DEBUGGING PROTOTYPES

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OVERVIEW

Multimeter 101 and Solder 101

ATmega and Arduino: Most common issues and problems

Debugging your prototypes

Datasheet walkthrough

Good sources of knowledge

How to Google your problem

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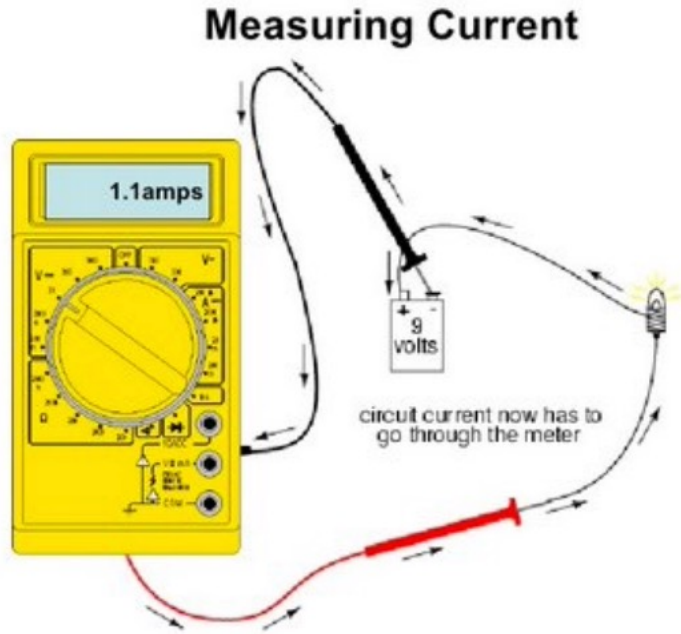
HOW TO USE A MULTIMETER

https://learn.sparkfun.com/tutorials/how-to-use-a-multimeter

Measure voltages in parallel (plus to plus, minus to minus)

Measure amps in series – remember that a load is necessary (see picture)

Measuring ohms one probe on each leg (on resistors) or non-wiper leg on pots.



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HOW TO SOLDER

https://www.makerspaces.com/how-to-solder/

Make sure to heat both elements that needs connected

300-315 degrees is a good starting point for lead-based solder

- Around 340 for lead-free.

On hard to solder elements, or when working with lots of metal – use flux

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MOST COMMON ATMEGA AND ARDUINO ISSUES

Bootloading process:

Make sure to keep the original chip from the Arduino. A newly bootloaded chip will "understand" Arduino sketches, but can't replace the original chip.

Make sure to upload the ArduinoISP sketch to the regular UNO first

Double check values of resistor and capacitors

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MOST COMMON ATMEGA AND ARDUINO ISSUES

avrdude: stk500_recv(): programmer is not responding
avrdude: stk500_getsync() attempt <n> of 10: not in sync

Often the result of incorrect wiring.

Test if the "Nano --> 328p" works instead of "Duemilanove"

Check if you actually selected the Arduino port

Check resistor and capacitor values

Consult the checklist (upcoming)

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PHYSICAL PROTOTYPE DEBUGGING TIPS

Cables, cables, cables, cables, cables, cables, cables, cables

Cluster GNDs and power nodes.

Use color coded cables while breadboarding (and for your schematic in report)

Use labels when using PCBS (and version numbers)

Separate prototype by function and/or feature

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DEBUGGING CHECKLIST

1. Cables, cables, cables, cables, cables...
2. "Software" setup: Correct port, programmer, chip etc. Try a different PC/IDE version
3. Check solderings or fit on components
4. Cheapest components: Resistors, capacitors, diodes, LEDs, crystals, generic motors.
5. More expensive components: Logic chips, microcontrollers, sensors, actuators.
6. "Is it the breadboard?!?!"
7. Brown-out or noise due to power issues: Try and separate power-hungry components.
8. Split! Try and separate features
9. If all else fails: Unplug it all, and start again.

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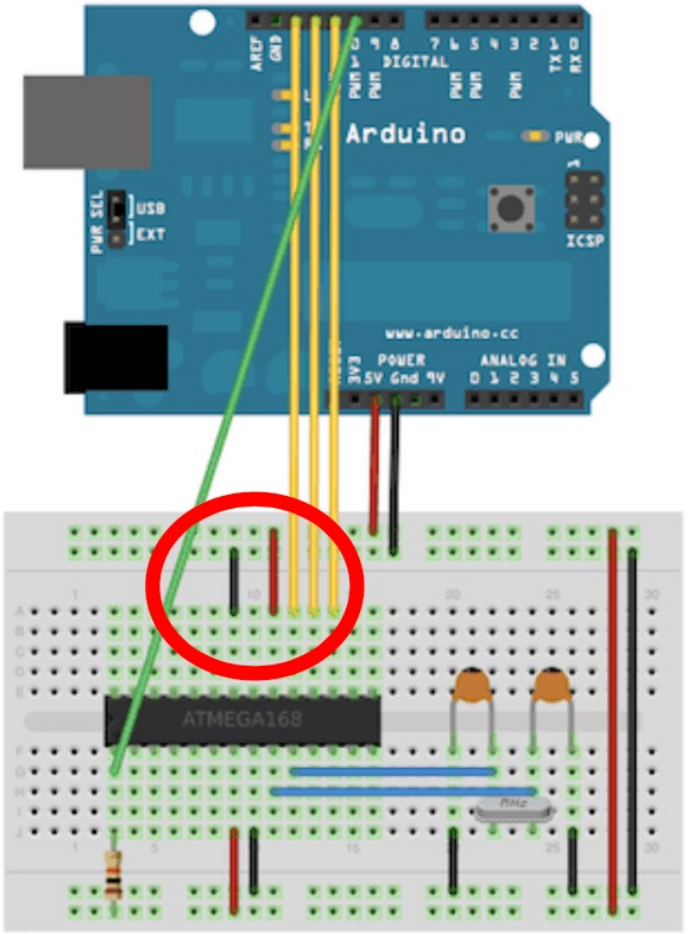
AVCC? WHAT?

AVCC pin = Alternative power / Analog power

ATmega328p designed to have separation of power for internal ADC conversion, ADC pins, internal clock

Plug. Them. In



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USING DATASHEETS

Looking up voltages and voltage ranges

Looking up current draw

Looking up resolution

Looking up example configurations (or code)

Looking up efficiency curves

Looking up similar components/alternatives

Looking up temperature ranges (PLA starts transitioning at 60 degrees)

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DATASHEETS

RF DIGITAL CORPORATION
www.RFdigital.com • sales@rfdigital.com
1601 Pacific Coast Hwy • Suite 290
Hermosa Beach • CA • 90254
Tel: 949.610.0008

RF Module
Model Number: R25
PN: RFD22301
PN: RFD22302

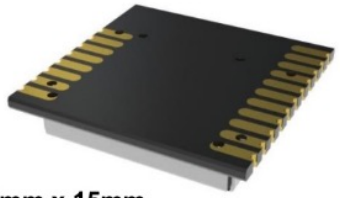
BLE

Compliance Approved
Bluetooth 4.0 Low Energy BLE RF Module
With Built-In ARM Cortex M0 Microconroller

RFD22301

CE, ETSI, IC, FCC Approved

Easy to solder 0.050 Inch SMT pads



15mm x 15mm
(0.600 x 0.600 Inch)

RFD22302

Optional Configuration

CE • ESTI

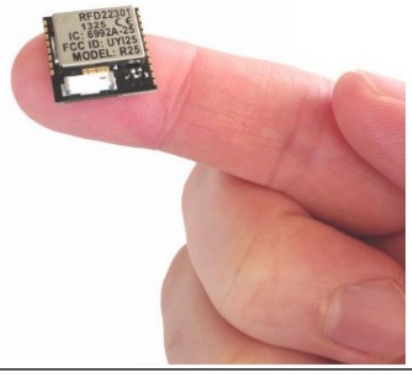
Requires Ext. Ant
External Antenna

CE, ETSI, IC, FCC Approved & Certified

Hi performance, professional grade Bluetooth 4.0 Low Energy radio transceiver with built-in ARM Cortex M0 microcontroller that can be programmed using the simple-to-use Arduino IDE using RFduino extensions.

Built-in user application microcontroller with ADC, I2C, SPI, UART and GPIO.

Can wirelessly communicate with with iOS iPhone, iPad or Android smartphones or tables.



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DATASHEETS: ELECTRICAL CHARACTERISTICS

Standard LED

Red Emitting Colour

multicom

Absolute Maximum Ratings at T_a = 25°C

Parameter	Maximum	Unit
Power Dissipation	80	mW
Peak Forward Current (1/10 Duty Cycle, 0.1 ms Pulse Width)	100	mA
Continuous Forward Current	20	
Derating Linear From 50°C	0.4	mA / °C
Reverse Voltage	5	V
Operating Temperature Range	-25°C to +80°C	
Storage Temperature Range	-40°C to +100°C	
Lead Soldering Temperature (4 mm (0.157) Inches from Body)	260°C for 5 s	

Electrical Optical Characteristics at T_a = 25°C

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Test Condition
Luminous Intensity	I_v		40		mcd	I_f = 20 mA (Note 1)
Viewing Angle	$2\theta_{1/2}$		25		Deg	(Note 2)
Peak Emission Wavelength	λp		640		nm	I_f = 20 mA
Dominant Wavelength	λd		635		nm	I_f = 20 mA (Note 3)
Spectral Line Half-Width	$\Delta\lambda$		25		nm	I_f = 20 mA
Forward Voltage	V_f		2	2.5	V	I_f = 20 mA
Reverse Current	I_R	-	-	100	µA	V_R = 5 V

DATASHEETS: ELECTRICAL CHARACTERISTICS

28. Electrical Characteristics

All DC/AC characteristics contained in this datasheet are based on characterization of Atmel® ATmega328P AVR® microcontroller manufactured in an automotive process technology.

28.1 Absolute Maximum Ratings

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Parameters	Min.	Typ.	Max.	Unit
Operating temperature	–55		+125	°C
Storage temperature	–65		+150	°C
Voltage on any pin except $\overline{\text{RESET}}$ with respect to ground	–0.5		V_{CC} + 0.5	V
Voltage on $\overline{\text{RESET}}$ with respect to ground	–0.5		+13.0	V
Maximum operating voltage		6.0		V
DC current per I/O pin		40.0		mA
DC current V_{CC} and GND pins		200.0		mA
Injection current at V_{CC} = 0V		±5.0(1)		mA
Injection current at V_{CC} = 5V		±1.0		mA

Note: 1. Maximum current per port = ±30mA

28.3 DC Characteristics

T_A = –40°C to +125°C, V_{CC} = 2.7V to 5.5V (unless otherwise noted)

Parameter	Condition	Symbol	Min.	Typ.(2)	Max.	Units
Power supply current(1)	Active 4MHz, V_{CC} = 3V	I_{CC}		1.5	2.4	mA
	Active 8MHz, V_{CC} = 5V			5.2	10	mA
	Active 16MHz, V_{CC} = 5V			9.2	14	mA
	Idle 4MHz, V_{CC} = 3V			0.25	0.6	mA
	Idle 8MHz, V_{CC} = 5V			1.0	1.6	mA
	Idle 16MHz, V_{CC} = 5V			1.9	2.8	mA
Power-down mode(3)	WDT enabled, V_{CC} = 3V				44	µA
	WDT enabled, V_{CC} = 5V				66	µA
	WDT disabled, V_{CC} = 3V				40	µA
	WDT disabled, V_{CC} = 5V				60	µA

Notes: 1. Values with Section 9.10 "Minimizing Power Consumption" on page 36 enabled (0xFF).
2. Typical values at 25°C.
3. The current consumption values include input leakage current.

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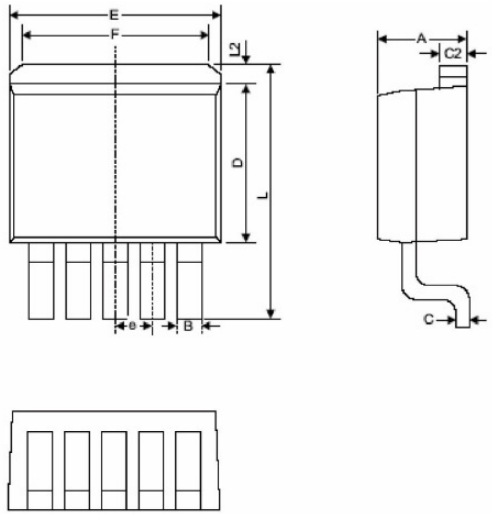
DATASHEETS: DIMENSIONS

Package Information

TO263-5L



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	4.06	4.83	0.160	0.190
B	0.76	1.02	0.030	0.040
C	0.36	0.64	0.014	0.025
C2	1.14	1.40	0.045	0.055
D	8.64	9.65	0.340	0.380
E	9.78	10.54	0.385	0.415
e	1.57	1.85	0.062	0.073
F	6.60	7.11	0.260	0.280
L	15.11	15.37	0.595	0.605
L2	-	1.40	-	0.055

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DATASHEETS: RESOLUTION

Product Specifications	
Mechanical	
Housing Material	Aluminum Alloy
Load Cell Type	Strain Gauge
Capacity	20kg
Dimensions	55.25x12.7x12.7mm
Mounting Holes	M5 (Screw Size)
Cable Length	550mm
Cable Size	30 AWG (0.2mm)
Cable - no. of leads	4
Electrical	
Precision	0.05%
Rated Output	1.0±0.15 mv/V
Non-Linearity	0.05% FS
Hysteresis	0.05% FS
Non-Repeatability	0.05% FS
Creep (per 30 minutes)	0.1% FS
Temperature Effect on Zero (per 10°C)	0.05% FS
Temperature Effect on Span (per 10°C)	0.05% FS
Zero Balance	±1.5% FS
Input Impedance	1130±10 Ohm
Output Impedance	1000±10 Ohm
Insulation Resistance (Under 50VDC)	≥5000 MOhm
Excitation Voltage	5 VDC
Compensated Temperature Range	-10 to ~+40°C
Operating Temperature Range	-20 to ~+55°C
Safe Overload	120% Capacity
Ultimate Overload	150% Capacity

Standard DC Series - Low Voltage DC Motors

Page	Dia. (mm)	DC Motor Platform Part Number	Series	Input Voltage (V)	No Load Speed (rpm)	Maximum Efficiency (%)	Stall Torque (mNm)	Maximum Output Power (W)	Application Examples
8-9	15.5	NF003SG-011	000	5.0	12623	50	2.09	0.69	Door Locks, Locks
10-11	20.4	NF113LG-011	100	13.0	25000	65	20.00	15.00	Hair Dryers
12-13	20.4	NF183LG-011	100	2.4	6200	65	8.00	1.30	Shavers
14-15	24.2	NF213G-011	200	2.4	7000	70	26.00	5.00	Hair Clipper, Trimmer
16-17	24.2	NF223G-011	200	1.2	7800	60	12.00	2.50	Hair Cutting
18-19	24.2	HF283LG-011	200	24.0	26000	70	85.00	60.00	Hair Dryers
20-21	24.0	HC213LG-011	200	21.0	30000	60	40.00	32.00	Hair Dryers, Hair Curlers, Hair Care
22-23	24.4	PC280LG-011	200	12.0	8200	62	25.50	5.50	Paper Feeds, Printers
24-25	27.5	HC313G-011	300	24.0	7200	55	20.00	4.00	Facial Massager, Massagers
26-27	27.5	HC315G-011	300	41.0	18000	65	38.00	18.00	Massagers
28-29	27.5	HC385G-011	300	18.0	9987	57	39.24	10.20	Paper Feeder, Paper Feeds, Printers
30-31	27.5	HC315MG-011	300	39.0	21000	70	70.00	40.00	Hair Dryers
32-33	27.5	HC315MG-012	300	24.0	22000	70	60.00	35.00	Hair Dryers
34-35	27.5	HC383XLG-011	300	7.2	17230	64	114.86	51.24	Power Equipment, Screw Drivers
36-36	27.5	HC385XLG-011	300	36.0	11000	70	90.00	25.00	Foot Massagers
38-39	27.5	HC385XLG-013	300	28.0	19000	75	140.00	70.00	Hair Dryers
40-41	29.0	HC485G-011	400	42.0	6400	64	92.00	15.50	Paper Feeds, Printers
42-43	42.3	HC785LP-012	700	18.0	20950	78	1175.03	644.74	Power Equipment, Drills
44-45	48.0	HC875SG-011	800	14.4	20120	66	787.72	415.00	Power Equipment, Drills
46-47	48.0	HC875SG-012	800	18.0	20281	69	656.65	348.79	Power Equipment, Drills
48-49	48.0	QC875SG-011	800	18.0	19600	66	1055.00	542.00	Power Equipment, Drills
50-51	48.0	HC877P-011	800	18.0	22500	76	1400.00	830.00	Power Equipment, Drills

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DATASHEETS: GLOSSARY

Glossary

Capacity
The maximum load the load cell is designed to measure within its specifications.

Creep
The change in sensor output occurring over 30 minutes, while under load at or near capacity and with all environmental conditions and other variables remaining constant.

FULL SCALE or FS
Used to qualify error - FULL SCALE is the change in output when the sensor is fully loaded. If a particular error (for example, Non-Linearity) is expressed as 0.1% F.S., and the output is 1.0mV/V, the maximum non-linearity that will be seen over the operating range of the sensor will be 0.001 mV/V. An important distinction is that this error doesn't have to only occur at the maximum load. If you are operating the sensor at a maximum of 10% of capacity, for this example, the non-linearity would still be 0.001mV/V, or 1% of the operating range that you are actually using.

Hysteresis
If a force equal to 50% of capacity is applied to a load cell which has been at no load, a given output will be measured. The same load cell is at full capacity, and some of the force is removed, resulting in the load cell operating at 50% capacity. The difference in output between the two test scenarios is called hysteresis.

Excitation Voltage
Specifies the voltage that can be applied to the power/ground terminals on the load cell. In practice, if you are using the load cell with the PhidgetBridge, you don't have to worry about this spec.

Input Impedance
Determines the power that will be consumed by the load cell. The lower this number is, the more current will be required, and the more heating will occur when the load cell is powered. In very noisy environments, a lower input impedance will reduce the effect of Electromagnetic interference on long wires between the load cell and PhidgetBridge.

Insulation Resistance
The electrical resistance measured between the metal structure of the load cell, and the wiring. The practical result of this is the metal structure of the load cells should not be energized with a voltage, particularly higher voltages, as it can arc into the PhidgetBridge. Commonly the load cell and the metal framework it is part of will be grounded to earth or to your system ground.

Maximum Overload
The maximum load which can be applied without producing a structural failure.

DATASHEETS: PIN CONFIGS

400KHz 60V 4A Switching Current Boost / Buck-Boost / Inverting DC/ DC Converter

Pin Configurations

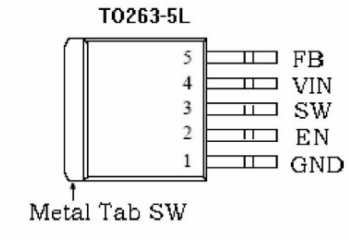

Figure2. Pin Configuration of XL6009 (Top View)

Table 1 Pin Description

Pin Number	Pin Name	Description
1	GND	Ground Pin.
2	EN	Enable Pin. Drive EN pin low to turn off the device, drive it high to turn it on. Floating is default high.
3	SW	Power Switch Output Pin (SW).
4	VIN	Supply Voltage Input Pin. XL6009 operates from a 5V to 32V DC voltage. Bypass Vin to GND with a suitably large capacitor to eliminate noise on the input.
5	FB	Feedback Pin (FB). Through an external resistor divider network, FB senses the output voltage and regulates it. The feedback threshold voltage is 1.25V.

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DATASHEETS: CURVES

DURACELL®

DURALOCK POWER PRESERVE™

ULTRA POWER

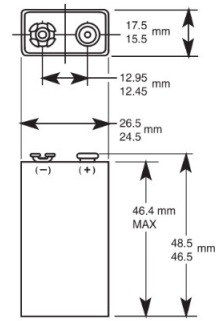
MX1604

Size: 9V (6LR61)

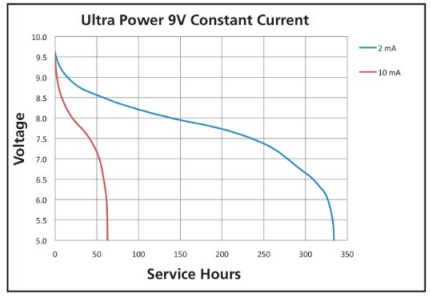
Alkaline-Manganese Dioxide Battery

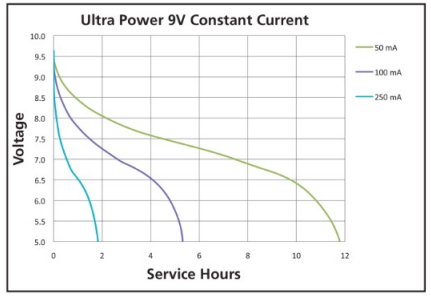
Zn/MnO_2

Nominal voltage	9 V
Impedance	1,700 m-ohm @ 1 kHz
Typical weight	45 g (1.6 oz)
Typical volume	22.8 cm^3 (1.4 in^3)
Terminals	Miniature snap
Storage temperature range	5°C to 30°C (41°F to 86°F)
Operating temperature range	-20°C to 54°C (-4°F to 130°F)
Designation	**IEC:** 6LR61



Dimensions shown are IEC standards





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DATASHEETS: CURVES

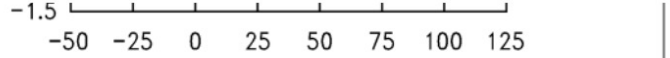

Figure 7-1. Normalized Output Voltage

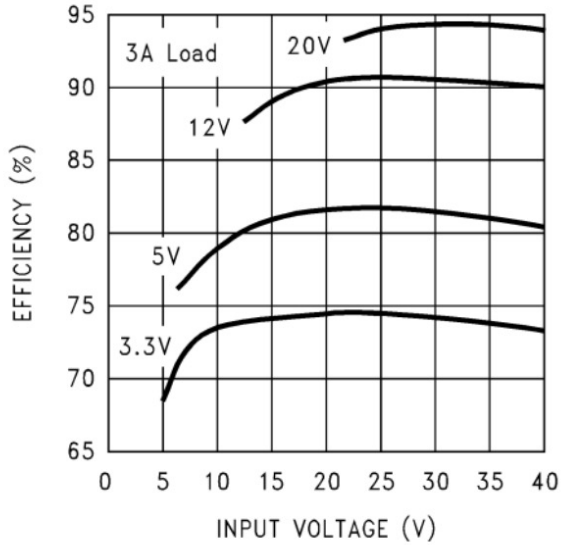

Figure 7-3. Efficiency

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DATASHEETS: ALTERNATIVES

VISHAY

1N4001, 1N4002, 1N4003, 1N4004, 1N4005, 1N4006, 1N4007

www.vishay.com

Vishay General Semiconductor

General Purpose Plastic Rectifier

DO-41 (DO-204AL)

FEATURES

- Low forward voltage drop
- Low leakage current
- High forward surge capability
- Solder dip 275 °C max. 10 s, per JESD 22-B106
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb e3 RoHS COMPLIANT

PRIMARY CHARACTERISTICS	
$I_{F(AV)}$	1.0 A
V_{RRM}	50 V, 100 V, 200 V, 400 V, 600 V, 800 V, 1000 V
I_{FSM} (8.3 ms sine-wave)	30 A
I_{FSM} (square wave t_p = 1 ms)	45 A
V_F	1.1 V
I_R	5.0 µA
T_J max.	150 °C
Package	DO-41 (DO-204AL)
Circuit configuration	Single

TYPICAL APPLICATIONS

For use in general purpose rectification of power supplies, inverters, converters, and freewheeling diodes application.

MECHANICAL DATA

Case: DO-41 (DO-204AL), molded epoxy body
Molding compound meets UL 94 V-0 flammability rating
Base P/N-E3 - RoHS-compliant, commercial grade

Terminals: matte tin plated leads, solderable per J-STD-002 and JESD 22-B102
E3 suffix meets JESD 201 class 1A whisker test

Polarity: color band denotes cathode end

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DATASHEETS: EXAMPLE SETUPS

Kylinchip 麟芯电子(上海)有限公司
KylinChip Electronic (Shanghai) Co.,Ltd

XL6009

400KHz 60V 4A Switching Current Boost / Buck-Boost / Inverting DC/DC Converter

Schottky Diode Selection Table

Current	Surface Mount	Through Hole	VR (The same as system maximum input voltage)				
			20V	30V	40V	50V	60V
1A		√	1N5817	1N5818	1N5819		
3A		√	1N5820	1N5821	1N5822		
		√	MBR320	MBR330	MBR340	MBR350	MBR360
	√		SK32	SK33	SK34	SK35	SK36
	√			30WQ03	30WQ04	30WQ05	
		√		31DQ03	31DQ04	31DQ05	
		√	SR302	SR303	SR304	SR305	SR306
5A		√	1N5823	1N5824	1N5825		
		√	SR502	SR503	SR504	SR505	SR506
		√	SB520	SB530	SB540	SB550	SB560
	√			50WQ03	50WQ04	50WQ05	

Typical System Application for EPC/Notebook Car Adapter – Boost (Output 18.5V/2.5A)

DATASHEETS: MATERIALS

Technical data sheet PLA

BCN3D

Description

PLA (Polylactic Acid) is a biodegradable, sustainable and food safe polymer made from organic sources.

It is the most common used filament in FFF 3D printers for its ease of use and awide range of applications, especially those not mechanically or thermally demanding. Definitely a good starting point to learn about the 3D Printing manufacturing process.

Properties

- Detailed and glossy surface quality
- Good tensile strength
- Rigid, fragile behaviour
- Good UV resistance
- Withstand operating temperatures up to 50 ˚C.
- Odor-free, ideal for educational and office environments
- Compatible with PVA supports
- Low humidity resistance

Recomendations

Plastics absorb moisture from the air. For long periods of time without printing, it is recommended to keep the PLA spools in a box or airtight container with desiccant to keep them dry.

PLA emits low levels of gasses and particles when printed. We recommend printing it in a well-ventilated area to ensure a healthy environment.

Filament specifications	
Diameter	Ø 2.85 mm
Max roundness deviation	≥ 95%
Net filament weight	750 g
Specific gravity (ISO 1183)	1.24 g/cm³

Mechanical properties	Typical value	Test method
MFR 210˚C/2.16 kg	9.56 gr/10 min	ISO 1133
Tensile strength at yield	70 Mpa	ISO 527
Strain at yield	5 %	ISO 527
Strain at break	20 %	ISO 527
Tensile Modulus	3120 MPa	ISO 527
Impact strength-Charpy method 23˚C	3.4 kJ/m²	ISO 179
Moisture absorption	1968 ppm	ISO 62

Thermal properties	Typical value	Test method
Melting temp.	115±35˚C	ISO 11357
Vicat softening temp.	60 ˚C	ISO 306
Glass transition temp.	57 °C	ISO 11357

Printing settings	
Extruder temperature	190 ˚C - 220 ˚C
Bed temperature	65 ˚C
Speed	10-70 mm/s
Retraction speed	40 mm/s
Retraction distance	4 mm
Cooling fan	Yes
Minimum layer height	0.05 mm

KNOWLEDGE HUBS

Component101 (example: https://components101.com/diodes/1n4001-diode-pinout-datasheet)

- great for finding specs and alternatives

Chomskylab.dk for inspiration

Vendor sites: Digikey, Mouser, RS, Farnell, Sparkfun, Adafruit, Polulu, Letelektronik, Elfa, Elav.

Arduino docs for code snippets and examples (and libraries)

Stackoverflow <3

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TIPS FOR GOOGLING YOUR PROBLEMS

Ask us for phrases that can help narrow search – or check datasheet glossary

Exact models... in the beginning

If no one has done it, it is probably beyond scope

Look for relevant "instructables" - YouTube, Instructables, Makerfaires, Stackoverflow etc.

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SUMMARY

Multimeter 101 and Solder 101

ATmega and Arduino: Most common issues and problems

Debugging your prototypes

Datasheet walkthrough

Good sources of knowledge

How to Google your problem

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ASSIGNMENT 1

APPROX. 20% OF GRADE

DEADLINE END OF WEEK 42* (TBA)

GROUP ASSIGNMENT

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ASSIGNMENT 1

Circuit Diagram and Breadboard Version of Chosen Prototype

1.1 Circuit Diagrams

Draw a schematic of your prototype using Eagle. Include as many components as possible, and make sure to follow schematic layout guidelines.

1.2 Breadboard Prototype

Wire up a breadboard version of your prototype with the Atmega and describe it.

As a group, students should submit 1 PDF and 1 video.

The PDF should include a quick introduction to your project idea, chosen target user group and then continue onto the schematic, a paragraph that describes how the circuit works in relation to your project prototype, and a description of the components on the breadboard and how they relate to the circuit diagram.

The **video** should show the functioning breadboard prototype. No voiceover is needed, just focus on showing working electronic

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ASSIGNMENT 1

Tips – BS → Assignment → Assignment 1 Report Tips
Color coding circuit diagram and breadboard prototype photo!

Handwritten circuit diagrams – we have not covered Eagle yet

Be honest and specific about bugs/problems and experiments done with components.

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FLIPPED CLASSROOM FOR NEXT WEEK!

Prep and tutorials (quite a lot)

More in-class supervision and time for other activities (live-demo + hands-on with…)

…3D printers!

Live-demo will be using the PRUSA Slic3r – please send me 3D models found on the interwebz, so I have some interesting “blind” slicing to do.

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