Z axis enable. Default value: 1 (0: Z axis disabled, 1: Z axis enabled)
Yen	Y axis enable. Default value: 1 (0: Y axis disabled, 1: Y axis enabled)
Xen	X axis enable. Default value: 1 (0: X axis disabled, 1: X axis enabled)

ODR<3:0> is used to set the power mode and ODR selection. In *Table 20* all frequencies resulting in a combination of ODR<3:0> are listed.

Table 20. Data rate configuration

ODR3	ODR2	ODR1	ODR0	Power mode selection
0	0	0	0	Power-down mode
0	0	0	1	Normal / low-power mode (1 Hz)
0	0	1	0	Normal / low-power mode (10 Hz)
0	0	1	1	Normal / low-power mode (25 Hz)
0	1	0	0	Normal / low-power mode (50 Hz)
0	1	0	1	Normal / low-power mode (100 Hz)
0	1	1	0	Normal / low-power mode (200 Hz)
0	1	1	1	Normal / low-power mode (400 Hz)

Table 20. Data rate configuration (continued)

ODR3	ODR2	ODR1	ODR0	Power mode selection
1	0	0	0	Low-power mode (1.620 KHz)
1	0	0	1	Normal (1.344 kHz) / low-power mode (5.376 KHz)

7.1.2 CTRL_REG2_A (21h)

Table 21. CTRL_REG2_A register

HPM1	HPM0	HPCF2	HPCF1	FDS	HPCLICK	HPIS2	HPIS1

Table 22. CTRL_REG2_A description

HPM1 -HPM0	High pass filter mode selection. Default value: 00 (refer to *Table 23*)
HPCF2 - HPCF1	High pass filter cut-off frequency selection
FDS	Filtered data selection. Default value: 0 (0: internal filter bypassed, 1: data from internal filter sent to output register and FIFO)
HPCLICK	High pass filter enabled for CLICK function. (0: filter bypassed, 1: filter enabled)
HPIS2	High pass filter enabled for AOI function on Interrupt 2, (0: filter bypassed, 1: filter enabled)
HPIS1	High pass filter enabled for AOI function on Interrupt 1, (0: filter bypassed, 1: filter enabled)

Table 23. High pass filter mode configuration

HPM1	HPM0	High pass filter mode
0	0	Normal mode (reset reading HP_RESET_FILTER)
0	1	Reference signal for filtering
1	0	Normal mode
1	1	Autoreset on interrupt event

7.1.3 CTRL_REG3_A (22h)

Table 24. CTRL_REG3_A register

I1_CLICK	I1_AOI1	I1_AOI2	I1_DRDY1	I1_DRDY2	I1_WTM	I1_OVERRUN	--

Table 25. CTRL_REG3_A description

I1_CLICK	CLICK interrupt on INT1. Default value 0. (0: disable, 1: enable)
I1_AOI1	AOI1 interrupt on INT1. Default value 0. (0: disable, 1: enable)
I1_AOI2	AOI2 interrupt on INT1. Default value 0. (0: disable, 1: enable)
I1_DRDY1	DRDY1 interrupt on INT1. Default value 0. (0: disable, 1: enable)
I1_DRDY2	DRDY2 interrupt on INT1. Default value 0. (0: disable, 1: enable)
I1_WTM	FIFO watermark interrupt on INT1. Default value 0. (0: disable, 1: enable)
I1_OVERRUN	FIFO overrun interrupt on INT1. Default value 0. (0: disable, 1: enable)

7.1.4 CTRL_REG4_A (23h)

Table 26. CTRL_REG4_A register

BDU	BLE	FS1	FS0	HR	0(1)	0(1)	SIM

1. This bit must be set to '0' for correct working of the device.

Table 27. CTRL_REG4_A description

BDU	Block data update. Default value: 0 (0: continuos update, 1: output registers not updated until MSB and LSB reading
BLE	Big/little endian data selection. Default value 0. (0: data LSB @ lower address, 1: data MSB @ lower address)
FS1-FS0	Full-scale selection. Default value: 00 (00: +/- 2G, 01: +/- 4G, 10: +/- 8G, 11: +/- 16G)
HR	High resolution output mode: Default value: 0 (0: high resolution disable, 1: high resolution enable)
SIM	SPI serial interface mode selection. Default value: 0 (0: 4-wire interface, 1: 3-wire interface).

7.1.5 CTRL_REG5_A (24h)

Table 28. CTRL_REG5_A register

BOOT	FIFO_EN	--	--	LIR_INT1	D4D_INT1	LIR_INT2	D4D_INT2

Table 29. CTRL_REG5_A description

BOOT	Reboot memory content. Default value: 0 (0: normal mode, 1: reboot memory content)
FIFO_EN	FIFO enable. Default value: 0 (0: FIFO disable, 1: FIFO enable)
LIR_INT1	Latch interrupt request on INT1_SRC register, with INT1_SRC register cleared by reading INT1_SRC itself. Default value: 0. (0: interrupt request not latched, 1: interrupt request latched)
D4D_INT1	4D enable: 4D detection is enabled on INT1 when 6D bit on INT1_CFG is set to 1.
LIR_INT2	Latch interrupt request on INT2_SRC register, with INT2_SRC register cleared by reading INT2_SRC itself. Default value: 0. (0: interrupt request not latched, 1: interrupt request latched)
D4D_INT2	4D enable: 4D detection is enabled on INT2 when 6D bit on INT2_CFG is set to 1.

7.1.6 CTRL_REG6_A (25h)

Table 30. CTRL_REG6_A register

I2_CLICKen	I2_INT1	I2_INT2	BOOT_I1	P2_ACT	- -	H_LACTIVE	--

Table 31. CTRL_REG6_A description

I2_CLICKen	CLICK interrupt on PAD2. Default value 0. (0: disable, 1: enable)
I2_INT1	Interrupt 1 on PAD2. Default value 0. (0: disable, 1: enable)
I2_INT2	Interrupt 2 on PAD2. Default value 0. (0: disable, 1: enable)
BOOT_I1	Reboot memory content on PAD2. Default value: 0 (0: disable, 1: enable)
P2_ACT	Active function status on PAD2. Default value 0. (0: disable, 1: enable)
H_LACTIVE	Interrupt active high, low. Default value 0. (0: active high, 1: active low)

7.1.7 REFERENCE/DATACAPTURE_A (26h)

Table 32. REFERENCE_A register

Ref7	Ref6	Ref5	Ref4	Ref3	Ref2	Ref1	Ref0

Table 33. REFERENCE_A register description

Ref 7-Ref0	Reference value for interrupt generation. Default value: 0

7.1.8 STATUS_REG_A (27h)

Table 34. STATUS_A register

ZYXOR	ZOR	YOR	XOR	ZYXDA	ZDA	YDA	XDA

Table 35. STATUS_A register description

ZYXOR	X, Y, and Z axis data overrun. Default value: 0 (0: no overrun has occurred, 1: a new set of data has overwritten the previous ones)
ZOR	Z axis data overrun. Default value: 0 (0: no overrun has occurred, 1: a new data for the Z-axis has overwritten the previous one)
YOR	Y axis data overrun. Default value: 0 (0: no overrun has occurred, 1: a new data for the Y-axis has overwritten the previous one)
XOR	X axis data overrun. Default value: 0 (0: no overrun has occurred, 1: a new data for the X-axis has overwritten the previous one)
ZYXDA	X, Y, and Z axis new data available. Default value: 0 (0: a new set of data is not yet available, 1: a new set of data is available)
ZDA	Z axis new data available. Default value: 0 (0: a new data for the Z-axis is not yet available, 1: a new data for the Z-axis is available)
YDA	Y axis new data available. Default value: 0 (0: a new data for the Y-axis is not yet available, 1: a new data for the Y-axis is available)
XDA	X axis new data available. Default value: 0 (0: a new data for the X-axis is not yet available, 1: a new data for the X-axis is available)

7.1.9 OUT_X_L_A (28h), OUT_X_H_A (29h)

X-axis acceleration data. The value is expressed in 2’s complement.

7.1.10 OUT_Y_L_A (2Ah), OUT_Y_H_A (2Bh)

Y-axis acceleration data. The value is expressed in 2’s complement.

7.1.11 OUT_Z_L_A (2Ch), OUT_Z_H_A (2Dh)

Z-axis acceleration data. The value is expressed in 2’s complement.

7.1.12 FIFO_CTRL_REG_A (2Eh)

Table 36. REFERENCE_A register

FM1	FM0	TR	FTH4	FTH3	FTH2	FTH1	FTH0

Table 37. REFERENCE_A register description

FM1-FM0	FIFO mode selection. Default value: 00 (see *Table 38*)
TR	Trigger selection. Default value: 0 0: trigger event linked to trigger signal on INT1 1: trigger event linked to trigger signal on INT2
FTH4:0	Default value: 0

Table 38. FIFO mode configuration

FM1	FM0	FIFO mode configuration
0	0	Bypass mode
0	1	FIFO mode
1	0	Stream mode
1	1	Trigger mode

7.1.13 FIFO_SRC_REG_A (2Fh)

Table 39. FIFO_SRC_A register

WTM	OVRN_FIFO	EMPTY	FSS4	FSS3	FSS2	FSS1	FSS0

7.1.14 INT1_CFG_A (30h)

Table 40. INT1_CFG_A register

AOI	6D	ZHIE/ ZUPE	ZLIE/ ZDOWNE	YHIE/ YUPE	YLIE/ YDOWNE	XHIE/ XUPE	XLIE/ XDOWNE

Table 41. INT1_CFG_A description

AOI	AND/OR combination of interrupt events. Default value: 0 (refer to *Table 42*)
6D	6-direction detection function enabled. Default value: 0 (refer to *Table 42*)
ZHIE/ ZUPE	Enable interrupt generation on Z high event or on direction recognition. Default value: 0 (0: disable interrupt request, 1: enable interrupt request)
ZLIE/ ZDOWNE	Enable interrupt generation on Z low event or on direction recognition. Default value: 0 (0: disable interrupt request, 1: enable interrupt request)

Table 41. INT1_CFG_A description (continued)

YHIE/ YUPE	Enable interrupt generation on Y high event or on direction recognition. Default value: 0 (0: disable interrupt request, 1: enable interrupt request.)
YLIE/ YDOWNE	Enable interrupt generation on Y low event or on direction recognition. Default value: 0 (0: disable interrupt request, 1: enable interrupt request.)
XHIE/ XUPE	Enable interrupt generation on X high event or on direction recognition. Default value: 0 (0: disable interrupt request, 1: enable interrupt request.)
XLIE/XDOWNE	Enable interrupt generation on X low event or on direction recognition. Default value: 0 (0: disable interrupt request, 1: enable interrupt request.)

Content of this register is loaded at boot. Write operation at this address is possible only after system boot.

Table 42. Interrupt mode

AOI	6D	Interrupt mode
0	0	OR combination of interrupt events
0	1	6-direction movement recognition
1	0	AND combination of interrupt events
1	1	6-direction position recognition

Difference between AOI-6D = ‘01’ and AOI-6D = ‘11’.

AOI-6D = ‘01’ is movement recognition. An interrupt is generated when orientation moves from unknown zone to known zone. The interrupt signal stays for a duration ODR.

AOI-6D = ‘11’ is direction recognition. An interrupt is generated when orientation is inside a known zone. The interrupt signal stays until orientation is inside the zone.

7.1.15 INT1_SRC_A (31h)

Table 43. INT1_SRC_A register

0(1)	IA	ZH	ZL	YH	YL	XH	XL

1. This bit must be set to ‘0’ for correct working of the device.

Table 44. INT1_SRC_A description

IA	Interrupt active. Default value: 0 (0: no interrupt has been generated, 1: one or more interrupts have been generated)
ZH	Z high. Default value: 0 (0: no interrupt, 1: Z high event has occurred)
ZL	Z low. Default value: 0 (0: no interrupt, 1: Z low event has occurred)
YH	Y high. Default value: 0 (0: no interrupt, 1: Y high event has occurred)

Table 44. INT1_SRC_A description (continued)

YL	Y low. Default value: 0 (0: no interrupt, 1: Y low event has occurred)
XH	X high. Default value: 0 (0: no interrupt, 1: X high event has occurred)
XL	X low. Default value: 0 (0: no interrupt, 1: X low event has occurred)

Interrupt 1 source register. Read only register.

Reading at this address clears the INT1_SRC IA bit (and the interrupt signal on the INT 1 pin) and allows the refreshing of data in the INT1_SRC register if the latched option was chosen.

7.1.16 INT1_THS_A (32h)

Table 45. INT1_THS_A register

0(1)	THS6	THS5	THS4	THS3	THS2	THS1	THS0

1. This bit must be set to '0' for correct working of the device.

Table 46. INT1_THS_A description

THS6 - THS0	Interrupt 1 threshold. Default value: 000 0000

7.1.17 INT1_DURATION_A (33h)

Table 47. INT1_DURATION_A register

0(1)	D6	D5	D4	D3	D2	D1	D0

1. This bit must be set to '0' for correct working of the device.

Table 48. INT1_DURATION_A description

D6 - D0	Duration value. Default value: 000 0000

D6 - D0 bits set the minimum duration of the Interrupt 1 event to be recognized. Duration steps and maximum values depend on the ODR chosen.

7.1.18 INT2_CFG_A (34h)

Table 49. INT2_CFG_A register

AOI	6D	ZHIE	ZLIE	YHIE	YLIE	XHIE	XLIE

Table 50. INT2_CFG_A description

AOI	AND/OR combination of interrupt events. Default value: 0 (see *Table 51*)
6D	6-direction detection function enabled. Default value: 0 (refer to *Table 51*)
ZHIE	Enable interrupt generation on Z high event. Default value: 0 (0: disable interrupt request, 1: enable interrupt request on measured accel. value higher than preset threshold)
ZLIE	Enable interrupt generation on Z low event. Default value: 0 (0: disable interrupt request, 1: enable interrupt request on measured accel. value lower than preset threshold)
YHIE	Enable interrupt generation on Y high event. Default value: 0 (0: disable interrupt request, 1: enable interrupt request on measured accel. value higher than preset threshold)
YLIE	Enable interrupt generation on Y low event. Default value: 0 (0: disable interrupt request, 1: enable interrupt request on measured accel. value lower than preset threshold)
XHIE	Enable interrupt generation on X high event. Default value: 0 (0: disable interrupt request, 1: enable interrupt request on measured accel. value higher than preset threshold)
XLIE	Enable interrupt generation on X low event. Default value: 0 (0: disable interrupt request, 1: enable interrupt request on measured accel. value lower than preset threshold)

Table 51. Interrupt mode

AOI	6D	Interrupt mode
0	0	OR combination of interrupt events
0	1	6-direction movement recognition
1	0	AND combination of interrupt events
1	1	6-direction position recognition

Difference between AOI-6D = ‘01’ and AOI-6D = ‘11’.

AOI-6D = ‘01’ is movement recognition. An interrupt is generated when orientation moves from unknown zone to known zone. The interrupt signal stays for a duration ODR.

AOI-6D = ‘11’ is direction recognition. An interrupt is generated when orientation is inside a known zone. The interrupt signal stays until orientation is inside the zone.

7.1.19 INT2_SRC_A (35h)

Table 52. INT2_SRC_A register

0(1)	IA	ZH	ZL	YH	YL	XH	XL

1. This bit must be set to ‘0’ for correct working of the device.

Table 53. INT2_SRC_A description

IA	Interrupt active. Default value: 0 (0: no interrupt has been generated, 1: one or more interrupts have been generated)
ZH	Z high. Default value: 0 (0: no interrupt, 1: Z high event has occurred)
ZL	Z low. Default value: 0 (0: no interrupt, 1: Z low event has occurred)
YH	Y high. Default value: 0 (0: no interrupt, 1: Y high event has occurred)
YL	Y low. Default value: 0 (0: no interrupt, 1: Y low event has occurred)
XH	X high. Default value: 0 (0: no interrupt, 1: X high event has occurred)
XL	X Low. Default value: 0 (0: no interrupt, 1: X low event has occurred)

Interrupt 2 source register. Read only register.

Reading at this address clears INT2_SRC IA bit (and the interrupt signal on the INT 2 pin) and allows the refreshing of data in the INT2_SRC register if the latched option was chosen.

7.1.20 INT2_THS_A (36h)

Table 54. INT2_THS_A register

0(1)	THS6	THS5	THS4	THS3	THS2	THS1	THS0

1. This bit must be set to '0' for correct working of the device

Table 55. INT2_THS_A description

THS6 - THS0	Interrupt 1 threshold. Default value: 000 0000

7.1.21 INT2_DURATION_A (37h)

Table 56. INT2_DURATION_A register

0(1)	D6	D5	D4	D3	D2	D1	D0

1. This bit must be set to '0' for correct working of the device

Table 57. INT2_DURATION_A description

D6-D0	Duration value. Default value: 000 0000

D6 - D0 bits set the minimum duration of the Interrupt 2 event to be recognized. Duration time steps and maximum values depend on the ODR chosen.

7.1.22 CLICK_CFG_A (38h)

Table 58. CLICK_CFG_A register

--	--	ZD	ZS	YD	YS	XD	XS

Table 59. CLICK_CFG_A description

ZD	Enable interrupt double CLICK on Z axis. Default value: 0 (0: disable interrupt request, 1: enable interrupt request on measured accel. value higher than preset threshold)
ZS	Enable interrupt single CLICK on Z axis. Default value: 0 (0: disable interrupt request, 1: enable interrupt request on measured accel. value higher than preset threshold)
YD	Enable interrupt double CLICK on Y axis. Default value: 0 (0: disable interrupt request, 1: enable interrupt request on measured accel. value higher than preset threshold)
YS	Enable interrupt single CLICK on Y axis. Default value: 0 (0: disable interrupt request, 1: enable interrupt request on measured accel. value higher than preset threshold)
XD	Enable interrupt double CLICK on X axis. Default value: 0 (0: disable interrupt request, 1: enable interrupt request on measured accel. value higher than preset threshold)
XS	Enable interrupt single CLICK on X axis. Default value: 0 (0: disable interrupt request, 1: enable interrupt request on measured accel. value higher than preset threshold)

7.1.23 CLICK_SRC_A (39h)

Table 60. CLICK_SRC_A register

--	IA	DCLICK	SCLICK	Sign	Z	Y	X

Table 61. CLICK_SRC_A description

IA	Interrupt active. Default value: 0 (0: no interrupt has been generated, 1: one or more interrupts have been generated)
DCLICK	Double CLICK-CLICK enable. Default value: 0 (0:double CLICK-CLICK detection disable, 1: double CLICK-CLICK detection enable)
SCLICK	Single CLICK-CLICK enable. Default value: 0 (0:Single CLICK-CLICK detection disable, 1: single CLICK-CLICK detection enable)
Sign	CLICK-CLICK Sign. 0: positive detection, 1: negative detection

Table 61. CLICK_SRC_A description (continued)

Z	Z CLICK-CLICK detection. Default value: 0 (0: no interrupt, 1: Z high event has occurred)
Y	Y CLICK-CLICK detection. Default value: 0 (0: no interrupt, 1: Y high event has occurred)
X	X CLICK-CLICK detection. Default value: 0 (0: no interrupt, 1: X high event has occurred)

7.1.24 CLICK_THS_A (3Ah)

Table 62. CLICK_THS_A register

--	Ths6	Ths5	Ths4	Ths3	Ths2	Ths1	Ths0

Table 63. CLICK_SRC_A description

Ths6-Ths0	CLICK-CLICK threshold. Default value: 000 0000

1 LSB = full-scale / 128. THS6 through THS0 define the threshold which is used by the system to start the click detection procedure. The threshold value is expressed over 7 bits as an unsigned number.

7.1.25 TIME_LIMIT_A (3Bh)

Table 64. TIME_LIMIT_A register

--	TLI6	TLI5	TLI4	TLI3	TLI2	TLI1	TLI0

Table 65. TIME_LIMIT_A description

TLI7-TLI0	CLICK-CLICK time limit. Default value: 000 0000

1 LSB = 1/ODR. TLI7 through TLI0 define the maximum time interval that can elapse between the start of the click detection procedure (the acceleration on the selected channel exceeds the programmed threshold) and when the acceleration goes back below the threshold.

7.1.26 TIME_LATENCY_A (3Ch)

Table 66. TIME_LATENCY_A register

TLA7	TLA6	TLA5	TLA4	TLA3	TLA2	TLA1	TLA0

Table 67. TIME_LATENCY_A description

TLA7-TLA0	CLICK-CLICK time latency. Default value: 000 0000

1 LSB = 1/ODR. TLA7 through TLA0 define the time interval that starts after the first click detection where the click detection procedure is disabled, in cases where the device is configured for double click detection.

7.1.27 TIME WINDOW_A (3Dh)

Table 68. TIME_WINDOW_A register

TW7	TW6	TW5	TW4	TW3	TW2	TW1	TW0

Table 69. TIME_WINDOW_A description

TW7-TW0	CLICK-CLICK time window

1 LSB = 1/ODR. TW7 through TW0 define the maximum interval of time that can elapse after the end of the latency interval in which the click detection procedure can start, in cases where the device is configured for double click detection.

7.2 Magnetic field sensing register description

7.2.1 CRA_REG_M (00h)

Table 70. CRA_REG_M register

TEMP_EN	0(1)	0(1)	DO2	DO1	DO0	0(1)	0(1)

1. This bit must be set to '0' for correct working of the device

Table 71. CRA_REG_M description

TEMP _EN	Temperature sensor enable. 0: temperature sensor disabled (default), 1: temperature sensor enabled
DO2 to DO0	Data output rate bits. These bits set the rate at which data is written to all three data output registers (refer to *Table 72*). Default value: 100

Table 72. Data rate configurations

DO2	DO1	DO0	Minimum data output rate (Hz)
0	0	0	0.75
0	0	1	1.5
0	1	0	3.0
0	1	1	7.5
1	0	0	15
1	0	1	30

Table 72. Data rate configurations (continued)

DO2	DO1	DO0	Minimum data output rate (Hz)
1	1	0	75
1	1	1	220

7.2.2 CRB_REG_M (01h)

Table 73. CRA_REG register

GN2	GN1	GN0	0(1)	0(1)	0(1)	0(1)	0(1)

1. This bit must be set to '0' for correct working of the device.

Table 74. CRA_REG description

GN1-0	Gain configuration bits. The gain configuration is common for all channels (refer to *Table 75*)

Table 75. Gain setting

GN2	GN1	GN0	Sensor input field range [Gauss]	Gain X, Y, and Z [LSB/Gauss]	Gain Z [LSB/Gauss]	Output range
0	0	1	±1.3	1100	980	0xF800–0x07FF (-2048–2047)
0	1	0	±1.9	855	760	
0	1	1	±2.5	670	600	
1	0	0	±4.0	450	400	
1	0	1	±4.7	400	355	
1	1	0	±5.6	330	295	
1	1	1	±8.1	230	205	

7.2.3 MR_REG_M (02h)

Table 76. MR_REG

0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	MD1	MD0

1. This bit must be set to '0' for correct working of the device.

Table 77. MR_REG description

MD1-0	Mode select bits. These bits select the operation mode of this device (refer to *Table 78*)

Table 78. Magnetic sensor operating mode

MD1	MD0	Mode
0	0	Continuous-conversion mode
0	1	Single-conversion mode
1	0	Sleep-mode. Device is placed in sleep-mode
1	1	Sleep-mode. Device is placed in sleep-mode

7.2.4 OUT_X_H_M (03), OUT_X_LH_M (04h)

X-axis magnetic field data. The value is expressed as 2's complement.

7.2.5 OUT_Z_H_M (05), OUT_Z_L_M (06h)

Z-axis magnetic field data. The value is expressed as 2's complement.

7.2.6 OUT_Y_H_M (07), OUT_Y_L_M (08h)

Y-axis magnetic field data. The value is expressed as 2's complement.

7.2.7 SR_REG_M (09h)

Table 79. SR register

--	--	--	--	--	--	LOCK	DRDY

Table 80. SR register description

LOCK	Data output register lock. Once a new set of measurements is available, this bit is set when the first magnetic file data register has been read.
DRDY	Data ready bit. This bit is when a new set of measurements are available.

7.2.8 IR_REG_M (0Ah/0Bh/0Ch)

Table 81. IRA_REG_M

0	1	0	0	1	0	0	0

Table 82. IRB_REG_M

0	0	1	1	0	1	0	0

Table 83. IRC_REG_M

0	0	1	1	0	0	1	1

7.2.9 TEMP_OUT_H_M (31h), TEMP_OUT_L_M (32h)

Table 84. TEMP_OUT_H_M register

TEMP11	TEMP10	TEMP9	TEMP8	TEMP7	TEMP6	TEMP5	TEMP4

Table 85. TEMP_OUT_L_M register

TEMP3	TEMP2	TEMP1	TEMP0	--	--	--	--

Table 86. TEMP_OUT resolution

TEMP11-0	Temperature data (8LSB/deg - 12-bit resolution). The value is expressed as 2's complement.

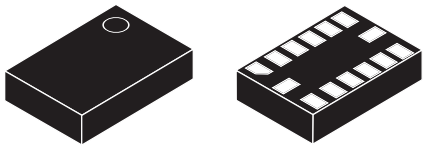
8 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions, and product status are available at: www.st.com. ECOPACK is an ST trademark.

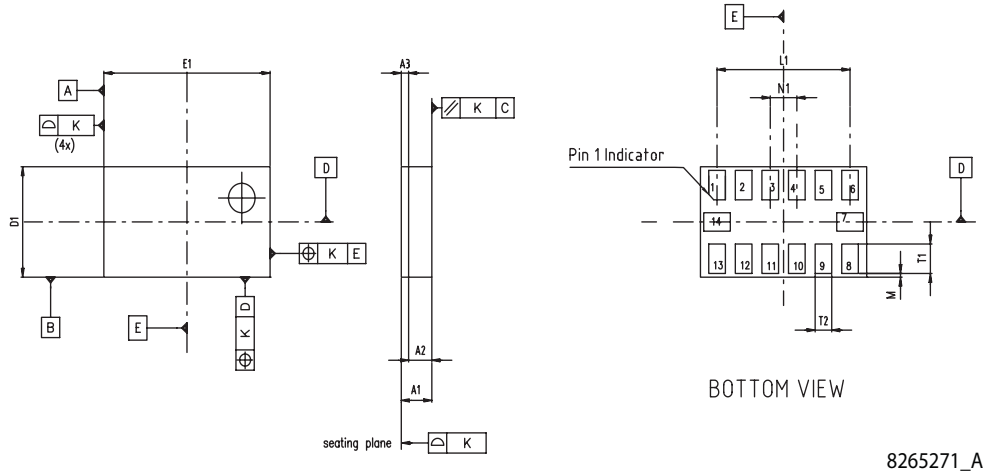
Figure 5. LGA-14: mechanical data and package dimensions

Dimensions			
Ref.	mm		
	Min.	Typ.	Max.
A1			1
A2		0.785	
A3	0.16	0.2	0.24
D1	2.85	3	3.15
E1	4.85	5	5.15
N1		0.8	
L1		4	
T1		0.8	
T2		0.5	
M		0.1	
k		0.05	

Outline and mechanical data



LGA 3x5x1 14L
Land Grid Array Package



9 Revision history

Table 87. Document revision history

Date	Revision	Changes
21-Apr-2011	1	Initial release.

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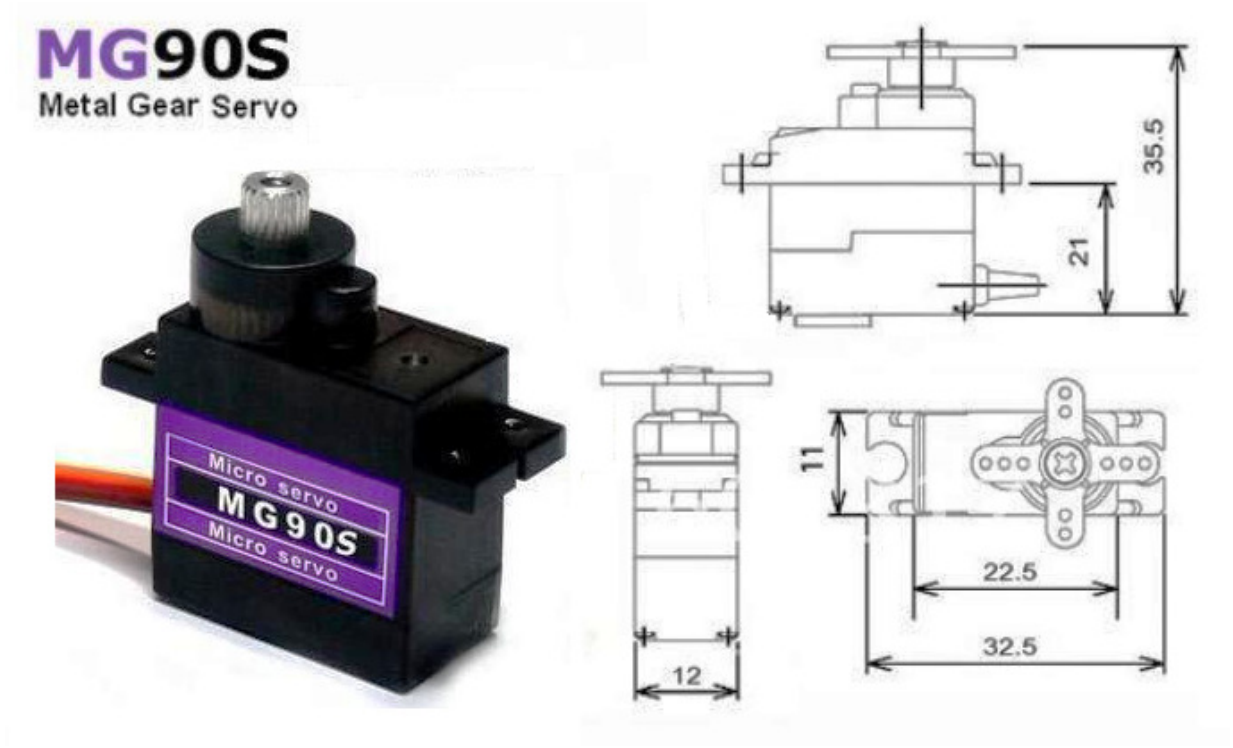
Annex 5.3. Servo MG90S Datasheet



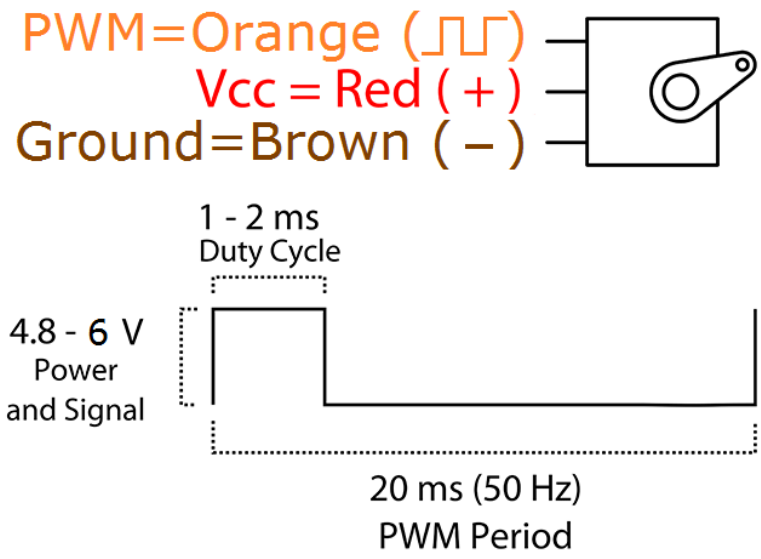
MG90S servo, Metal gear with one bearing

Tiny and lightweight with high output power, this tiny servo is perfect for RC Airplane, Helicopter, Quadcopter or Robot. This servo has *metal gears* for added strength and durability.

Servo can rotate approximately 180 degrees (90 in each direction), and works just like the standard kinds but *smaller*. You can use any servo code, hardware or library to control these servos. Good for beginners who want to make stuff move without building a motor controller with feedback & gear box, especially since it will fit in small places. It comes with a 3 horns (arms) and hardware.

Specifications

- Weight: 13.4 g
- Dimension: 22.5 x 12 x 35.5 mm approx.
- Stall torque: 1.8 kgf·cm (4.8V), 2.2 kgf·cm (6 V)
- Operating speed: 0.1 s/60 degree (4.8 V), 0.08 s/60 degree (6 V)
- Operating voltage: 4.8 V - 6.0 V
- Dead band width: 5 µs



Position "0" (1.5 ms pulse) is middle, "90" (~2 ms pulse) is all the way to the right, "-90" (~1 ms pulse) is all the way to the left.

Annex 5.4. ESC Datasheet

MANUAL OF ESC FOR AIRCRAFT AND HELICOPTER

REV 2.2

Features

1. Equipped with high-speed, small-sized, multifunctional MCU.
2. Full protection feature including low-voltage protection, over-heat protection, signal lost protection, safe power on protection, and self-check functions.
3. 4 seconds very soft start performance which is very suitable for helicopters.
4. Excellent startup performance, great throttle linear and quick throttle response, excellent low-speed performance.
5. Max speed: 240,000 RPM (2 poles), 80,000 RPM (6 poles), 40,000 RPM (12 poles).
6. Individual power circuit for MCU and BEC to improve anti-interference capability.
7. The parameters of ESC can be configured via program card or transmitter.
8. Built-in linear BEC or switch mode BEC.
9. The low-voltage threshold and start-up power can be programmed quantized and precisely by program card.
10. Throttle range can be configured to be compatible with different receivers.
11. Three throttle curve options make helicopter control more flexible.
12. Motor reverse rotation available.

Specification

Table 1 (BEC is Linear Mode)

Model	Continuous Current	Burst current (10S)	Li-XX	Size(mm) L*W*H	Weiht (g)	BEC （Linear）	Program Function
XP-3A	3A	4A	1	11×13×4	0.7	N/A	YES
XP-7A	7A	9A	1-2	22×12×5	5	1A	YES
XP-12A	12A	15A	1-3	22×17×7	8	1A	YES
XP-18A	18A	23A	2-3	45×24×6	18	2A	YES
XP-25A	25A	30A	2-4	50×28×12	31	2A	YES
XP-30A-I	30A	40A	2-4	50×28×12	34	2A	YES
XP-30A-II	30A	40A	2-4	50×28×12	36	3A	YES
XP-35A	35A	45A	2-4	59×28×12	38	3A	YES
XP-40A	40A	50A	2-5	58×28×11	35	3A	YES
XP-45A	45A	55A	2-5	58×28×11	35	3A	YES
XP-50A	50A	65A	2-5	59×28×15	44	3A	YES
XP-60A	60A	80A	2-6	63×28×18	51	3A	YES
XP-80A	80A	100A	2-6	63×28×18	60	3A	YES
XP-100A	100A	120A	3-6	96×55×21	130	N/A	YES
XP-120A	120A	150A	3-6	96×55×21	150	N/A	YES
XP-150A	150A	180A	3-6	96×55×21	180	N/A	YES
XP-80A-HV	80A	100A	3-10	96×55×21	150	N/A	YES
XP-100A-HV	100A	120A	3-10	96×55×21	160	N/A	YES
XP-120A-HV	120A	150A	3-10	96×55×21	180	N/A	YES

Max. load of Built-in Linear BEC（5V/3A）:

Li-xx Battery	2 cells	3 cells	4 cells	5 cells
Qty of standard servo (Max.)	5	5	4	3

Note: For ESC without built-in BEC, an UBEC or individual battery pack should be required to power the receiver and servos. and the red line (+5V) in 3 pin must be pulled out !

Table 2 (BEC is Switch Mode)

Model	Continuous Current	Burst current (10S)	Li-XX	Size(mm) L*W*H	Weiht (g)	BEC （switch）	Program Function
XP-35A-SW	35A	45A	2-4	59×28×12	38	3A	YES
XP-40A-SW	40A	50A	2-5	58×28×11	35	3A	YES
XP-45A-SW	45A	55A	2-5	58×28×11	35	3A	YES
XP-50A-SW	50A	65A	2-5	59×28×15	44	3A	YES
XP-60A-SW	60A	80A	2-6	63×28×18	51	3A	YES
XP-80A-SW	80A	100A	2-6	63×28×18	60	3A	YES

Note: This series of production adopts high efficiency switch mode BEC. Even it work with high voltage, BEC still can export stable 3A current, so it can drive more servos and keep self-heating small. The series of production is very suitable for helicopters with more servos.

Using ESC

Normal Startup Procedure

Move throttle stick to the bottom position (full Off throttle) → Switch on the transmitter →Connect battery pack to ESC → System detects the Min throttle signal, makes a long "beep" sound → System detects battery voltage and makes several short "**beep-**" sounds, which denotes the number of battery cells → when self-test is finished → "♪ **1 2 3**" tone should be emitted →ready for start.

Set Throttle Range (Throttle range should be setup when a new transmitter is being used)

Push the throttle stick to the top position (full On throttle) → switch on the transmitter →Connect battery pack to ESC → System detects the Max throttle signal, and makes two "**beep-**" sounds, which denotes that Max throttle has been confirmed and saved → Pull the throttle stick to the bottom position within 5 seconds(program mode will be entered if you wait for 6 seconds) →System detects the Min throttle signal, makes a long "**beep-**" sound → System detects battery voltage and makes several short "**beep-**" sounds, which denotes the number of battery cells →when self-test is finished → "♪ **1 2 3**" tone should be emitted → Ready for start.

If the system doesn't detect the throttle signal, it will make "**beep-**" sounds continuously without stopping.

Any fault in self- test, it will make 20 very short "**beep-**" sounds.

Protection

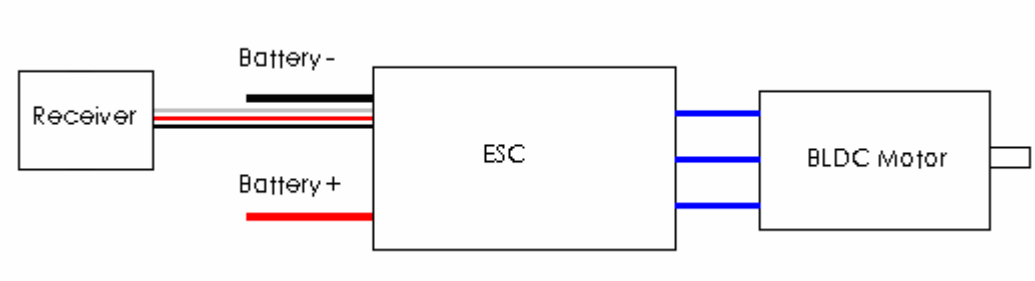
A. Low voltage protection: When power voltage is lower than the cutoff threshold, ESC will reduce output power or cut off. Read the "Configurable parameter" for more information.

B. Throttle signal lost protection: The ESC will reduce output power to 20% if throttle signal lost for 1 second, the output power will recover if signal is detected.

C. Over heat protection: when the temperature of ESC is over 110℃,the ESC will reduce output power, the min output power can be reduced to 35%. The output power will raise after temperature gets low.

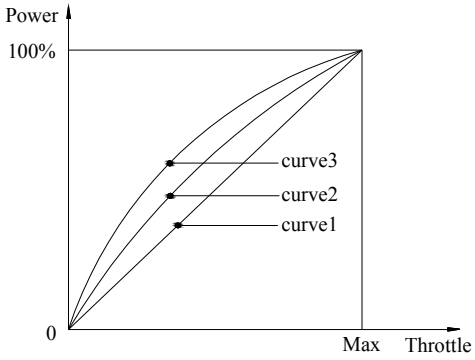
D. Self-test: ESC will start self-test when power on.. If self-test fail, ESC will continuously emit 20 short "**beep-**" tones.

Wiring Diagram



Configurable parameter with program card

1. **OffVolt**(Low Voltage Protection Threshold): user can set proper voltage threshold according to cell quantity in range of 00.0-49.9V, default is 00.0V.
   Note: System will calculate battery cells and set proper threshold automatically if this setting is 00.0V, Protection voltage for each Li-XX cell is 2.85V.
2. **BrakeType**: Off,Soft brake and Hard brake. default is Off (brake disable). Soft brake: less forceful and brake time is longer. Hard brake: more forceful and brake time is shorter .If Soft brake or Hard brake is selected, When the Motor is stop and the throttle is closed, brake will be continued. Soft brake and hard brake are designed for glider, especially suitable for folding propeller glider.
3. **AdvanceT**(Timing Mode): Low, Middle and High, default is Middle. Low advance timing is recommended for high inductance and low KV motors. High advance timing is recommended for low inductance and high KV motors, e.g. high KV outrunner motors. For some high KV motors, if it shakes while rotating in high speed, the "**High**" timing mode is recommended.
4. **Start**: Fast, Soft and Very Soft. Default is Fast. Fast is preferred for fixed-wing aircraft. Soft and Very Soft both are 4 seconds very soft start. The speed of propeller rotation rises in slow-speed during the 4 seconds. The rotation speed is little faster in Soft and is slower in Very Soft. Soft and Very Soft are suitable for helicopters. When setting Soft or Very Soft mode, if the throttle is closed then the motor stopped and the throttle opened again within 4 seconds, start will be Fast mode. But if beyond 4 seconds, start will be 4 seconds Soft mode or Very Soft mode again.
5. **OffType** (Cutoff Mode,Low Voltage Protection Mode): Reduce power and Cutoff output power for selecting, default is Reduce the output power gradually to 50% of the current power.
6. **Curve**(Throttle Curve Mode): Curve1, Curve2 and Curve3. Default is Curve1.

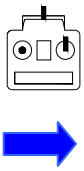


7. **StPercent** (Start power) : to set the Percent of output power when motor start in range of 00% - 39%, default is 00%. Under default setting, output power is decided automatically by system according to throttle stick position.
8. **Reverse**(Motor Rotation): Normal and Reverse. default is Normal.

Program ESC with transmitter

1.Enter program mode

1. Switch on transmitter ,move throttle stick to top position,connect the battery pack to ESC
2. Wait for 2 seconds ,the motor should emit **"beeb-beeb-"**tone
3. Wait for another 6 seconds ,special tone like **"♪ i3i3"** should be emitted ,which means program mode is entered

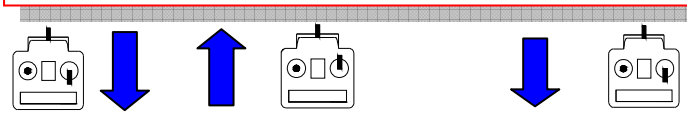


2.Select programmable items

After entering program mode ,you will hear 9 tones in a loop in the following sequence. If you move the throttle stick to bottom within 2 seconds after one kind of tone, this item will be selected.

(1) "beeb-"	(1 short tone)	**Brake**
(2) "beeb- beeb-"	(2 short tone)	**Timing**
(3) "beeb- beeb- beeb-"	(3 short tone)	**Startup mode**
(4) "beeb- beeb- beeb- beeb-"	(4 short tone)	**Cutoff mode**
(5) "beeb----- "	(1 long tone)	**Throttle curve**
(6) "beeb----- beeb- "	(1 long 1 short)	**Li-xx cells**
(7) "beeb----- beeb- beeb-"	(1long 2 short)	**Cutoff threshold**
(8) "beeb----- beeb- beeb- beeb-"	(1 long 3 short)	**Reverse setting**
(9) "beeb----- beeb----- beeb-----"	(3 long stone)	**Exit**

Note: 1 long "beeb-----" = 5 short "beeb-".

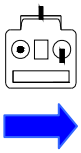


3.Set item value

After entering the item, you will hear several tones in loop, Set the value matching to a tone by moving throttle stick to top within 2 second when you hear the tone, then you will hear special tone like **"♪ 5 6 5 6".** It means the value is set and saved.

Wait for 3 second, you will go back to step 2, if push the throttle stick to the bottom position within 2 second, you will exit the program mode quickly.

Tone / Items	beeb- 1 tone	beeb-beeb- 2 tone	beeb-beeb-beeb- 3 tone	beeb- beeb-… N tone
1.Brake	Off	Soft brake	Hard brake	
2.Timing	Low	Mid	High	
3.Start Mode	Fast	Soft	Very Soft	
4.Cutoff Mode	Reduce power	Shut down		
5.Throttle Curve	Curve 1	Curve 2	Curve 3	
6.Li-xx Cells Number	Auto detect	2 cells	3 cells	N cells
7.Cutoff threshold	Low(2.6V)	Mid(2.85V)	High(3.1V)	
8.Motor Rotation	Normal	Reverse		



4.Exit program

There are two ways to exit program mode:

1. In step 2, after 3 long tone (The item #9)， please move throttle stick to the bottom position within 2 seconds.
2. In step 3,after special tone **"♪ 5 6 5 6"**, please move throttle stick to the bottom position within 2 seconds.

Note: 1. In "Li-xx Cells Number"setting, 1 long "**beeb-----**" = 5 short "**beeb-**". For example,1 long "**beeb-----**" plus 3 short "**beeb-**" (5+3 =8), means a 8 cells Li-xx battery pack..

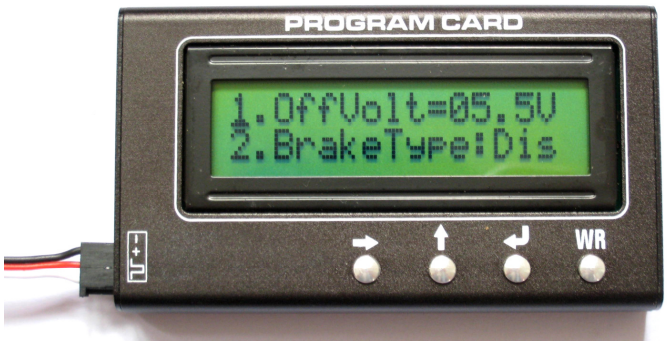
2. If a Li-xx battery pack is more than 4 cells, you'd better set the "Li-xx Cells Number" manually.

Program example with transmitter

Setting "**Timing Mode**"to "**High**", i.e. value #3 in program item #2

1． Enter Program mode Push the throttle stick to the top position, switch on the transmitter, connect battery to the ESC; wait for 2 seconds, **"beeb- beeb-"** will be emitted, then wait for another 6 seconds, special tone **"♪ i 3 i 3"** will be heard, that means program mode is entered.
2． Select Programmable Items There are 9 different tones in loop, when you hear **"beeb- beeb-"**(2 short tone),push the throttle stick to the bottom position within 2 seconds, the "**Timing Mode**"is selected.
3． Set Item Value (Programmable Value) There are 3 tones match to 3 item value. When you hear **"beeb- beeb- beeb-"** (3 short tone),push the throttle stick to the top position within 2 seconds, special tones **"♪ 5 6 5 6"** will be heard, that means "**Timing Mode**"is set as "**High**" and saved.
4． Exit Program Mode After hearing special tones **"♪ 5 6 5 6"** , push the throttle stick to the bottom within 2 seconds, you will exit program mode.

Using program card



Adopting 2x16 point LCD panel, program card can make all setting conveniently and directly.

The keys function

KEY	→	↑	↵	WR
FUNCTION	To move the cursor horizontally	To move the cursor vertically and change item or item value	To confirm selected item or item value.	To write and save setting parameter to ESC

Program procedure

1. Unplug the battery of ESC and connect the PPM wire to program card properly.
2. Connect the battery to ESC, program card will read the parameter from ESC and display on LCD panel.
3. Push ↑ to select programmable items and push ↵ to enter the item.
4. Use → key to move the cursor to proper place (if it need), use ↑ to select or change item value (programmable Value) and push ↵ to confirm.
5. When all setting is finished, push **WR** to save to ESC. After that, you can push ↵ to check updated

parameter.

Parameter Display

Item	Specification	Option or value	Default
1.OffVolt	Low Voltage Protection Threshold	00.0**V**－49.9**V**	00.0V
2.BrakeType	Brake Mode	**Off, Soft** brake**, Hard** brake	Off (brake disable)
3.AdvanceT	Timing Mode	**Low, Mid, High**	Mid
4.Start	Start Mode	**Fast , Soft , VerySoft**	Soft
5.OffType	Low Voltage Protection Mode	**Reduce ,Close (shut down)**	Reduce
6.Curve	Throttle Curve Select	Curve1, Curve2, Curve3	Curve1
7.StPercent=	Start Power Percent	00％－39%	+00%
8.Reverse	Motor rotation	**Normal, Reverse**	Normal

Annex 5.5 Battery Tattu 2300 Datasheet

TATTU

less is more

General Series | High Voltage Series | Smart Series

Connector Information | Customized Services

Headquarter:
Shenzhen Grepow Battery co.,ltd

Tel: 86-755-88376378
Email: info@grepow.com
Website: www.grepow.com

USA Office:
Grepow Inc.

Tel: 1-925-364-7166
Email: info@genstattu.com
Online shop: www.genstattu.com

Germany Office:
Genspow GmbH.

Tel: 49-(0)218-25700755
Email: info@genspow.com
Online shop: www.gensace.de

GREPOW SHENZHEN GREPOW BATTERY CO.,LTD

- Tattu, the sister brand of Gens Ace, focuses on Drones / Multirotors / UAV battery packs. We have a high reputation for our products' stable performance in the market.
- With advanced technology and exquisite craft, we are committed to supplying safe and stable batteries with long cycle lives for UAVs. Our superior raw material and strict production control system guarantee an outstanding performance from Tattu batteries.

— **Sufficient capacity for long fly time**
— **Stable performance for long time use.**

- Our Tattu brand focuses on the high capacity and high discharge rate of cells, as well as the efficient design, manufacturing, and assembling of battery packs. We use an advanced automatic stacking machine for cell production, which ultimately maintains consistency and a high quality of battery cells. We are one of the biggest battery manufacturers in the world, and we provide the best batteries with high discharge rate.
- Tattu products are an indispensable power source for a variety of fields such as aerial film and video, agricultural protection, geological survey, forest fire prevention, power line inspection, flood fight and rescue, and environmental monitoring.

Content

1 GENERAL SERIES

The Tattu batteries that are a part of the general series have a high capacity, high discharge rate, and great compatibility. They can be widely used for aerial photography, agricultural protection, security and surveys, etc.

TATTU 6000mAh

Minimum Capacity: 6000mAh	Configuration: 6S1P /22.2V / 6cells
Discharge Rate: 35C	Net Weight(±20g): 885g
Connector Type: XT60	Wire Gauge: AWG10#
Discharge Wire Length: 120mm	Balancer Wire Length: 65mm
Dimensions: 148mm Length x 45mm Width x 59mm Height	

TATTU 7000mAh

Minimum Capacity: 7000mAh	Configuration: 6S1P /22.2V / 6cells
Discharge Rate: 25C	Net Weight(±20g): 870g
Connector Type: XT60	Wire Gauge: AWG10#
Discharge Wire Length: 120mm	Balancer Wire Length: 65mm
Dimensions: 138mm Length x 42mm Width x 65mm Height	

TATTU 8000mAh

Minimum Capacity: 8000mAh	Configuration: 6S1P /22.2V / 6cells
Discharge Rate: 25C	Net Weight(±20g): 1160g
Connector Type: XT60	Wire Gauge: AWG10#
Discharge Wire Length: 120mm	Balancer Wire Length: 65mm
Dimensions: 168mm Length x 65mm Width x 51mm Height	

TATTU 9000mAh

Minimum Capacity: 9000mAh	Configuration: 6S1P /22.2V / 6cells
Discharge Rate: 25C	Net Weight(±20g): 1173g
Connector Type: EC5	Wire Gauge: AWG10#
Discharge Wire Length: 150mm	Balancer Wire Length: 65mm
Dimensions: 208mm Length x 73mm Width x 37mm Height	

TATTU 10000mAh

Minimum Capacity: 10000mAh	Configuration: 4S1P /14.8V / 4cells
Discharge Rate: 25C	Net Weight(±20g): 940g
Connector Type: AS150	Wire Gauge: AWG10#
Discharge Wire Length: 120mm	Balancer Wire Length: 65mm
Dimensions: 169mm Length x 65mm Width x 39mm Height	

TATTU 10000mAh

Minimum Capacity: 10000mAh	Configuration: 6S1P /22.2V / 6cells
Discharge Rate: 25C	Net Weight(±20g): 1400g
Connector Type: AS150	Wire Gauge: AWG10#
Discharge Wire Length: 120mm	Balancer Wire Length: 65mm
Dimensions: 165mm Length x 64mm Width x 59mm Height	

TATTU 12000mAh

Minimum Capacity: 12000mAh	Configuration: 6S1P /22.2V / 6cells
Discharge Rate: 15C	Net Weight(±20g): 1620g
Wire Gauge: AWG10#	Connector Type: AS150+XT150/EC5/ XT90
Discharge Wire Length: 120mm	Balancer Wire Length: 65mm
Dimensions: 184mm Length x 71mm Width x 61mm Height	

TATTU 14000mAh

Minimum Capacity: 14000mAh	Configuration: 6S1P /22.2V / 6cells
Discharge Rate: 25C	Net Weight(±20g): 1870g
Connector Type: XT90S	Wire Gauge: AWG10#
Discharge Wire Length: 150mm	Balancer Wire Length: 65mm
Dimensions: 233mm Length x 68mm Width x 55mm Height	

TATTU 16000mAh

Minimum Capacity: 16000mAh	Configuration: 4S1P /14.8V / 4cells
Discharge Rate: 15C	Net Weight(±10g): 1241g
Wire Gauge: AWG10#	Connector Type: EC5
Discharge Wire Length: 120mm	Balancer Wire Length: 65mm
Dimensions: 180mm Length x 74mm Width x 44mm Height	

TATTU 16000mAh

Minimum Capacity: 16000mAh Configuration: 6S1P /22.2V / 6cells

Discharge Rate: 15C Net Weight(±10g): 1990g

Wire Gauge: AWG10# Connector Type: AS150 +XT150

Discharge Wire Length: 120mm Balancer Wire Length: 65mm

Dimensions: 193mm Length x 77mm Width x 66mm Height

TATTU 22000mAh

Minimum Capacity: 22000mAh Configuration: 4S1P /14.8V / 4cells

Discharge Rate: 25C Net Weight(±10g): 1673g

Connector Type:EC5 Wire Gauge: AWG10#

Discharge Wire Length: 120mm Balancer Wire Length: 65mm

Dimensions: 195mm Length x 91mm Width x 43mm Height

TATTU 22000mAh

Minimum Capacity: 22000mAh Configuration: 6S1P /22.2V / 6cells

Discharge Rate: 25C Net Weight(±10g): 2509g

Charge Plug: AS150 +XT150 Wire Gauge: AWG10#

Discharge Wire Length: 120mm Balancer Wire Length: 65mm

Dimensions: 195mm Length x 91mm Width x 64mm Height

TATTU 28000mAh

Minimum Capacity: 28000mAh Configuration: 6S1P /22.2V / 6cells

Discharge Rate: 25C Net Weight(±10g): 3505g

Connector Type:AS150&XT150 Wire Gauge: AWG10#

Discharge Wire Length: 150mm Balancer Wire Length: 65mm

Dimensions: 205mm Length x 121mm Width x 67mm Height

TATTU 30000mAh

Minimum Capacity: 30000mAh Configuration: 6S1P /22.2V / 6cells

Discharge Rate: 25C Net Weight(±10g): 3505g

Connector Type:AS150&XT150 Wire Gauge: AWG10#

Discharge Wire Length: 150mm Balancer Wire Length: 65mm

Dimensions: 217mm Length x 120mm Width x 65mm Height

2 HIGH VOLTAGE SERIES

- Up to 4.35V per cell
- Additional 15% usable capacity
- Longer flight time and cycle life

Tattu HV 16000mAh

Minimum Capacity: 16000mAh Configuration: 6S1P /22.8V / 6cells

Discharge Rate: 15C Net Weight(±20g): 1870g

Wire Gauge: AWG10# Charge Plug: XT90-S

Discharge Wire Length: 150mm

Dimensions: 190mm Length x 76mm Width x 61mm Height

Tattu HV 17000mAh

Minimum Capacity: 17000mAh Configuration: 6S1P /22.8V / 6cells

Discharge Rate: 15C Net Weight(±30g): 1860g

Wire Gauge: AWG10# Charge Plug: XT150+AS150

Discharge Wire Length: 150mm

Dimensions: 195mm Length x 78mm Width x 64.5mm Height

Tattu HV 23000mAh

Minimum Capacity: 23000mAh Configuration: 6S1P /22.8V / 6cells

Discharge Rate: 25C Net Weight(±30g): 2470g

Wire Gauge: AWG10# Charge Plug: AS150 + XT150

Discharge Wire Length: 150mm

Dimensions: 210mm Length x 93mm Width x 66mm Height

Tattu HV 25000mAh

Minimum Capacity: 25000mAh Configuration: 6S1P /22.8V / 6cells

Discharge Rate: 10C Net Weight(±20g): 2577g

Wire Gauge: AWG8# Charge Plug: XT90-S

Discharge Wire Length: 150mm

Dimensions: 207mm Length x 91mm Width x 65mm Height

3 SMART SERIES

The smart battery line is specially designed for UAVs. Tattu smart batteries combine high performance. low power MCU, and an advanced BMS (battery management system) in order to provide users with a clearer understanding of their batteries' status. Multiple protection features have been adapted for a better flying experience.

Tattu PLUS 1.0

Intelligent Display
Shows charging state

Intelligent Management
Cell abnormal alert; Over voltage and under voltage alert; Over Temperature and low temperature alert;

Intelligent Storage
Self-balancing function; Self-discharge function at 100%SOC Storage

SMBus Communication Port:
Shows battery information

Tattu Plus 10000mAh

Minimum Capacity: 10000mAh	Configuration: 6S1P /22.2V / 6cells
Discharge Rate: 25C	Net Weight(±10g): 1466g
Wire Gauge: AWG58#	Charge Plug: AS150 + XT150
Discharge Wire Length: 160mm	
Dimensions: 186mm Length x 70mm Width x 53mm Height	

Tattu Plus 12000mAh

Minimum Capacity: 12000mAh	Configuration: 6S1P /22.2V / 6cells
Discharge Rate: 15C	Net Weight(±10g): 1640g
Wire Gauge: AWG8#	Charge Plug: AS150 + XT150
Discharge Wire Length: 160mm	
Dimensions: 202mm Length x 76mm Width x 61mm Height	

Tattu Plus 16000mAh

Minimum Capacity: 16000mAh	Configuration: 6S1P /22.2V / 6cells
Discharge Rate: 15C	Net Weight(±10g): 2040g
Wire Gauge: AWG8#	Charge Plug: AS150 + XT150
Discharge Wire Length: 160mm	
Dimensions: 214mm Length x 96mm Width x 68mm Height	

Tattu Plus 22000mAh

Minimum Capacity: 22000mAh	Configuration: 6S1P /22.2V / 6cells
Discharge Rate: 25C	Net Weight(±10g): 2063g
Wire Gauge: AWG8#	Charge Plug: AS150 + XT150
Discharge Wire Length: 160mm	
Dimensions: 288.5mm Length x 112.5mm Width x 165.5mm Height	

Tattu PLUS 12S

The updated version with high performance

- Communication protocol
- Self-inspection
- Current detection
- Abnormal log
- SOC Indicator
- Discharge cycle recording
- Ultra-Low power consumption

Tattu Plus 1.0 16000mAh

Minimum Capacity: 16000mAh	Configuration: 12S1P /44.4V /12cells
Discharge Rate: 15C	Net Weight(±10g): 4740g
Wire Gauge: AWG8#	Charge Plug: AS150U
Discharge Wire Length: 230mm	
Dimensions: 90mm Length x 163mm Width x 224mm Height	

Tattu Plus 1.0 22000mAh

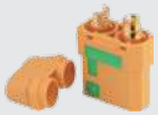
Minimum Capacity: 22000mAh	Configuration: 12S1P /44.4V /12cells
Discharge Rate: 25C	Net Weight(±100g): 6000g
Wire Gauge: AWG8#	Charge Plug: AS150U
Discharge Wire Length: 230mm	
Dimensions: 172mm Length x 116mm Width x 235.5mm Height	

Tattu Plus 2.0 Pro 16000mAh

Minimum Capacity: 16000mAh	Configuration: 12S1P /44.4V /12cells
Discharge Rate: 15C	Net Weight(±100g): 5000g
Wire Gauge: AWG8#	Charge Plug: AS150U-F
Discharge Wire Length: 230mm	
Dimensions: 166.5mm Length x 113mm Width x 290mm Height	

4 Connector Information

All products can be fitted to the following discharge plugs.



Plug Type:	XT90S
Constant Current:	60A
Peak Current:	100A

Plug Type:	XT150
Constant Current:	80A
Peak Current:	150A

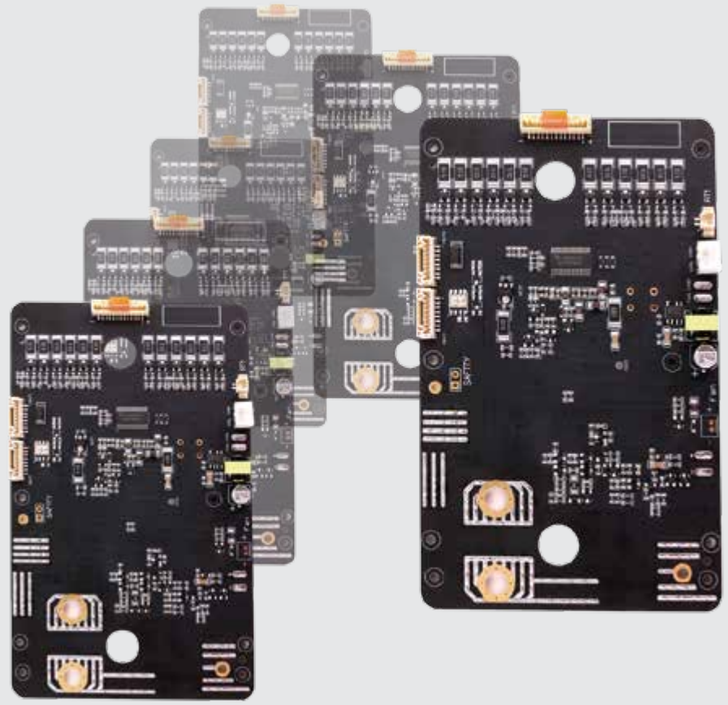
Plug Type:	AS150
Constant Current:	100A
Peak Current:	150A

Plug Type:	XT60
Constant Current:	40A
Peak Current:	70A

Plug Type:	EC5
Constant Current:	70A
Peak Current:	110A

5 Customized SMART BMS

Current/ Voltage/ Temperature protections,
Communication protocol
Customized as request
Up to 14S,customized to match all Grepow cells



Customized SMART BMS

Annex 5.6 BLDC Datasheet

Brushless Motor Turbine 64mm for RC Airplane
Model: QF2611-4500KV

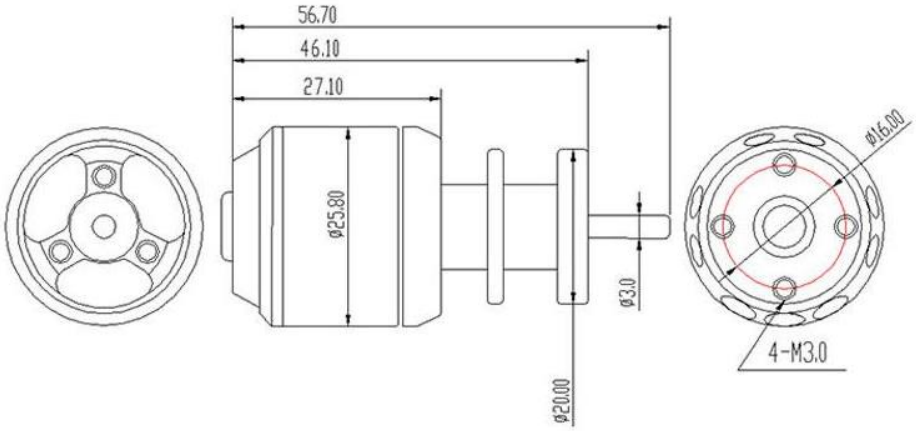
Features:

- Excellent heat dissipation quality ensures reliable duct and aircraft system.
- It provides airplane with high-speed running.
- The blade can convert the rotation of the motor into the propulsion of the aircraft in maximum efficiency.
- Motor offers the airplane strong power and high efficiency.
- It is made of high quality metal with long lifetimes and better work efficiency.

Specifications:

- Speed: 4500rpm/V
- Configuration: 9N6P
- No. of blades: 5 blades
- Idle current @ 10.0v: 2.0A
- No. of cells: 3-4s Lipo
- Max continuous power /10s: 280W
- Max continuous current /1min: 27A
- Max efficiency: <70%
- Shaft diameter: 20.2mm
- Stator length: 11mm
- Motor dimension: 26x47mm
- Applicable airplane duct: 64mm
- Weight: 49g

Motor Dimensions Diagram:



More Detailed Photos:

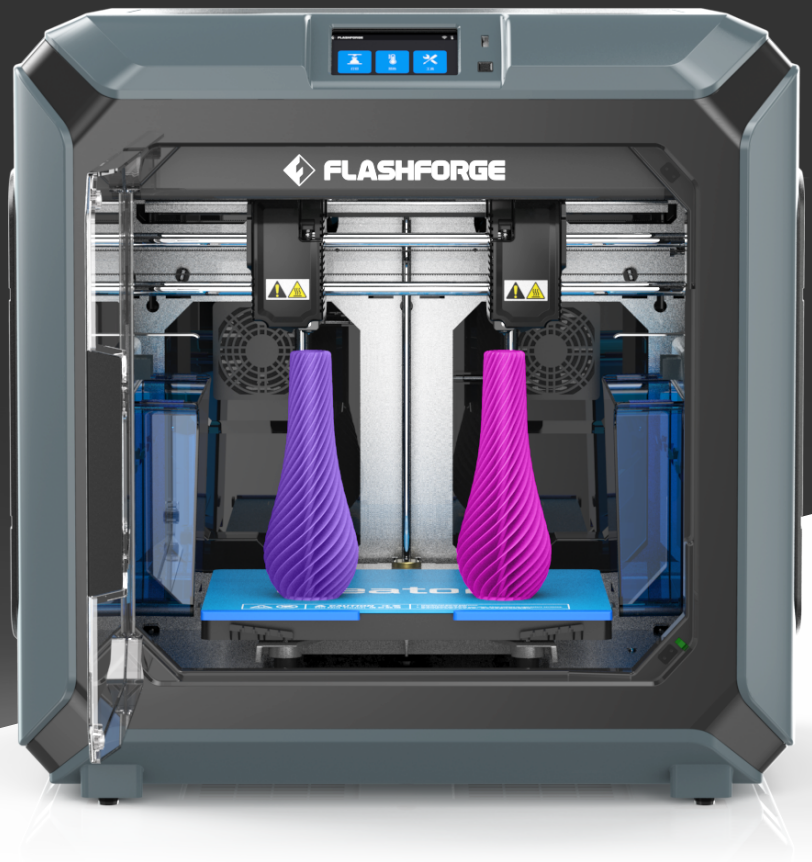
Made in China

Annex 6. FlashForge Creator 3 Datasheet

FLASHFORGE 3D PRINTER

Creator 3

Advanced independent dual-extruder system



Creator 3 Desktop Professional 3D Printer

Creator 3 is a creative independent dual-extruder 3D printer, designed to print complex shapes with soluble filament support to get better details.The independent dual nozzles can also print two identical parts at the same time, it runs at twice the efficiency for small-scale production. Creator 3 uses stainless steel nozzles that are compatible with PLA, ABS, carbon fiber composite, nylon and PC.

Excellent product interaction design and the integration of software, hardware and cloud platforms, Creator 3 provides the possibility of remote collaboration operations to better meet modern office requirements.
Creator 3 meets the efficiency of prototype development and design and the economics of direct application, and can be widely used in automotive, art design, product design and other applications.

Heatable flexible platform to 120℃	Residue scraping	Auto-calibration in Z-axis
Multi-printing mode	Independent dual-extruder	Multi connectivity: Wi-Fi, Ethernet
Built-in camera	Filament detector	Air filter

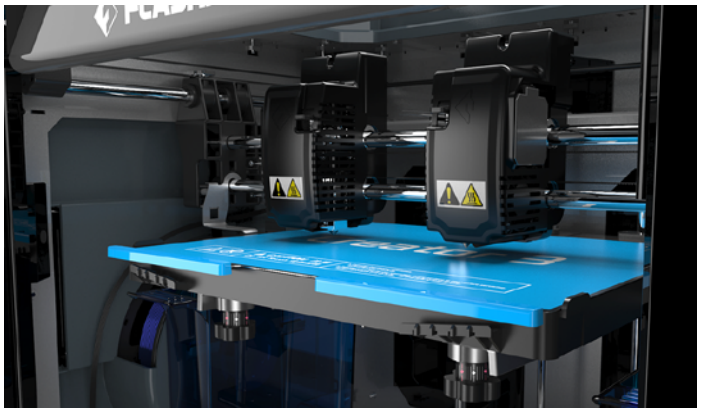
www.flashforge.com

Max. 300°C

High-temperature nozzle

Built-in sensor

No need to adjust the extruder height manually. Detect and compensate the height difference automatically from the platform to the two nozzles.



0.4mm Standard

Steel nozzle

Maximum Temp. 300°C

Support filament:
PLA/ABS/PETG/PA/PC/
ASA/PVA/HIPS

0.4mm Optional

Hardened nozzle

Maximum Temp. 320°C

Support filament:
ABS/PA/PC/ASA/HIPS/
PA-CF/PA-GF/PAHT

0.6mm Optional

Hardened nozzle

Maximum Temp. 320°C

Support filament:
ABS/PA/PC/ASA/HIPS/
PA-CF/PA-GF/PAHT

0.8mm Optional

Steel nozzle

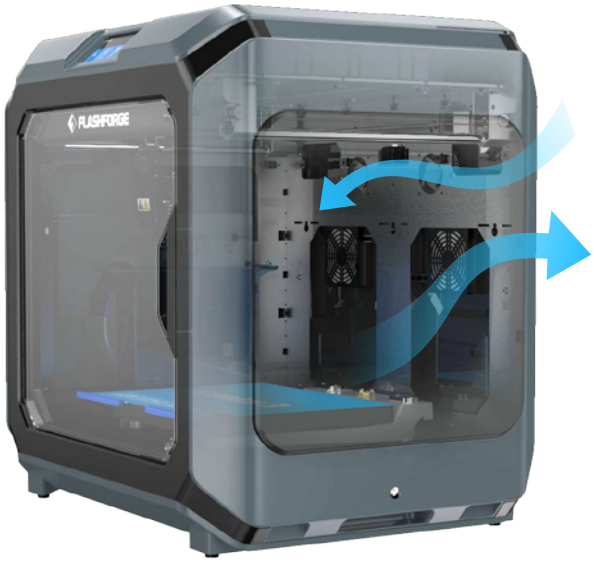
Maximum Temp. 300°C

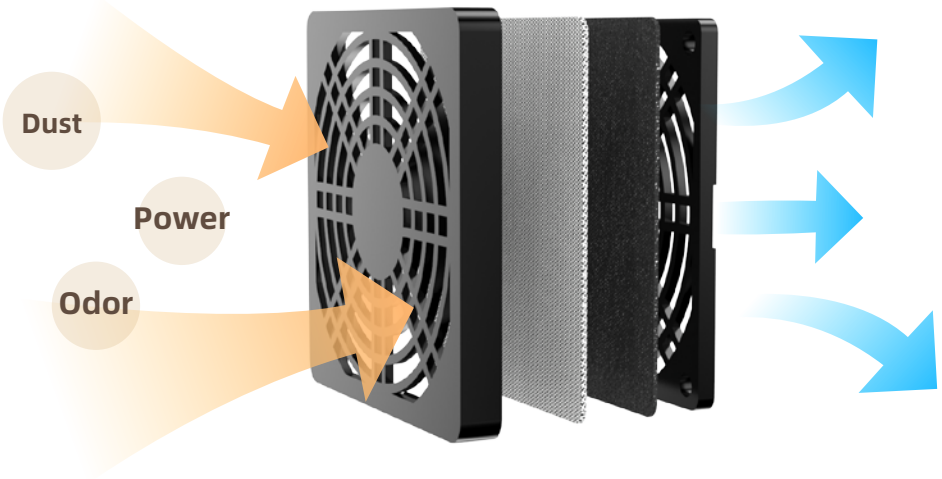
Support filament:
PLA/ABS/PETG/PA/PC/
ASA/PVA/HIPS

Note: For a hardened nozzle, it is necessary to set the extruder temperature 5-15°C higher than a normal one; A hardened filament feeder is suggested to be used together with the hardened nozzle

Four built-in ventilating fans

Displacing the internal and external air to adjust the temperature of the chamber to create a better printing environment temperature.

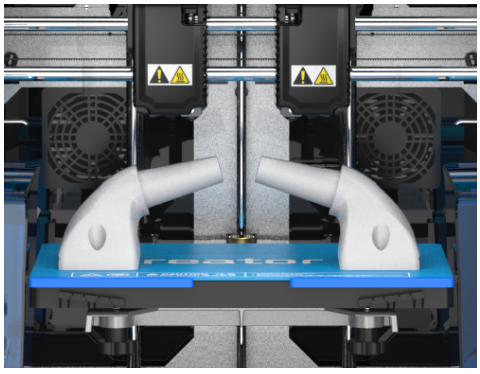




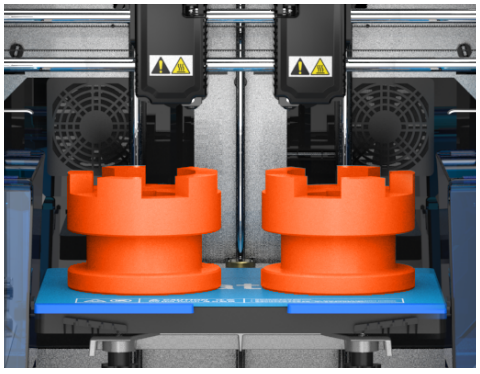
Hepa h13 filter and activated carbon filter cotton can effectively filter fine dust. Filtration efficiency **>95%**.
(Hepa filter is optional)

Independent dual-extruder system support multi-printing mode

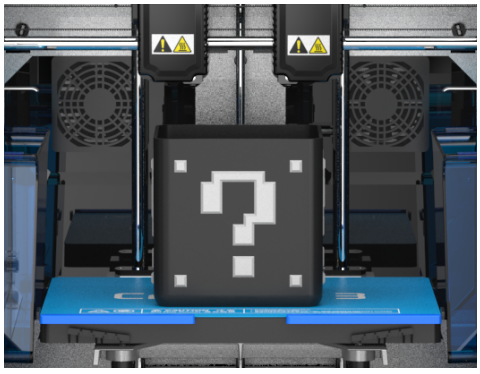
Mirror mode

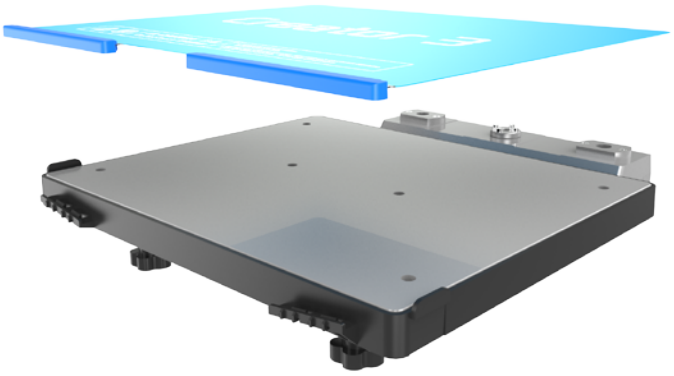


Duplication mode



Two-color mode





Flexible Steel Plate

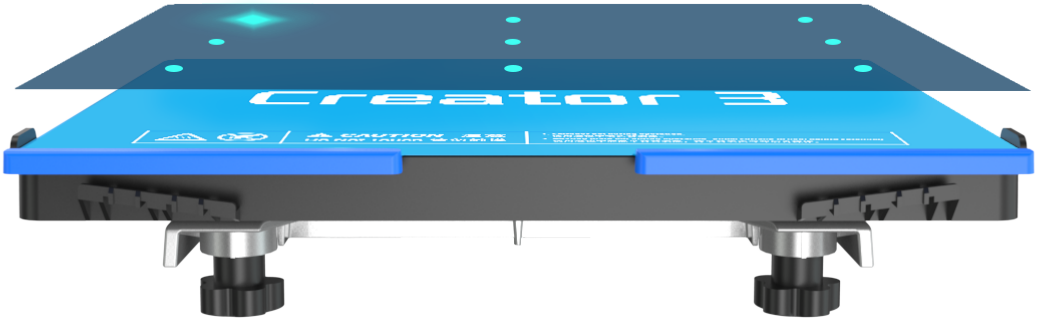
Easy remove/ Easy installation/ Better flatness

Magnetic suction installation is effortless; the entire CNC aluminum plate support surface provides better flatness.

It is constructed from durable spring steel ensuring flatness and easier model removal. It is able to withstand print bed temperatures of up to 120 degrees Celsius.

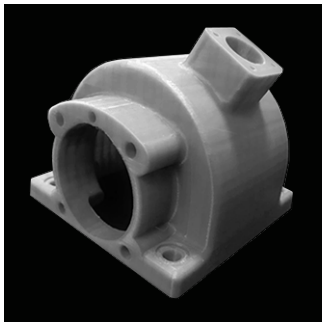
Auto leveling

Confirms that the printing platform is level whenever preparing to print. Creating a uniform build area to make sure the print quality of first layer is good and improves the bed adhesion.

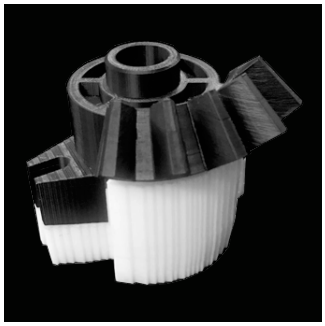


Creator 3 Printed Models

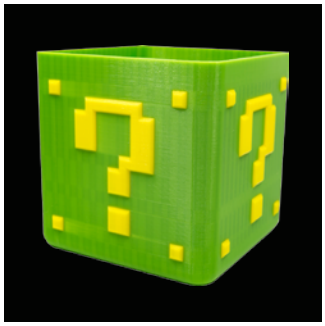
PC



PLA+PVA



ABS+HIPS



PLA+PLA

FILAMENT

ASA | PETG | PC | PA | ABS | PLA | HIPS

PLA Change Color | PLA METAL | PA-CF | PA-GF

Easier printed，better surface
PLA / HS PLA

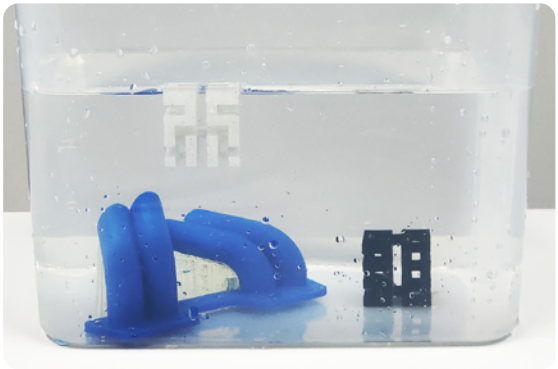
Industry filament
ABS / ASA / PC

Wear-resistant filament
PA / PP

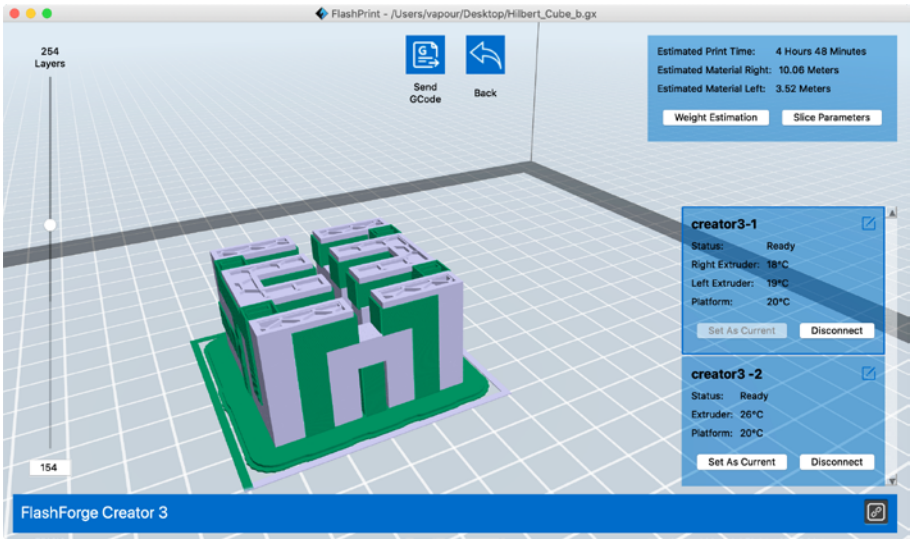
Support filament
PVA / HIPS

Composite filament
PA-CF / PA-GF

Note：Creator3 nozzle is non-high-strength steel. Please replace nozzle timely, when using carbon fiber and glass fiber filament.



Printing with soluble support structures



FlashPrint

Slicing Software

（Multi-device management）FlashPrint supports the user of various print modes including single and dual material printing.

www.flashforge.com

FLASHFORGE 3D PRINTER

PARAMETERS

PRINT	
Extruder number:	2
Extruder diameter:	0.4mm
Highest set temperature of extruder:	Standard 300℃
	Max 320℃ (Hardened nozzle)
Build Volume:	300*250*200mm
Print Speed:	10-150mm/s
Highest set temperature of platform:	120℃
DEVICE	
Printer Volume:	627*485*615mm
Screen:	4.5-inch Touch Screen
Net Weight:	40kg
Input:	100-240 VAC,48-63Hz
Power:	500w
Internal Storage:	8G
Spool:	48mm
COMMUNCATION	
Data transmission:	USB stick,Wi-Fi,Ethernet,FlashCloud
Software:	FlashPrint
Output:	GX/G files
Input:	3MF/STL/OBJ/FPP/BMP/PNG/JPG/JPEG files

Annex 7. Arduino Programming Code

```
#include <Adafruit_LSM303DLH_Mag.h>
#include <Adafruit_Sensor.h>
#include <Wire.h>
#include <Servo.h>
#include <math.h>
Adafruit_LSM303DLH_Mag_Unified mag = Adafruit_LSM303DLH_Mag_Unified(12345);

#define SERVO  8
#define CENTER 90
#define GOAL   0
Servo myservo;
Servo esc;

double  goal = 0;
double  servo_csg=90;
int     i=1;
int     prt=0;
double kp = 0.1, ki = 0.0005, kd = 0;
double elapsedTime, elapsedT;
double error, cumError=0;
unsigned long currentTime, previousTime, Time;
double output;
int val=1000;
int Stop=0;




void setup() {

   Serial.begin(9600);
```

```
  /* Serial.println("Magnetometer Test");
   Serial.println("");
   /* Initialise the sensor */

   if (!mag.begin()) {
    /* There was a problem detecting the LSM303 ... check your connections */
    Serial.println("Ooops, no LSM303 detected ... Check your wiring!");
    while (1);
   }

    myservo.attach(8);
    myservo.write(servo_csg);
    esc.attach(9);
    esc.writeMicroseconds(1000);
    goal= getDegrees(); /* set the goal direction*/

    delay(5000); /* let time to the user to get ready*/
    Time = millis();
    previousTime = Time;

}



void loop() {

  /*  read current time and heading*/

  currentTime = millis(); //get current time
  elapsedTime =(currentTime - previousTime); //compute time elapsed from previous
computation
  int angle = getDegrees(); // read the current direction from the function getDegrees
```

```
float error = goal - angle;

 if (error > 180) {
   error -= 360;
 }

 if (error < -180) {
   error += 360;
 }



/* Compute PID*/

cumError += error * elapsedTime; // compute integral
output = -kp*error - ki*cumError; //PID output
previousTime = currentTime; //remember current time



/* Send the command to the servomotor*/

servo_csg=output +90;

if (servo_csg<=0){
  servo_csg=0;
}

if (servo_csg>=180){
  servo_csg=180;
}
```

```
myservo.write(servo_csg);



/* Print the current data by the serial monitor*/

if(prt==10) {

Serial.print("Goal: ");
Serial.println(goal);

Serial.print("heading: ");
Serial.println(angle);

/* Serial.print("error: ");
Serial.println(error);

Serial.print("PI out: ");
Serial.println(output);*/

Serial.print("Servo order: ");
Serial.println(servo_csg);

Serial.println( "." );
Serial.println( "." );

prt=0;
}
prt=prt+1;
```

```
  /* If the process hadn't end yet, accelerates the dolly graduately to the 30% of max power of the ducted fan*/


  if ( val<1300 && Stop==0 ) {


       val+=10;

       esc.writeMicroseconds(val);


    }




  /* If the BLDC motor is running for 10s, then stop the motor*/


  elapsedT = currentTime - Time;


  if ( elapsedT >=7){ /* es conta 7 segons desde linici de la propulsio i després es para el motor*/


      val=1000;

      esc.writeMicroseconds(val);

      Stop=1;

   }


}




int getDegrees () {
```

```
  sensors_event_t event;

  mag.getEvent(&event);

  float Pi = 3.14159;


  float heading = (atan2(event.magnetic.y, event.magnetic.x) * 180) / Pi;    // Calculate the
angle of the vector y,x


  // Normalize to 0-360


  if (heading < 0) {


    heading = 360 + heading;


  }


return heading;


}
```