Pololu 37D Metal Gearmotors are powerful brushed DC motors paired with 37mm-diameter gearboxes, and they are available with or without an integrated 64 CPR quadrature encoder on the motor shaft. The motors are intended for operation at 12 V, though in general, this kind of motor can run at voltages above and below the nominal voltage, and they can begin rotating at voltages as low as 1 V. Please note that higher voltages could start negatively affecting the lifetime of the motor. We characterized each version at 12 V and also at 6 V, and this datasheet includes performance graphs at both of these voltages.

The gearmotors are available in a variety of different gear ratios, offering many different combinations of speed and torque. The original versions of these gearmotors, denoted by “Spur Pinion” in the product names, had gearboxes with all spur gears. In August 2019, these were replaced by functionally identical “Helical Pinion” versions that feature helical gears for the first stage of the gearbox, which reduces noise and vibration and improves efficiency. The picture on the right shows the helical pinion gear and first mating gear.

Performance summary and table of contents

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<td>Current</td>
<td>Speed RPM</td>
<td>Torque kg-mm</td>
<td>Current</td>
<td>Power W</td>
<td>Torque kg-mm</td>
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<tr>
<td>12 V</td>
<td>1, 10,000</td>
<td>5</td>
<td>470</td>
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<td>0.76</td>
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<td>18.75</td>
<td>1102, 1103</td>
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<td>18</td>
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<td>50</td>
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<td>22</td>
<td>0.66</td>
<td>4.0</td>
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<td>187</td>
<td>4753</td>
<td>70</td>
<td>130</td>
<td>32</td>
<td>0.68</td>
<td>4.2</td>
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<tr>
<td>50</td>
<td>4743, 4744, 4754</td>
<td>102.08</td>
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<td>42</td>
<td>0.72</td>
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<td>131.25</td>
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<td>1106, 1107</td>
<td>66</td>
<td>60</td>
<td>0.74</td>
<td>4.1</td>
<td>6</td>
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<td>76</td>
<td>2828, 2829</td>
<td>150</td>
<td>58</td>
<td>65</td>
<td>0.72</td>
<td>3.8</td>
<td>6</td>
</tr>
</tbody>
</table>

Notes:
1) Max efficiency data and performance graphs currently unavailable for the motor without gearbox (items #2821 and #4750).
2) Listed stall torques and currents are theoretical extrapolations; units will typically stall well before these points as the motors heat up. Stalling or overloading gearmotors can greatly decrease their lifetimes and even result in immediate damage. The recommended upper limit for continuously applied loads is 100 kg-mm, and the recommended upper limit for instantaneous torque is 250 kg-mm. Stalls can also result in rapid (potentially on the order of seconds) thermal damage to the motor windings and brushes; a general recommendation for brushed DC motor operation is 25% or less of the stall current.
Dimensions (units: mm over [inches])

Gearmotor versions without encoders (items #1102-1107, 2829, 4741-4746) weight: 185 g to 195 g

<table>
<thead>
<tr>
<th>Gear ratio</th>
<th>L</th>
</tr>
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<tbody>
<tr>
<td>19:1, 30:1</td>
<td>21.5 mm [0.87 in]</td>
</tr>
<tr>
<td>50:1, 70:1</td>
<td>24.0 mm [0.94 in]</td>
</tr>
<tr>
<td>100:1, 131:1, 150:1</td>
<td>26.5 mm [1.04 in]</td>
</tr>
</tbody>
</table>

Gearmotor versions with encoders (items #2822-2828, 4751-4756) weight: 200 g to 210 g

Depth of mounting holes is 3.0 mm [0.12 in].

Leads are approximately 200 mm [8 in] long and are terminated by a 1x6 female header with a 2.34 mm [0.1 in] pitch.
Motor with encoder and no gearbox (items #2821, 4750)  

weight: 110 g

Using the encoder

Versions with encoders have additional electronics mounted on the rear of the motor. Two Hall-effect sensors are used to sense the rotation of a magnetic disc on a rear protrusion of the motor shaft. The encoder electronics and magnetic disc are enclosed by a removable plastic end cap. The following pictures show what the encoder portion looks like with the end cap removed:

The quadrature encoder provides a resolution of 64 counts per revolution (CPR) of the motor shaft when counting both edges of both channels. To compute the counts per revolution of the gearbox output, multiply the gear ratio by 64.

The motor/encoder has six color-coded, 20 cm (8") leads terminated by a 1×6 female connector with a 2.54 mm (0.1") pitch. This connector works with standard 0.1" male breakaway headers and our male premium jumper and precrimped wires. If this header is not convenient, the crimped wires can be pulled out of the 1×6 housing and used with different crimp connector housings instead (e.g. 1×2 for the motor power and 1×1 housings for the other four leads), or the connectors can be cut off entirely.
The Hall sensors require an input voltage, Vcc, between 3.5 V and 20 V and draw a maximum of 10 mA. The A and B outputs are square waves from 0 V to Vcc approximately 90° out of phase. The speed of the motor can be determined from the frequency of the, and the direction of rotation can be determined from the order of the transitions. The following oscilloscope capture shows the A and B (yellow and white) encoder outputs using a motor voltage of 12 V and a Hall sensor Vcc of 5 V:

By counting both the rising and falling edges of both the A and B outputs, it is possible to get 64 counts per revolution of the motor shaft. Using just a single edge of one channel results in 16 counts per revolution of the motor shaft, so the frequency of the A output in the above oscilloscope capture is 16 times the motor rotation frequency.
Pololu Items #1102, #2822, #4741, #4751 (19:1 Metal Gearmotor 37D)

Performance at 6 V

- **Max power:** 3.5 W at 25 kg⋅mm, 35% efficiency, 130 rpm, 1.6 A
- **Torque (kg⋅mm):**
  - **Stall torque:** ≈ 50 kg⋅mm
  - **Stall current:** ≈ 3.2 A

- **Max efficiency:** 53% at 7.2 kg⋅mm, 1.7 W, 230 rpm, 0.53 A

- **No-load speed:** 270 rpm
- **No-load current:** 0.091 A

- **f(τ) = 270 − 5.4τ**
- **f(τ) = 0.089 + 0.062τ**

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Pololu Items #1102, #2822, #4741, #4751 (19:1 Metal Gearmotor 37D) Performance at 12 V

- Max power: 12 W at 42 kg mm, 35% efficiency, 270 rpm, 2.8 A
- Max efficiency: 55% at 10 kg mm, 5.0 W, 470 rpm, 0.76 A

Graph showing power, efficiency, speed, and current vs. torque.
Pololu Items #1103, #2823, #4742, #4752 (30:1 Metal Gearmotor 37D) Performance at 6 V

- **Max power**: 3.4 W at 39 kg⋅mm, 36% efficiency, 83 rpm, 1.5 A
- **Max efficiency**: 54% at 12 kg⋅mm, 1.7 W, 140 rpm, 0.53 A

**Torsion Model**

\[ f(\tau) = 170 - 2.1\tau \]

\[ f(\tau) = 0.093 + 0.037\tau \]

**Stall Torque**

\[ \tau_{\text{stall}} \approx 79 \text{ kg}\cdot\text{mm} \]

**Stall Current**

\[ I_{\text{stall}} \approx 3.0 \text{ A} \]

**No-load Speed**

170 rpm

**No-load Current**

0.091 A

\[
\begin{align*}
\text{Power} & \approx 170 \text{ rpm} - 2.1 \tau \\
\text{Efficiency} & \approx 0.093 + 0.037 \tau \\
\text{Torque} & \approx 79 \text{ kg}\cdot\text{mm} \\
\text{Current} & \approx 3.0 \text{ A} \\
\end{align*}
\]
Pololu Items #1103, #2823, #4742, #4752 (30:1 Metal Gearmotor 37D) Performance at 12 V

- **max power**: 12 W at 72 kg⋅mm, 35% efficiency, 160 rpm, 2.8 A
- **max efficiency**: 54% at 18 kg⋅mm, 5.1 W, 280 rpm, 0.78 A

**f(τ) = 320 − 2.2τ**

**τ_{stall} ≈ 140 kg⋅mm | I_{stall} ≈ 5.6 A**

- **no-load current**: 0.15 A
- **no-load speed**: 330 rpm

**f(τ) = 0.11 + 0.038τ**
Pololu Items #1104, #2824, #4743, #4753 (50:1 Metal Gearmotor 37D) Performance at 6 V

- **max power**: 3.1 W at 59 kg⋅mm, 34% efficiency, 50 rpm, 1.5 A
- **max efficiency**: 52% at 17 kg⋅mm, 1.5 W, 87 rpm, 0.48 A

**f(τ) = 100 − 0.85τ**

- **τ_{stall} ≈ 120 kg⋅mm**
- **I_{stall} ≈ 2.9 A**
- **no-load speed**: 100 rpm
- **no-load current**: 0.088 A

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Pololu Items #1104, #2824, #4743, #4753 (50:1 Metal Gearmotor 37D) Performance at 12 V

max power: 10 W at 100 kg⋅mm, 32% efficiency, 98 rpm, 2.7 A
torque (kg⋅mm)

max efficiency: 51% at 22 kg⋅mm, 4.0 W, 180 rpm, 0.66 A

no-load speed: 200 rpm

f(τ) = 200 − 1.0τ
f(τ) = 0.080 + 0.026τ

τ_{stall} ≈ 210 kg⋅mm
I_{stall} ≈ 5.4 A

no-load current: 0.12 A

no-load speed: 200 rpm

Pololu Items #1105, #2825, #4744, #4754 (70:1 Metal Gearmotor 37D) Performance at 6 V

- Max power: 2.9 W at 79 kg⋅mm, 32% efficiency, 36 rpm, 1.5 A
- Max efficiency: 49% at 21 kg⋅mm, 1.4 W, 63 rpm, 0.47 A
- No-load speed: 73 rpm, no-load current: 0.082 A
- Stall torque: ≈ 160 kg⋅mm, Stall current: ≈ 3.0 A
Pololu Items #1105, #2825, #4744, #4754 (70:1 Metal Gearmotor 37D) Performance at 12 V

- **max power**: 10 W at 140 kg.mm, 33% efficiency, 73 rpm, 2.6 A
- **max efficiency**: 52% at 32 kg.mm, 4.2 W, 130 rpm, 0.68 A
- **no-load speed**: 150 rpm
- **no-load current**: 0.11 A
- **torque (kg-mm)**: 
  - Stall torque $\tau_{\text{stall}} \approx 270$ kg-mm
  - Stall current $I_{\text{stall}} \approx 5.2$ A

The graph shows the relationship between torque, speed, and current at different operating points, with equations for calculating these values.

$f(\tau) = 150 - 0.53\tau$

$f(\tau) = 0.088 + 0.018\tau$
Pololu Items #1106, #2826, #4745, #4755 (100:1 Metal Gearmotor 37D) Performance at 6 V

- **max power:** 2.6 W at 100 kg⋅mm, 27% efficiency, 25 rpm, 1.6 A
- **no-load current:** 0.087 A
- **no-load speed:** 49 rpm
- **max efficiency:** 41% at 29 kg⋅mm, 1.3 W, 43 rpm, 0.51 A
- **τ_{stall} ≈ 210 kg⋅mm
- **I_{stall} ≈ 3.2 A
- **f(τ) = 50 - 0.24τ
- **f(τ) = 0.082 + 0.015τ

Power (W) vs. Efficiency (%) graph shows:
- **max power** at 100 kg⋅mm, 27% efficiency, 25 rpm, 1.6 A
- **max efficiency** at 29 kg⋅mm, 1.3 W, 43 rpm, 0.51 A
- **no-load speed** 49 rpm
- **no-load current** 0.087 A
- **τ_{stall} ≈ 210 kg⋅mm
- **I_{stall} ≈ 3.2 A

Current (A) vs. Torque (kg⋅mm) graph shows:
- **max power** at 100 kg⋅mm, 27% efficiency, 25 rpm, 1.6 A
- **max efficiency** at 29 kg⋅mm, 1.3 W, 43 rpm, 0.51 A
- **no-load speed** 49 rpm
- **no-load current** 0.087 A
- **τ_{stall} ≈ 210 kg⋅mm
- **I_{stall} ≈ 3.2 A

Speed (rpm) vs. Current (A) graph shows:
- **max power** at 100 kg⋅mm, 27% efficiency, 25 rpm, 1.6 A
- **max efficiency** at 29 kg⋅mm, 1.3 W, 43 rpm, 0.51 A
- **no-load speed** 49 rpm
- **no-load current** 0.087 A
- **τ_{stall} ≈ 210 kg⋅mm
- **I_{stall} ≈ 3.2 A

The diagram illustrates the performance characteristics of the gearmotor at different loads and currents, showing how power, efficiency, speed, and current vary with torque.
Pololu Items #1106, #2826, #4745, #4755 (100:1 Metal Gearmotor 37D) Performance at 12 V

- **Max Power:** 8.7 W at 170 kg mm, 28% efficiency, 50 rpm, 2.6 A
- **Max Efficiency:** 44% at 42 kg mm, 3.8 W, 87 rpm, 0.72 A

**No-load Speed:** 100 rpm

**No-load Current:** 0.12 A

**Stall Torque:** ≈ 340 kg mm

**Stall Current:** ≈ 5.1 A
max power: 2.7 W at 140 kg·mm, 29% efficiency, 19 rpm, 1.6 A

max efficiency: 43% at 40 kg·mm, 1.3 W, 33 rpm, 0.51 A

no-load speed: 38 rpm

no-load current: 0.095 A

\( f(\tau) = 38 - 0.14\tau \)

\( f(\tau) = 0.085 + 0.011\tau \)

\( \tau_{\text{stall}} \approx 280 \text{ kg}\cdot\text{mm} \)

\( I_{\text{stall}} \approx 3.1 \text{ A} \)
Pololu Items #1107, #2827, #4746, #4756 (131:1 Metal Gearmotor 37D) Performance at 12 V

- **max power:** 8.7 W at 200 kg⋅mm, 30% efficiency, 38 rpm, 2.5 A
- **max efficiency:** 45% at 60 kg⋅mm, 4.1 W, 66 rpm, 0.74 A

**f(τ) = 76 − 0.17τ**

- **no-load speed:** 76 rpm
- **no-load current:** 0.13 A

**f(τ) = 0.12 + 0.011τ**

- **τ_{stall} ≈ 450 kg⋅mm**
- **I_{stall} ≈ 4.8 A**

Pololu Items #2829, #2828, #150:1 Metal Gearmotor 37D, # () Performance at 6 V

- **max power:** 2.5 W at 150 kg⋅mm, 27% efficiency, 17 rpm, 1.5 A
- **max efficiency:** 41% at 43 kg⋅mm, 1.3 W, 28 rpm, 0.51 A
- **no-load speed:** 33 rpm
- **no-load current:** 0.10 A
- **τ_{stall} ≈ 300 kg⋅mm**
- **I_{stall} ≈ 3.0 A**

\[ f(\tau) = 33 - 0.11\tau \]
\[ f(\tau) = 0.086 + 0.010\tau \]
Pololu Items #2829, #2828, #150:1 Metal Gearmotor 37D, # () Performance at 12 V

- **Max power:** 8.4 W at 250 kg-mm, 29% efficiency, 33 rpm, 2.4 A
- **Max efficiency:** 44% at 65 kg-mm, 3.8 W, 58 rpm, 0.72 A

No-load speed: 67 rpm

No-load current: 0.12 A

$\tau_{\text{stall}} \approx 490 \text{ kg-mm}$

$I_{\text{stall}} \approx 4.8 \text{ A}$

$f(\tau) = 0.11 + 0.0095 \tau$

$f(\tau) = 67 - 0.13 \tau$

Current (A)

Speed (rpm)

Efficiency (%)