**Tracked Robot Design**

# Chassis

The Dagu Rover 5 is a tracked robot chassis.

|  |  |
| --- | --- |
| **Dagu Rover 5 Specifications** | |
| Rated motor voltage | 7.2 V |
| Rated motor stall current | 2.5 A |
| Output shaft stall torque | 10 Kg/cm |
| Gearbox ratio | 86.8:1 |
| Encoder type | Quadrature |
| Encoder resolution | 1000 pulses per 3 wheel revolutions |
| Speed | 1 km/h |

|  |  |  |
| --- | --- | --- |
| **Encoder Interface** | | |
| Signal | Value | Wire Color |
| Power | 5 V | Red |
| Ground | 0 V | Black |
| Encoder A | 0 V / 5 V | White |
| Encoder B | 0 V / 5 V | Yellow |

## Estimated Current Draw

Estimate motor continuous current as 20-25% of the stall current, and motor controller maximum current rating approximately 2 × motor continuous current:

|  |  |  |
| --- | --- | --- |
|  | 2.5 A × 0.25 × 2 = 1.25 A | (1) |

## Measured Current Draw

The total measured current draw of the platform with both motors operating at 7.2 V and no track resistance was approximately 350 mA. The current draw with the platform moving on a level surface with 1140 gram payload was approximately 400 mA.

# Controller

## Raspberry Pi GPIO

Raspberry Pi GPIO 3.3V

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Motor Driver** | **GPIO** | **Pin** |  |  | **Pin** | **GPIO** | **Motor Driver** |
|  |  | 1 |  |  | 2 |  | 5V |
|  |  | 3 |  |  | 4 |  | 5V |
|  |  | 5 |  |  | 6 |  | Ground |
|  |  | 7 |  |  | 8 |  |  |
| Ground |  | 9 |  |  | 10 |  |  |
|  |  | 11 |  |  | 12 |  |  |
|  |  | 13 |  |  | 14 |  | Ground |
|  |  | 15 |  |  | 16 |  |  |
| +3.3V |  | 17 |  |  | 18 |  |  |
|  |  | 19 |  |  | 20 |  | Ground |
|  |  | 21 |  |  | 22 |  |  |
|  |  | 23 |  |  | 24 |  |  |
| Ground |  | 25 |  |  | 26 |  |  |
|  |  | 27 |  |  | 28 |  |  |
| Motor 1 Direction | GPIO5 | 29 |  |  | 30 | Ground | Ground |
| Motor 2 Direction | GPIO6 | 31 |  |  | 32 | GPIO12 | Motor 1 PWM |
| Motor 2 PWM | GPIO13 | 33 |  |  | 34 | Ground | Ground |
|  |  | 35 |  |  | 36 |  |  |
|  |  | 37 |  |  | 38 |  |  |
| Ground |  | 39 |  |  | 40 |  |  |
|  |  |  |  |  |  |  |  |

Check out Raspberry Pi version 2.0

# Motor Driver

The Pololu DRV8835 Dual Motor Driver Kit for Raspberry Pi B+ is a dual motor driver that can be stacked on the GPIO header of the Raspberry Pi B+.

* Dual H-bridge motor driver: drive two DC motors or one bipolar stepper motor
* Reverse-voltage protection on motor power supply
* Under-voltage lockout and protection against over-current and over-temperature
* PWM operation up to 250 kHz (ultrasonic frequencies allow for quieter motor operation)
* Two possible interface modes
  + PHASE/ENABLE (default – one pin for direction, another for speed)
  + IN/IN (outputs mostly mirror inputs)
* Python library available
* Can optionally power the Raspberry Pi base directly through add-on regulator
* GPIO pin mappings can be customized

|  |  |
| --- | --- |
| **DRV8835 Dual Motor Driver Kit for Raspberry Pi B+** | |
| Logic power supply voltage | 2-7 V |
| Motor power supply voltage | 1.5-11 V |
| Output current per channel – continuous | 1.2 A |
| Output current per channel – peak | 1.5 A |
| Maximum PWM frequency | 250 kHz |

|  |  |  |  |
| --- | --- | --- | --- |
| **DRV8835 Dual Low Voltage H-Bridge IC** | | | |
|  |  |  |  |
| PARAMETER | MIN | TYP | MAX |
| Recommended device power supply | 2 V |  | 7 V |
| Recommended motor power supply | 0 V |  | 11 V |
| Recommended H-bridge output | 0 A |  | 1.5 A |
| Overcurrent protection trip level | 1.6 A |  | 3.5 A |
| Overcurrent deglitch time |  | 1 μs |  |
| Overcurrent protection retry time |  | 1 ms |  |

Rover 5 rated motor stall current is 2.5 A. ***Detect stall conditions in high-level control loop to prevent motor driver over-current.***

$7.49 <https://www.pololu.com/product/2753>

$7.49 <http://www.robotshop.com/en/drv8835-dual-motor-driver-kit-raspberry-pi-b.html>

## Alternatives Considered

RaspiRobot Controller Board – Insufficient output current (25 mA)

Raspberry Pi I/O Expansion Card – Marginal output current (1 A)

# Power Supply

## Estimated Power

|  |  |  |  |
| --- | --- | --- | --- |
| **Estimated Power Usage** | | | |
| Device | Conditions | Current |  |
| Raspberry Pi B+ | shutdown state | 50 mA | [1] |
|  | USB/LAN chip disabled | 150 mA | [1] |
|  | keyboard dongle | 240 mA | [1] |
|  | keyboard + Edimax Wi-Fi | 280 mA | [1] |
|  | command line interface – idle | 210 mA | [2] |
|  | opening LXDE (startx) | 250 mA | [2] |
| Camera module | nominal | 250 mA | [3] |
|  | idle | 210 mA | [1] |
|  | dark object | 270 mA | [1] |
|  | bright light | 330 mA | [1] |
| USB Wi-Fi module | Edimax EW-7811Un – idle | 40 mA | [2] |
|  | Edimax EW-7811Un – active | 70 mA | [2] |
| DRV8835 motor driver | Bridge A – max | 1500 mA | [4] |
|  | Bridge B – max | 1500 mA | [4] |

Sources:

[1] How Much Less Power does the Raspberry Pi B+ use than the old model B?

<http://raspi.tv/2014/how-much-less-power-does-the-raspberry-pi-b-use-than-the-old-model-b>

[2] PiHut WiFi dongle vs Edimax – Power Usage

<http://raspi.tv/2014/pihut-wifi-dongle-vs-edimax-power-usage>

[3] Raspberry Pi Hardware Documentation – Power Supply

<http://www.raspberrypi.org/documentation/hardware/raspberrypi/power/README.md>

[4] Texas Instruments DRV8835 Dual Voltage H-Bridge IC Datasheet (revised Jan 2014)

Additional Notes:

A 1.2 A power supply is typically sufficient for Raspberry Pi:

<http://www.raspberrypi.org/documentation/hardware/raspberrypi/power/README.md>

Adding wi-fi to a Raspberry Pi without a powered hub:

<http://www.mike-worth.com/2012/11/26/adding-wi-fi-to-a-raspberry-pi-without-a-powered-hub/>

Disable power management for Ralink RT5370:

<http://www.raspberrypi.org/forums/viewtopic.php?t=46569&p=647343>

## Measured Power

|  |  |
| --- | --- |
| **Measured Power** | |
| Attribute | Value |
| Lab power supply voltage | 7.2 V |
| Raspberry Pi B+ with HDMI output, keyboard, mouse, Wi-Fi,  DRV8835 dual motor driver kit, S7V7F5 switching 5V regulator | 200-230 mA |
| Dagu Rover 5 platform |  |
| No track resistance | 350 mA |
| Platform on level surface with 1140 gram payload | 400 mA |

## ~~S7V7F5 Voltage Regulator~~

|  |  |  |
| --- | --- | --- |
| **Power Requirements** | | |
|  |  |  |
| DEVICE | LOW | HIGH |
| Raspberry Pi B+ | 210 mA | 250 mA |
| RaspPi Camera module | 210 mA | 330 mA |
| Edimax USB Wi-Fi module | 40 mA | 70 mA |
| DRV8835 Driver Logic | 4 mA | 4 mA |
| Logic Current | 464 mA | 654 mA |
|  |  |  |
| DRV8835 Driver Motor | 400 mA | 3000 mA |
|  |  |  |
| Total Current | 864 mA | 3654 mA |

The DRV8835 dual low voltage H-bridge IC features separate logic (VCC) and motor (VM) power supply pins. Maximum VCC and VM operating supply current is 2 mA each.

Motor driver LOW requirement is based on measured platform current draw while moving on a level surface with 1140 gram payload. HIGH requirement is based on rated peak power delivered by the DRV8835 motor driver.

The Pololu S7V7F5 is a 5V Step-Up/Step-Down Voltage Regulator.

|  |  |
| --- | --- |
| **S7V7F5 Step-Up / Step-Down Voltage Regulator** | |
| Attribute | Value |
| Operating voltage | 2.7-11.8 V |
| Default output voltage | 5 V |
| Continuous output current – stepping down | 1 A |
| Continuous output current – stepping up | 500 mA |

$4.95 <https://www.pololu.com/product/2119>

$4.95 <http://www.robotshop.com/en/step-up-step-down-voltage-regulator-s7v7f5.html>

# Battery

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | LOW | | HIGH | | Voltage |
| Eneloop NiMH | 1900 | mAh | 1900 | mAh | 7.2 V |
| Logic Power | 464 | mA | 654 | mA | 5.0 V |
| Motor Power | 400 | mA | 3000 | mA | 7.2 V |

Six Eneloop 1.2 V NiMH batteries rated at 1900 mAh:

|  |  |  |
| --- | --- | --- |
|  | 1900 mAh × 7.2 V = 13.7 Wh | (2) |

*Alternative:*

Power Battery 7.4V 2200 mAh 25C MAX 40C T Plug for RC Car

<http://www.ebay.com/itm/like/371218893350?lpid=82&chn=ps>

*Alternative:*

2 × 18650

18650 Li-ion battery: 4.2 V full charge, 2.75 V cut-off discharge

Typical capacity: 1500-3400 mAh

*Alternative:*

Portable power bank

## Nominal Power Conditions

Nominal motor operating power (measured with 1140 gram payload):

|  |  |  |
| --- | --- | --- |
|  | Pm = 400 mA × 7.2 V = 2.88 W | (3) |

Raspberry Pi B+ with camera module, Edimax EW-7811Un Wi-Fi module, and DRV8835 motor driver device power (high estimate):

|  |  |  |
| --- | --- | --- |
|  | Pr = 654 mA × 5 V = 3.27 W | (4) |

Total power:

|  |  |  |
| --- | --- | --- |
|  | Pm + Pr = 6.15 W | (5) |

Operating time under nominal power conditions:

|  |  |  |
| --- | --- | --- |
|  | 13.7 Wh / 6.15 W = 2.22 h = 2 hours 13 minutes | (6) |

## Peak Power Conditions

Maximum motor operating power:

|  |  |  |
| --- | --- | --- |
|  | Pm = 3000 mA × 7.2 V = 21.6 W | (7) |

Raspberry Pi B+ with camera module, Edimax EW-7811Un Wi-Fi module, and DRV8835 motor driver device power (high estimate):

|  |  |  |
| --- | --- | --- |
|  | Pr = 654 mA × 5 V = 3.27 W | (8) |

Total power:

|  |  |  |
| --- | --- | --- |
|  | Pm + Pr = 24.9 W | (9) |

Operating time under peak power conditions:

|  |  |  |
| --- | --- | --- |
|  | 13.7 Wh / 24.9 W = 0.55 h = 33 minutes | (10) |

## Battery Voltage Monitoring

**TBD**

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