EECE72545

# Power Budget

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**Device Power Consumption:**

| Component/Device | Number of units | Worst case | Standby | Nominal Voltage | Total power | Note |
|---|---|---|---|---|---|---|
| **TPS562201** | 1 | 750 µA | 1 µA | 14.8V | 11 mW | [1] |
| **Power LED** | 1 | 0.73 mA | 0.73 mA | 3V3 | 2.4 mW | |
| **CAT6219** | 1 | 90 µA | 1 µA | 5V | 0.45 mW | Quiescent |
| **INA219** | 1 | 1 mA | 6 µA | 3V3 | 3.3 mW | |
| **'Heartbeat' LED** | 1 | 0.07 mA | 0 | 3V3 | 231 mW | |
| **ICL3232** | 1 | 121 mA | 1 µA | 3V3 | 399 mW | |
| **TX/RX LED** | 2 | 2.86 mA | 0 | 3V3 | 9.5 mW | |
| **MCP2542** | 1 | 140 mA | 4 µA | 3V3 | 100 mW | |
| **LCD** | 1 | 3 mA | 1 mA | 5V | 15 mW | |
| **LCD Backlight** | 1 | 20 mA | 0 | 5V | 100 mW | |
| **MCP23S08** | 1 | 125 mA | 1 µA | 3V3 | 412.5 mW | |
| **DRV8814** | 1 | | | | | [2] |
| **Stepper Motor** | 1 | 400 mA | 0 | 14.8V | 5.92 W | Half-stepping |
| **DRV8884** | 1 | | | | | [3] |
| **DC Motor** | 2 | 3 A | 0 | 14.8V | 44.4 W | Stall |
| **Fault LED** | 2 | 20 mA | 0 | 3V3 | 66 mW | |
| **74LVC2G14** | 1 | 200 mA | 8 µA | 3V3 | 660 mW | Outputs shorted |
| **Servo** | 1 | 300 mA | 0 | 5V | 1.5W | |
| **HC-10 Bluetooth** | 1 | 50 mA | 200 µA | 3V3 | 165 mW | Transmit mode |
| **µSD Card** | 1 | 50 mA | - | 3V3 | 165 mW | Writing |
| **NTC Thermistor** | 2 | 2.2 mA | 2.2 mA | 3V3 | 7.3 mW | |
| **Ultrasonic Rangefinder** | 1 | 20 mA | 2.5mA | 5V | 100 mW | Transmitting |

[1] **TPS562201 Power Consumption:**

Worse case power dissipation ($I_{OUT}$ = 1A, 25°C):

*The following method was taken from TI: Application Report AN-1566 "Techniques for Thermal Analysis of Switching Power Supply Designs"*

$$P_{BIAS} = I_q \times V_{IN} = 750\mu A \times 14.8V = 0.011W$$

$$P_{COND} = Duty \times \left[\left(R_{DS(ON)HS} \times {I_{OUT}}^2\right) + \left(R_{DS(ON)LS} \times {I_{OUT}}^2\right)\right]$$

$$= 35\% \times [(0.14\Omega \times 1A^2) + (0.084\Omega \times 1A^2)]$$

$$= 0.078W$$

$$P_{SW} = \frac{(I_{OUT} \times V_{IN})}{2} \times f_{SW} \times (t_R + t_F)$$

$$= \frac{(1A \times 14.8V)}{2} \times 580KHz \times (50ns) = 0.215W$$

$$P_{TOTAL} = P_{BIAS} + P_{COND} + P_{SW} = \mathbf{0.31W}$$

[2] **DRV8814 Power Consumption:**

The DRV8814 has internal 5V and 3V3 regulators.

Worse case power dissipation ($V_M$ = 14.8V, $I_{OUT}$ = 1.5A, 25°C):

$$P_{RDS(ON)} = (2)\left(R_{DS(ON)HS+LS}\right)\left({I_{OUT}}^2\right) = (2)(0.525\Omega)(1.5A^2) = 2.36W$$

$$P_{SW} = (V_M)(I_{OUT})\left(t_{F,R}\right)(f_{SW}) = (14.8V)(1.5A)(300ns)(50KHz) = 0.333W$$

$$P_{IVM} = (V_M)(I_{IVM}) = (14.8V)(5mA) = 0.074W$$

$$P_{LDO} = (V_M - V_{LDO})(I_{LDO\ OUT}) = (14.4V - 3.3V)(1mA) = 0.0115W$$

$$P_{TOTAL} = P_{RDS(ON)+}P_{SW} + P_{IVM}+P_{LDO} = \mathbf{2.775W}$$

[3] **DRV8884 Power Consumption:**

The DRV8884 has internal 5V and 3V3 regulators.

Worse case power dissipation ($V_M$ = 14.8V, $I_{OUT}$ = 0.4A, 25°C):

$$P_{RDS(ON)} = \left(R_{DS(ON)HS}\right)\left({I_{OUT}}^2\right) + \left(R_{DS(ON)LS}\right)\left({I_{OUT}}^2\right)$$

$$= (0.798\Omega)(0.4A^2) + (0.749\Omega)(0.4A^2) = 0.247W$$

$$P_{SW} = (V_M)(I_{OUT})\left(t_{F,R}\right)(f_{SW}) = (14.8V)(0.4A)(100ns)(50KHz) = 0.029W$$

$$P_{IVM} = (V_M)(I_{IVM}) = (14.8V)(5mA) = 0.074W$$

$$P_{TOTAL} = P_{RDS(ON)} + P_{SW} + P_{IVM} = \mathbf{0.35W}$$

**Per Rail Power Consumption:**

| Rail | Total Power |
|---|---|
| **5V** | 1715.45 mW |
| **3V3** | 2311 mW |

**Efficiency Corrected Power Consumption:**

Because the 5V and 3V3 rails are converted from the battery voltage, there are losses associated with each conversion. The efficiency of the TPS562201 is about 91% at 300mA, and the CAT6219, being a linear regulator, is about 50%. Therefore, 3V3 rail could draw a total 2.888W from the 5V rail. The 5V rail, along with the previously calculated 3V3 draw, could draw a total 5.058W from the 14.8V battery.