Pololu 20D Metal Gearmotors are available in 12 different gear ratios, from 25:1 up to 488:1, and with three different motor options:

- **6V**: 6 V windings with precious metal brushes
- **6V CB**: 6 V windings with long-life carbon brushes
- **12V CB**: 12 V windings with long-life carbon brushes

The **12V CB** versions offer approximately the same speed and torque performance at 12 V as their **6V CB** counterparts do at 6 V, just with approximately half the current draw.

Each motor is available with an optional extended rear motor shaft to allow for the addition of an encoder such as Pololu item #3499 Magnetic Encoder Pair Kit. This rear shaft rotates at the same speed as the input to the gearbox.

**Dimensions**

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Units are mm over [inches]. Weight ranges from approximately 45 g to 50 g.
Performance summary and table of contents

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Notes:
1) Performance data currently unavailable for 20D versions with precious metal brushes (items #3450-3473), but it should generally be similar to the performance of the versions with carbon brushes (6V CB) listed in this datasheet.
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 50 kg-mm for the versions with carbon brushes (6V CB and 12V CB), and 35 kg-mm for versions with precious metal brushes. 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.
Pololu Items #3700, #3712 (25:1 Metal Gearmotor 20D 6V CB) Performance at 6 V

- **max power**: 2.3 W
  - at 8.0 kg \(\cdot\) mm,
  - 25% efficiency,
  - 270 rpm, 1.5 A

- **max efficiency**: 33%
  - at 3.3 kg \(\cdot\) mm, 1.5 W,
  - 440 rpm, 0.74 A

- **no-load speed**: 570 rpm
- **no-load current**: 0.14 A

- **\(\tau\) stall**: \(\approx 16\) kg \(\cdot\) mm
- **\(I_{\text{stall}}\)**: \(\approx 2.9\) A

\[f(\tau) = 550 - 34\tau\]
\[f(\tau) = 0.19 + 0.17\tau\]
Pololu Items #3701, #3713 (31:1 Metal Gearmotor 20D 6V CB) Performance at 6 V

- **Max power**: 2.3 W at 10 kg⋅mm, 26% efficiency, 220 rpm, 1.5 A
- **Max efficiency**: 37% at 3.9 kg⋅mm, 1.4 W, 360 rpm, 0.65 A

**No-load speed**: 450 rpm

**No-load current**: 0.13 A

**Torque**
- $f(\tau) = 440 - 22\tau$
- $f(\tau) = 0.15 + 0.13\tau$

**Stall torque**: $\tau_{\text{stall}} \approx 20$ kg⋅mm

**Stall current**: $I_{\text{stall}} \approx 2.8$ A
Pololu Items #3702, #3714 (63:1 Metal Gearmotor 20D 6V CB) Performance at 6 V

- **No-load speed**: 230 rpm
- **Efficiency**
  - Max efficiency: 37%
  - At 7.1 kg⋅mm, 1.4 W, 190 rpm, 0.61 A
- **Power**
  - Max power: 2.4 W
  - At 20 kg⋅mm, 26% efficiency, 110 rpm, 1.5 A
- **Torque**
  - Stall torque: ≈ 40 kg⋅mm
  - Stall current: ≈ 2.9 A
- **No-load current**: 0.13 A

\[
f(\tau) = 230 - 5.7\tau \\
\text{max power: } 2.4 \text{ W} \\
f(\tau) = 0.13 + 0.068\tau \\
\text{at } 20 \text{ kg} \cdot \text{mm}, \\
26\% \text{ efficiency}, \\
110 \text{ rpm}, 1.5 \text{ A} \\
\tau_{\text{stall}} = \approx 40 \text{ kg} \cdot \text{mm} \\
I_{\text{stall}} = \approx 2.9 \text{ A} \\
\text{no-load speed: } 230 \text{ rpm} \\
\text{no-load current: } 0.13 \text{ A}
\]
Pololu Items #3703, #3715 (78:1 Metal Gearmotor 20D 6V CB) Performance at 6 V

- **max power:** 2.1 W at 22 kg⋅mm, 23% efficiency, 91 rpm, 1.5 A
- **max efficiency:** 33% at 7.6 kg⋅mm, 1.2 W, 150 rpm, 0.59 A

**f(τ) = 180 − 4.2τ**

**f(τ) = 0.12 + 0.061τ**

- **τ_{stall} ≈ 44 kg⋅mm**
- **I_{stall} ≈ 2.8 A**
- **no-load speed:** 180 rpm
- **no-load current:** 0.14 A
Pololu Items #3704, #3716 (100:1 Metal Gearmotor 20D 6V CB) Performance at 6 V

- **max power**: 2.0 W at 27 kg⋅mm, 22% efficiency, 71 rpm, 1.5 A
- **max efficiency**: 30% at 10 kg⋅mm, 1.1 W, 120 rpm, 0.63 A

**Graphs**

- **no-load speed**: 140 rpm
- **no-load current**: 0.15 A
- **f(τ) = 140 – 2.6τ**
- **f(τ) = 0.14 + 0.051τ**
- **τ_{stall} ≈ 54 kg⋅mm**
- **I_{stall} ≈ 2.9 A**
- **speed (rpm)** vs **current (A)**
- **power (W)** vs **efficiency (%)**
- **torque (kg mm)**

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Pololu Items #3705, #3717 (125:1 Metal Gearmotor 20D 6V CB) Performance at 6 V

- **max power**: 1.9 W at 32 kg mm, 21% efficiency, 57 rpm, 1.5 A
- **max efficiency**: 30% at 12 kg mm, 1.1 W, 93 rpm, 0.62 A

\[
\tau(\tau) = 110 - 1.8\tau \\
\tau(\tau) = 0.14 + 0.042\tau
\]

- **no-load speed**: 110 rpm
- **no-load current**: 0.13 A
- **\(\tau_{\text{stall}}\) ≈ 64 kg mm
- **\(I_{\text{stall}}\) ≈ 2.8 A
Pololu Items #3706, #3718 (156:1 Metal Gearmotor 20D 6V CB) Performance at 6 V

- Max power: 1.8 W at 39 kg⋅mm, 21% efficiency, 45 rpm, 1.4 A
- Max efficiency: 29% at 14 kg⋅mm, 1.1 W, 74 rpm, 0.60 A
- Torque (kg⋅mm)
- No-load speed: 91 rpm

f(τ) = 90 − 1.1τ
f(τ) = 0.13 + 0.034τ

τ_{stall} ≈ 79 kg⋅mm
I_{stall} ≈ 2.8 A

No-load current: 0.16 A

Pololu Items #3707, #3719 (195:1 Metal Gearmotor 20D 6V CB) Performance at 6 V

- Max power: 1.7 W at 47 kg⋅mm, 20% efficiency, 36 rpm, 1.5 A
- Max efficiency: 28% at 17 kg⋅mm, 1.0 W, 60 rpm, 0.61 A

- Torque (kg⋅mm) vs. Efficiency
- Power (W) vs. Speed (rpm)
- Current (A) vs. Torque (kg⋅mm)

- No-load speed: 73 rpm
- No-load current: 0.15 A

- Maximum: f(τ) = 73 − 0.78τ
- Efficiency: f(τ) = 0.13 + 0.028τ

- Stall torque: τ\_stall ≈ 94 kg⋅mm
- Stall current: I\_stall ≈ 2.8 A

Pololu Items #3708, #3720 (250:1 Metal Gearmotor 20D 6V CB) Performance at 6 V

- **max power:** 1.8 W at 60 kg⋅mm, 20% efficiency, 29 rpm, 1.5 A
- **no-load speed:** 57 rpm
- **no-load current:** 0.15 A
- **max efficiency:** 28% at 21 kg⋅mm, 1.0 W, 47 rpm, 0.62 A

**Torque (kg⋅mm) vs. Power (W):**
- **f(τ) = 57 - 0.48τ**
- **f(τ) = 0.13 + 0.023τ**

**Current vs. Torque (kg⋅mm):**
- **τ_{stall} ≈ 120 kg⋅mm**
- **I_{stall} ≈ 2.9 A**
Pololu Items #3709, #3721 (313:1 Metal Gearmotor 20D 6V CB) Performance at 6 V

max efficiency: 25%
at 24 kg\(\cdot\)mm, 0.93 W, 38 rpm, 0.61 A

\[ f(\tau) = 46 - 0.34\tau \]

\[ f(\tau) = 0.13 + 0.020\tau \]

\(\tau_{\text{stall}} \approx 130 \text{ kg}\cdot\text{mm} \)

\(I_{\text{stall}} \approx 2.9 \text{ A} \)

no-load speed: 45 rpm

no-load current: 0.15 A

Pololu Items #3710, #3722 (391:1 Metal Gearmotor 20D 6V CB) Performance at 6 V

max efficiency: 23%
at 27 kg\cdot mm, 0.84 W, 30 rpm, 0.60 A

no-load speed: 36 rpm

\begin{equation}
f(\tau) = 36 - 0.23\tau
\end{equation}

\begin{equation}
f(\tau) = 0.12 + 0.018\tau
\end{equation}

\tau_{\text{stall}} \approx 160 \text{ kg}\cdot \text{mm}

I_{\text{stall}} \approx 2.9 \text{ A}

no-load current: 0.13 A

Pololu Items #3711, #3723 (488:1 Metal Gearmotor 20D 6V CB) Performance at 6 V

- Max efficiency: 24%
- At 35 kg mm, 0.89 W, 24 rpm, 0.61 A
- No-load speed: 30 rpm
- No-load current: 0.14 A
- Theoretical max power

\[ f(\tau) = 29 - 0.14\tau \]
\[ f(\tau) = 0.12 + 0.014\tau \]

\[ \tau_{\text{stall}} \approx 210 \text{ kg mm} \]
\[ I_{\text{stall}} \approx 2.9 \text{ A} \]
Pololu Items #3474, #3486 (25:1 Metal Gearmotor 20D 12V CB) Performance at 12 V

- Max power: 2.6 W at 9.5 kg mm, 27% efficiency, 270 rpm, 0.83 A
- Max efficiency: 37% at 3.4 kg mm, 1.6 W, 440 rpm, 0.35 A

Torque

\[ f(\tau) = 540 - 29\tau \]
\[ f(\tau) = 0.077 + 0.079\tau \]

Stall torque: \( \tau_{\text{stall}} \approx 19 \text{ kg mm} \)

Stall current: \( I_{\text{stall}} \approx 1.6 \text{ A} \)

No-load current: 0.073 A

No-load speed: 550 rpm

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max power: 2.8 W at 12 kg⋅mm, 28% efficiency, 220 rpm, 0.83 A

max efficiency: 39% at 4.4 kg⋅mm, 1.7 W, 360 rpm, 0.35 A

no-load speed: 450 rpm
no-load current: 0.076 A

\( f(\tau) = 450 - 18\tau \)
\( f(\tau) = 0.079 + 0.062\tau \)

\( \tau_{\text{stall}} \approx 24 \text{ kg} \cdot \text{mm} \)
\( I_{\text{stall}} \approx 1.6 \text{ A} \)
Pololu Items #3476, #3488 (63:1 Metal Gearmotor 20D 12V CB) Performance at 12 V

- **Max efficiency**: 39% at 8.0 kg mm, 1.5 W, 180 rpm, 0.32 A
- **No-load current**: 0.075 A
- **Stall current**: \( I_{\text{stall}} \approx 1.5 \text{ A} \)
- **Stall torque**: \( \tau_{\text{stall}} \approx 46 \text{ kg mm} \)
- **No-load speed**: 220 rpm
- **Max power**: 2.6 W at 23 kg mm, 27% efficiency, 110 rpm, 0.81 A

The graph shows the relationship between power (W), efficiency (%), speed (rpm), current (A), and torque (kg mm). The equations for predicting the performance are:

- \( f(\tau) = 220 - 4.8\tau \)
- \( f(\tau) = 0.067 + 0.032\tau \)
Pololu Items #3477, #3489 (78:1 Metal Gearmotor 20D 12V CB) Performance at 12 V

- **Max power**: 2.5 W
  - at 27 kg⋅mm
  - 25% efficiency
  - 89 rpm, 0.83 A

- **Max efficiency**: 36%
  - at 9.3 kg⋅mm, 1.4 W, 150 rpm, 0.33 A

- **Torque**:
  - **Stall**: 
    - $\tau_{\text{stall}} \approx 54$ kg⋅mm
    - $I_{\text{stall}} \approx 1.6$ A
  - **No-load**: 
    - Speed: 180 rpm
    - Current: 0.075 A

- **Speed and current equations**:
  - $f(\tau) = 180 - 3.3\tau$
  - $f(\tau) = 0.069 + 0.028\tau$
Pololu Items #3478, #3490 (100:1 Metal Gearmotor 20D 12V CB) Performance at 12 V

- **Max power**: 2.2 W at 30 kg⋅mm, 22% efficiency, 70 rpm, 0.83 A
- **Max efficiency**: 32% at 10 kg⋅mm, 1.2 W, 120 rpm, 0.31 A

**Displacement: f(τ) = 140 − 2.3τ, f(τ) = 0.062 + 0.025τ**

- **Stall torque**: τ_{stall} ≈ 61 kg⋅mm
- **Stall current**: I_{stall} ≈ 1.6 A
- **No-load speed**: 140 rpm
- **No-load current**: 0.075 A

The graph illustrates the relationship between power, efficiency, speed, current, and torque for the specified gearmotor configuration at 12 V.
Pololu Items #3479, #3491 (125:1 Metal Gearmotor 20D 12V CB) Performance at 12 V

- Max power: 2.2 W at 39 kg mm, 23% efficiency, 56 rpm, 0.82 A
- Max efficiency: 33% at 13 kg mm, 1.2 W, 94 rpm, 0.31 A
- Torque (kg mm): 
  - \( f(\tau) = 110 - 1.4\tau \)
  - \( f(\tau) = 0.062 + 0.020\tau \)
  - \( \tau_{\text{stall}} \approx 78 \text{ kg mm} \)
  - \( I_{\text{stall}} \approx 1.6 \text{ A} \)

- No-load speed: 110 rpm
- No-load current: 0.065 A
Pololu Items #3480, #3492 (156:1 Metal Gearmotor 20D 12V CB) Performance at 12 V

- **Max power**: 2.0 W at 45 kg⋅mm, 21% efficiency, 45 rpm, 0.81 A
- **Max efficiency**: 31% at 15 kg⋅mm, 1.1 W, 75 rpm, 0.30 A

**Torque (kg⋅mm)**
- $\tau_{\text{stall}} \approx 90$ kg⋅mm
- $I_{\text{stall}} \approx 1.6$ A

**No-load current**: 0.063 A

**No-load speed**: 89 rpm

**Power**

\[ f(\tau) = 89 - 1.0\tau \]

**Current**

\[ f(\tau) = 0.058 + 0.017\tau \]
Pololu Items #3481, #3493 (195:1 Metal Gearmotor 20D 12V CB) Performance at 12 V

- Max power: 1.9 W at 52 kg⋅mm, 20% efficiency, 36 rpm, 0.80 A
- Max efficiency: 29% at 17 kg⋅mm, 1.0 W, 60 rpm, 0.30 A
- Torque (kg⋅mm) vs. Efficiency
- Current (A) vs. Speed (rpm)
- Power (W) vs. Speed (rpm)

f(τ) = 72 − 0.70τ
f(τ) = 0.057 + 0.014τ

τ stall ≈ 100 kg⋅mm
I stall ≈ 1.5 A

No-load speed: 72 rpm
No-load current: 0.068 A

Pololu Items #3482, #3494 (250:1 Metal Gearmotor 20D 12V CB) Performance at 12 V

max efficiency: 30%

at 24 kg⋅mm, 1.2 W, 47 rpm, 0.33 A

no-load speed: 55 rpm

f(τ) = 56 − 0.39τ

f(τ) = 0.067 + 0.011τ

I_{stall} = 1.6 A

τ_{stall} ≈ 140 kg⋅mm

no-load current: 0.076 A

no-load speed: 55 rpm

no-load current: 0.076 A
Pololu Items #3483, #3495 (313:1 Metal Gearmotor 20D 12V CB) Performance at 12 V

**Maximum Efficiency:** 27%

- At 26 kg⋅mm, 1.0 W, 38 rpm, 0.31 A

- **Stall Torque:** $\tau_{\text{stall}} \approx 160 \text{ kg⋅mm}$

- **Stall Current:** $I_{\text{stall}} \approx 1.6 \text{ A}$

- **No-Load Speed:** 44 rpm

- **No-Load Current:** 0.077 A

**Power and Efficiency Equations:**

- $f(\tau) = 45 - 0.28\tau$
- $f(\tau) = 0.060 + 0.010\tau$

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Pololu Items #3484, #3496 (391:1 Metal Gearmotor 20D 12V CB) Performance at 12 V

max efficiency: 29%

at 35 kg\cdot mm, 1.1 W, 30 rpm, 0.31 A

no-load speed: 36 rpm

no-load current: 0.063 A

f(τ) = 36 - 0.17τ

f(τ) = 0.062 + 0.0072τ

τ_{stall} ≈ 210 kg\cdot mm

I_{stall} ≈ 1.6 A

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Pololu Items #3485, #3497 (488:1 Metal Gearmotor 20D 12V CB) Performance at 12 V

max efficiency: 27%
at 43 kg ⋅ mm, 1.0 W, 24 rpm, 0.32 A

f(τ) = 29 − 0.11τ
f(τ) = 0.065 + 0.0060τ

τ_{stall} ≈ 250 kg ⋅ mm
I_{stall} ≈ 1.6 A

no-load speed: 28 rpm
no-load current: 0.075 A