ES2C6 – Electro-mechanical System Design

Self-balancing Robot Project (WMG)

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Robot Design Do's and Don'ts

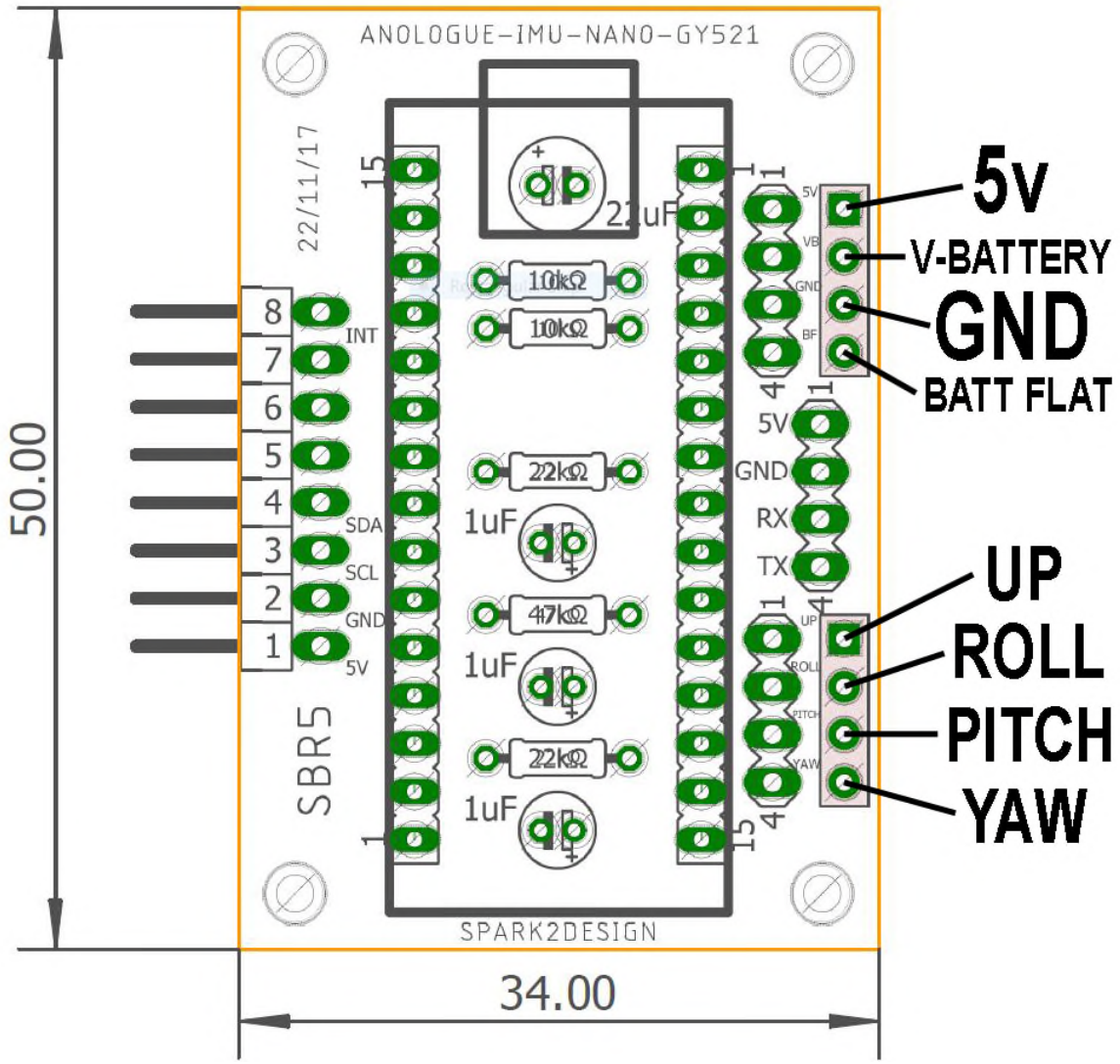
- Please look online at resources on the internet as well as your lecture notes for ES2C6. Many people have undertaken similar projects using similar kit. However unless it is from an official credible source, information may be erroneous or inaccurate particularly if it comes from forums or blogs etc. Officially provided information from web sites like Arduino or other suppliers is usually reliable. Much of this information is provided on the Moodle page for this project in a folder (including diagrams and exported CAD models of some supplied key components).
- You can use this project to test ideas and theory but always acknowledge sources of information (including designs and code) taken from other sources. Use your log book to record the sources when undertaking your project research. Any sources of information used in the final design, the presentation and final design report must be acknowledged and referenced in the report and presentation. See Engineering's skills handbook for referencing.
- The mechanical system is described as an **inverted pendulum** and can be modelled like this. It has inherent instability and can only remain upright if it uses a control system to control the motor torques and motor rotation direction. The input to the control system must be a sensor which monitors the tilt angle (or pitch angle) of the "pendulum" or robot. If you have ever tried to balancing an upturned broomstick or similar shaped object on the end of your finger then you are trying to mimic the same control system using your hand-eye co-ordination. Working out the mechanics is more 3rd or 4th year so we don't expect you to do this but please consult staff if you are interested to know how it can be done.
- Ask why it is easier to balance something with the centre of mass high-up (like an upturned broomstick) on your finger tip than with the centre of mass closer to your finger? The mechanical properties of your robot will need to take into consideration this phenomena. So solve this before finalising your design and in particular where you are going to locate the heaviest component, the battery.
- Keep your components safe, and don't lose or damage parts. The 18 compartment box and the project box have been supplied to help you keep your components safe and organised. The kit list and pictures supplied will help you to identify parts.
- When cutting the aluminium extrusion ask for the correct bench clamps. Ask for assistance when you have any doubts about using any equipment in the design space. Staff are there to help you and will be expecting you to ask questions about how to do things. If you are not asking questions you are not progressing your project work!
- Check all design work before committing to manufacture. As this is a team effort, every designer should get their designs checked by another member of the team. This is a group project and success will be as a result of good team work and fostering a positive collaborative environment. Checkers should be supportive of the achievements of the designers, as every team member should have a design role and a checking role.
- Only supply the Arduino Nano with 5V and no more. The battery can supply over 7.2V! The Arduino Leonardo can provide the 5V supply for the Arduino Nano. So do not use the battery to supply power to the Arduino Nano
- Do not short circuit the battery. This will damage the battery and other components, also will become a fire hazard.

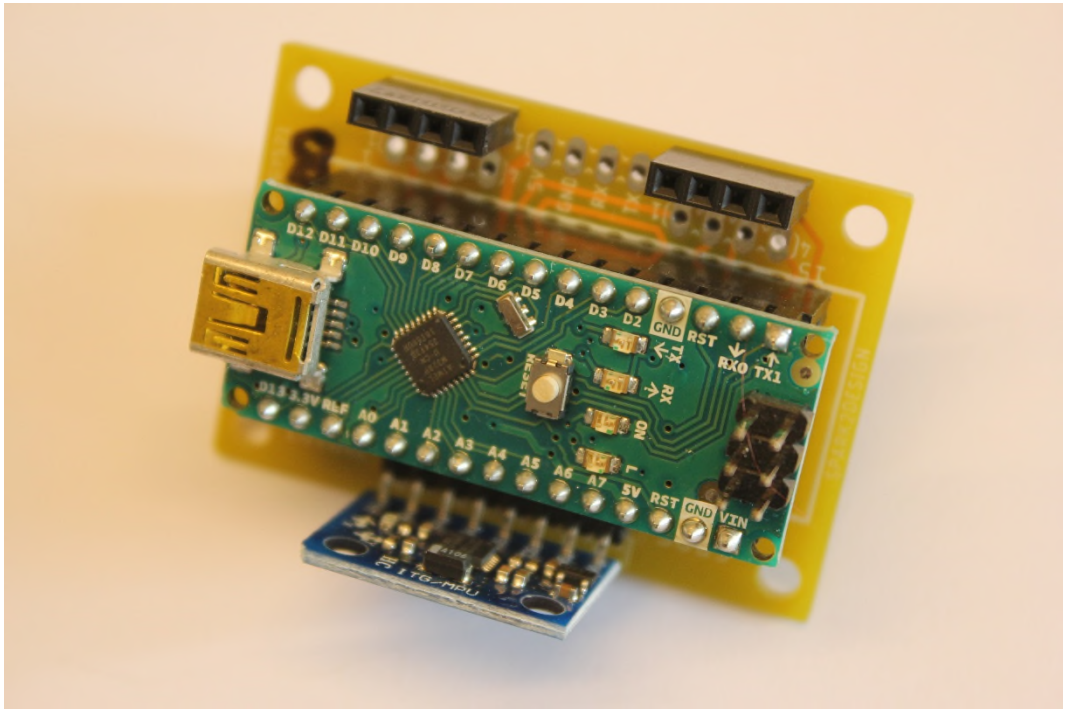
- The Nano can measure the battery voltage VB (Vbat or Vbattery). IF the battery voltage drops below 7 V then the robot will not be able to stabilise itself consistently. BF goes high if VB< 7 V.
- Incorrect connection of the red and green LED switches can cause a battery short circuit and wires to melt. The brass coloured connector on the switch is the GROUND. The black wires on the wiring loom should be connected to GROUND. The two silver coloured connectors are switched. The red wires on the wiring loom should be connected to the silver connectors.
- The wiring loom connects the battery to the two switches (one red and one green) and the connector on the Leonardo Motor Shield PCB.
- Use the green LED switch to turn on power to the Arduino. Use the red LED switch to turn on power to the motors. Therefore, to power-up the robot, switch on the green LED switch first to power up the control, and then switch on the red LED switch to give power to the motors.
- Power to both DC motors is controlled using an H-bridge which is the L293B driver IC mounted on the Leonardo motor Shield PCB.
- Use the LED's on the Leonardo motor Shield PCB to visually indicate that the power to the motors is working correctly to balance the robot prior to connecting the motors.
- The H-bridge needs two powers supplies: Vss is the power for the motors and Vs is the power for the H-bridge itself. The latter is just for logic control and is normally just 5V.
- The power for the H-bridge should only come from the 2x5 header pin on the Leonardo motor Shield. The ground for the H-bridge is already connected.
- For the dual H-bridge (the L293B driver IC) DO NOT SET EN1, EN2 (ENABLES) and all the "INs" (i.e. IN1, IN2, IN3, IN4 all short for INPUT1, INPUT2, INPUT3, INPUT4) at the same time. Always switch the IN pins low first prior to swapping the direction of the H-Bridge.
- The voltage regulator will get hot with use, so attach the heat sink provided (its like a mini radiator). So be careful when touching this and monitor this when testing the robot.
- Ensure that the resistor network is put in the correct way round as it is easy to get wrong. The LEDS, and Capacitors also have to be put the correct way round.
- Do use Arduino IDE to program the Arduino Leonardo. This is available from the Arduino website (www.arduino.cc) or on Engineering's computers. IDE stands for Integrated Development Environment and provides facilities for Arduino programming and software development. The Arduino IDE software is available for Windows, Mac's and Linux. It can be downloaded onto your personal computers. There are also books in the library plus an extensive online community for supporting Arduino programming.
- The control of the inputs of the H-bridge should use basic maths functions. Please do not use third party content (i.e. someone else's) for this.

Do not:

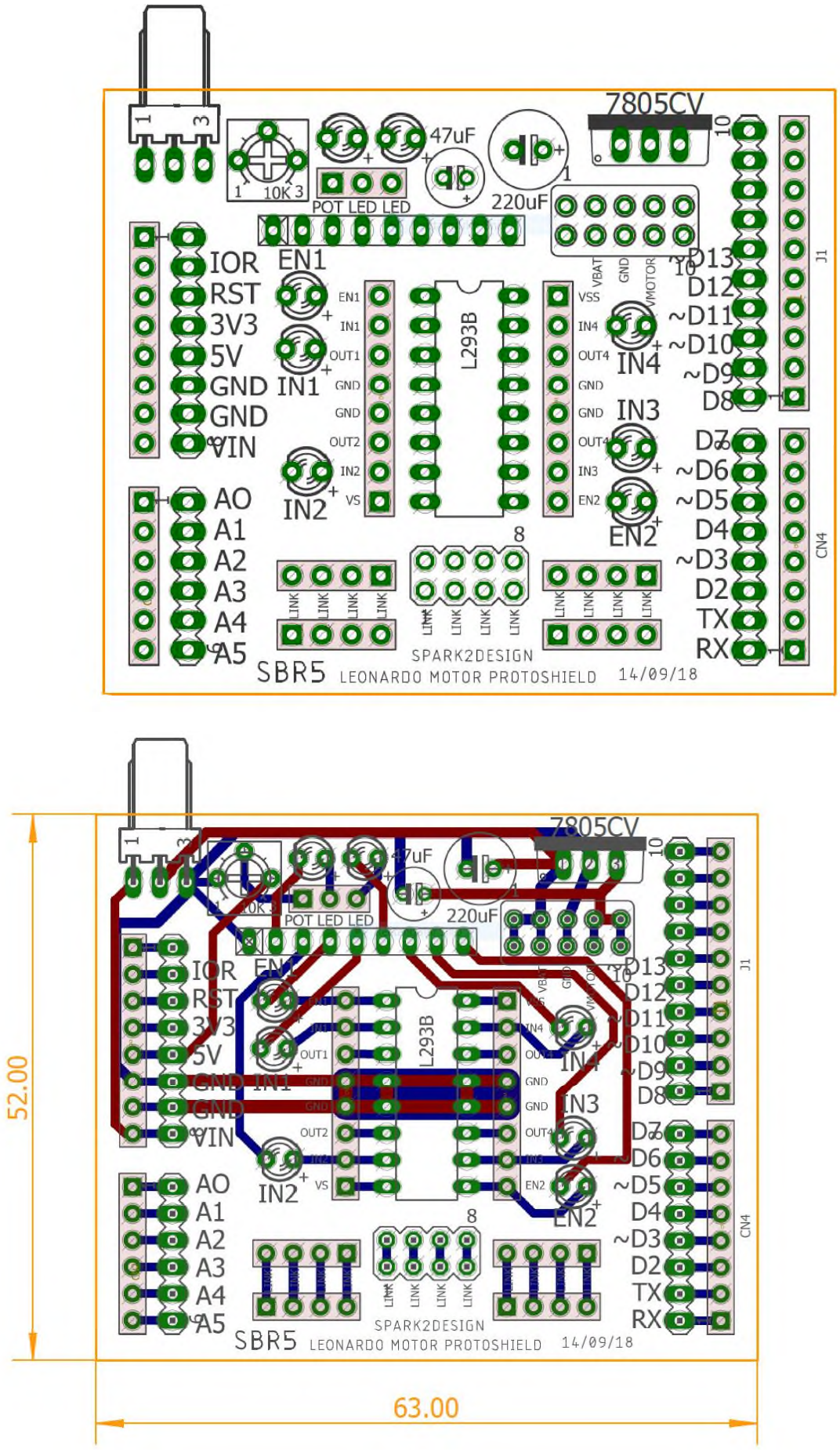
- Use Simulink to program the Arduino Leonardo.
- Use any Arduino library content, this is indicated in the IDE code by something like #include ***.h.
- Reprogram the Arduino Nano
- Do not use I^2C to connect to the GY521. The Arduino Nano looks after all this for you as an analogue IMU which is different to examples given online.
- Drop the robot or test it on a surface where it can fall
- Hold the robot by its USB Cable as this will break the Arduino Leonardo.
- Misuse the battery

See next 3 pages for pictures, layouts and tracks for Arduino Nano shoe and Leonardo board and shield.

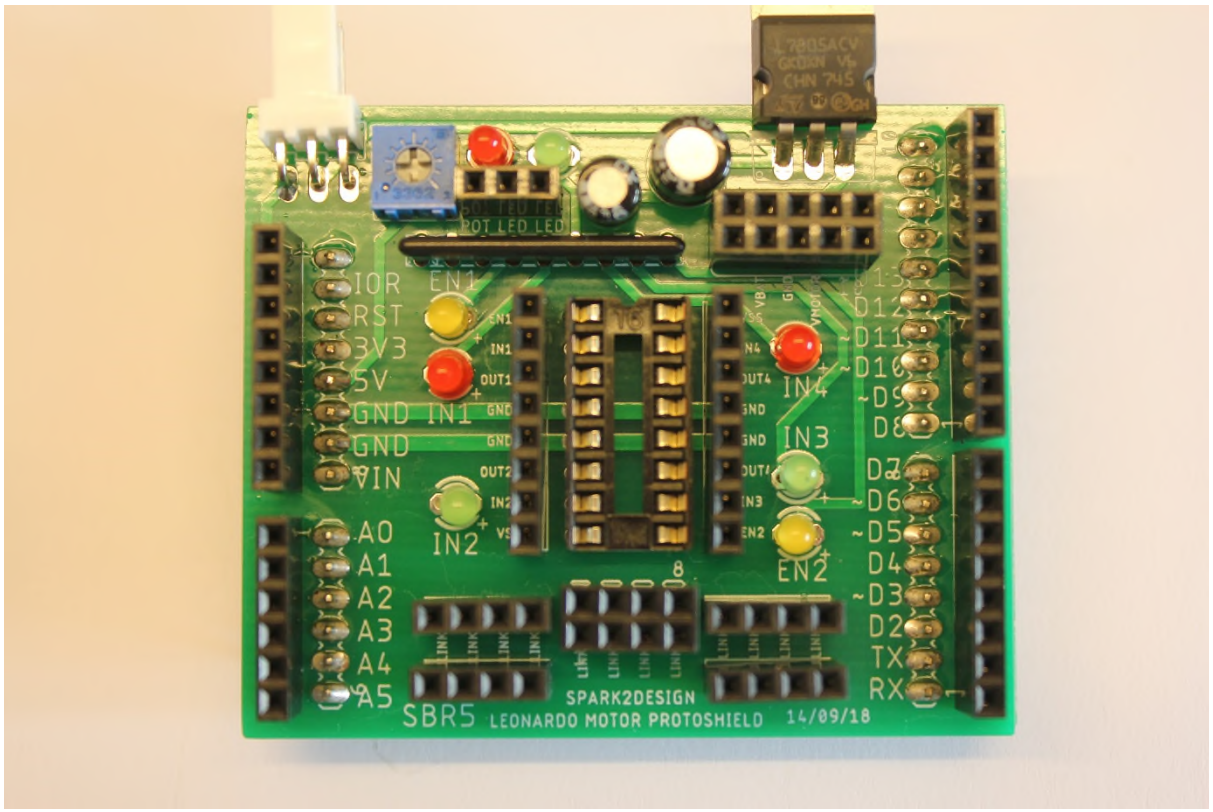




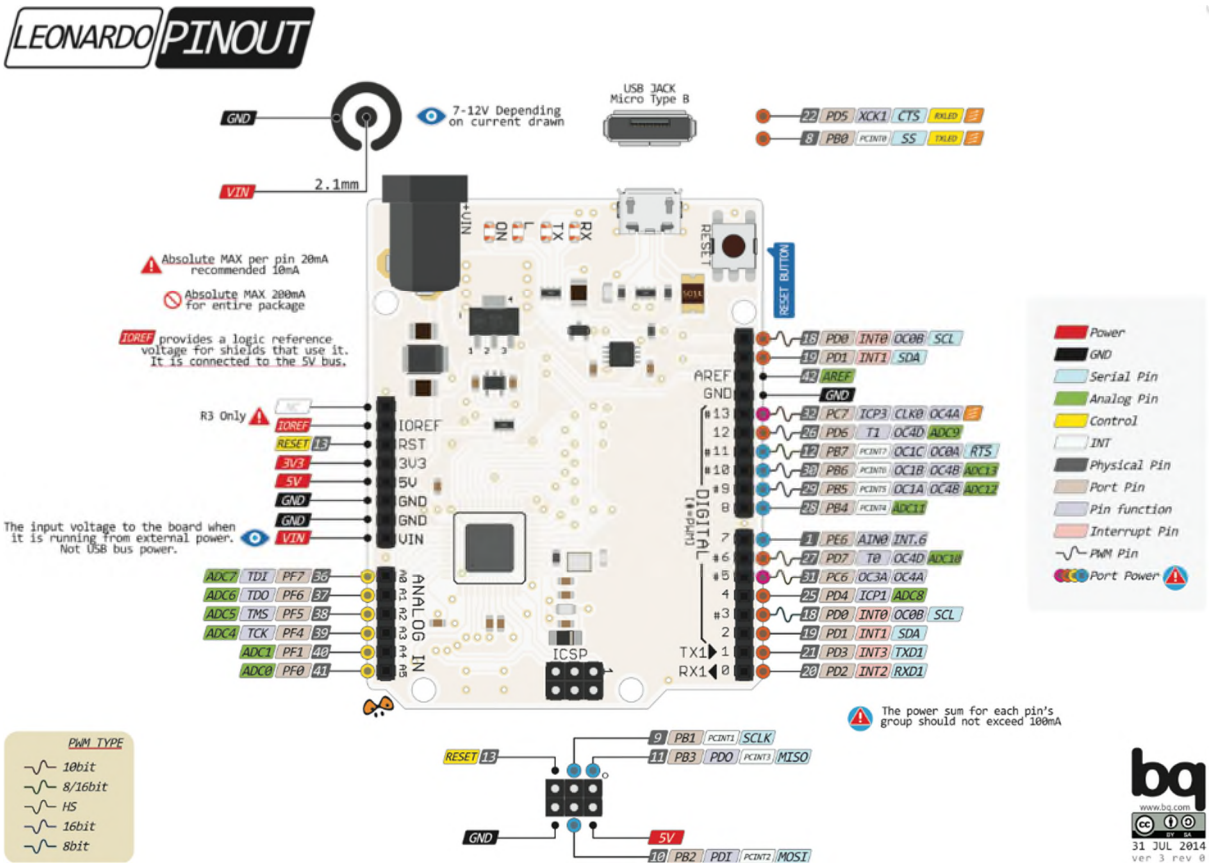
ANOLOGUE IMU (Arduino NANO with GY521)



SBR5 LEONARDO MOTOR PROTOSHIELD PCB without and with tracks.



SBR5 LEONARDO MOTOR PROTOSHIELD PCB with components



Arduino. 2018. Topic: Unofficial Leonardo Pinout Diagram. [ONLINE] Available at: https://forum.arduino.cc/index.php?topic=148308.0. [Accessed 28 October 2018].