The current used to drive the DC motor typically come from one of these sources:

**Fixed voltage:**
- a battery (changes with discharge)
- a voltage regulator (from rectified AC or battery)

**Adjustable voltage:**
- a linear power transistor (or power op-amp),
- a pulse-width-modulated (PWM) current source, or
- a silicon-controlled-rectifier (SCR) modulated AC source.
LM 317 Voltage Regulator

Current Rating:
LM317T – 1.5 A
(with heat sink)

LM317 - $0.56

R1 = 260Ω
R2 = 1kΩ

+12 to +24 VDC

Motor Leads

1 kΩ potentiometer
Linear power transistors and power op-amps are generally limited to low power (<100 W) applications.
Pulse-Width Modulation

\[ V_{\text{max}} \]

\[ V_a \]
PWM - 80% of Vmax

Average $V_a$ is 80% of $V_{max}$
PWM - 60% of Vmax

Average Va is 60% of Vmax

Armature Voltage, Va

0.00006 sec

0.00010 sec
PWM - 40% of Vmax

Average Va is 40% of Vmax
PWM - 20% of Vmax

Average Va is 20% of Vmax

Armature Voltage, Va

0.00002 sec

0.00010 sec
If the time period $T$ is short compared to the time constants of the system, the motor response will be the same

- PWM switching frequencies in the 10 kHz (or higher) range are frequently used.

Relatively high drive efficiency (up to 80%)

- inefficiency creates heat in the amplifier that must be dissipated!
Pulse Width Modulator for 12 and 24 Volt applications

Q1 Current Rating:
3 A with an IRF521 FET,
>10A with an IRFZ34N FET and heat sink

U1 is an LM339 Quad Comparator

IRF521 - $1.21
IRFZ34N - $1.25
7812 - $0.40
LM339 - $0.32
Half-Wave Rectifier

\[ V_{AC} \]

\[ V_a \]
Full-Wave Rectifier

\[ V_{\text{AC}} \]

\[ V_a \]

\[ + \]

\[ - \]
Silicon Controlled Rectifier

Delay time is adjustable by gate signal
Silicon-Controlled Rectifier Drive

Gate

$V_{AC}$

$V_a$

$+$

$-$

Diagram showing the connection of silicon-controlled rectifiers and the control gate.
Form Factor

- Form factor (FF) is a measure of departure from pure direct current (DC)

\[ FF = \frac{RMS\ current}{average\ current} \]

- half-wave rectified AC
  unfiltered FF = 1.6-2.0, filtered FF = 1.1-1.5

- full-wave rectified AC
  unfiltered FF = 1.1-1.6, filtered FF = 1.0-1.1
DC Motor Current Drives

- Most higher power application use either the PWM or SCR drive methods.
- SCR drives are rated at 90 VDC (for use with 115-120 VAC) or 180 VDC (for use with 230 VAC).