MAX14874 4.5V to 36V Dual Relay/Valve/Motor Driver

General Description

The MAX14874 dual push-pull driver provides a small and simple solution for driving and controlling relays and valves with voltages between 4.5V and 36V.

The MAX14874 is also designed to drive brushed DC motors. Separate COM pins allow monitoring of individual driver load currents. Peak currents up to 2.5A ensure for PWM controlled large motor torque. Low driver on-resistance reduces power dissipation.

The MAX14874 features a charge-pump-less design for reduced external components and low supply current.

The MAX14874 features shoot-through protection and internal free-wheeling diodes that absorb inductive currents. Driver outputs are short-circuit protected against shorts to the supply, and between M1 and M2. An active-low $\overline{\text{FAULT}}$ output signals thermal overload and overcurrents during fault conditions.

The MAX14874 is available in a 12-pin TDFN-EP (3mm x 3mm) package and operates over the -40°C to +85°C temperature range.

Applications

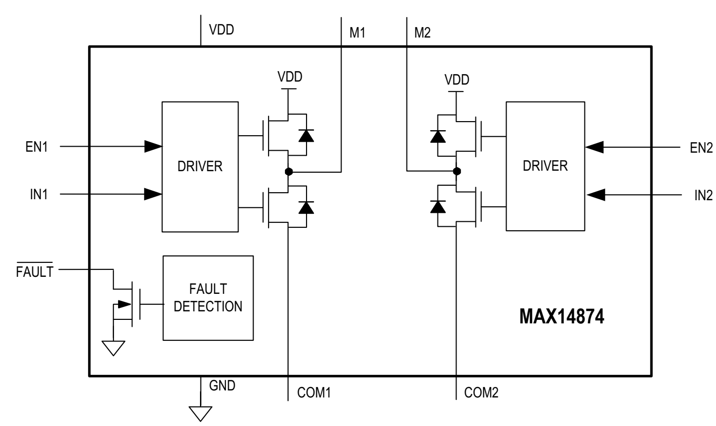
- Valve and Relay Control
- Motor Control
- Coffee Machines

Benefits and Features

- Drive More Power and Reduce Footprint
  - Up to 2.5A Peak Motor Current
  - Flexible 4.5V–36V Supply Enables Longer Runtime
  - Small 3mm x 3mm TDFN-EP Package
- Low Power Dissipation Runs Cooler and Longer
  - 480mΩ (typ) Bridge On-Resistance
- Simplified Designs Reduces Time to Market
  - Individual Current Sensing to Sense Voltages up to 1V
  - Charge-Pump-Less Architecture
  - Independent Driver Control for Each Driver
- Integrated Protection Provides Robust Driving Solutions
  - Thermal Shutdown Undervoltage Lockout
  - Diagnostic $\overline{\text{FAULT}}$ Output
  - -40°C to +85°C Temperature Range

***Ordering Information* appears at end of data sheet.**

Functional Diagram



Absolute Maximum Ratings

(All voltages referenced to GND)
V_{DD} ....-0.3V to +40V
M1, M2 .... -0.3V to (V_{DD}+0.3V)
IN1, IN2, EN1, EN2, $\overline{FAULT}$ .... -0.3V to +6.0V
COM1, COM2 ....-0.3V to +1.2V
Current Into M1, M2 ....±3A

Continuous Power Dissipation (T_A = +70°C)
Multiple-Layer Board (derate at 24.4mW/°C above +70°C) 1951mW
Operating Temperature Range .... -40°C to +85°C
Junction Temperature ....+150ºC
Storage Temperature Range ....-65ºC to +150°C
Lead Temperature (Soldering, 10s) ....+300°C
Solder Temperature (Reflow) ....+260°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Package Thermal Characteristics (Note 1)

Junction-to-Case Thermal Resistance (θ_{JC})
TDFN-EP (Single-Layer Board) ....8.5°C/W
TDFN-EP (Multiple-Layer Board) ....8.5°C/W

Junction-to-Ambient Thermal Resistance (θ_{JA})
TDFN-EP (Single-Layer Board) ....63°C/W
TDFN-EP (Multiple-Layer Board) ....41°C/W

Note 2: Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to www.maximintegrated.com/thermal-tutorial.

Electrical Characteristics

(V_{DD} = 4.5V to 36V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V_{DD} = 12V, T_A = +25°C)(Note 2)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
POWER SUPPLY							
Supply Voltage	V_{DD}			4.5		36	V
Supply Current	I_{DD}	EN1 = EN2 = high, M1/M2 not connected	switching at 50kHz		1		mA
			No switching		0.5	1.2	
Undervoltage Lockout Threshold	V_{UVLO}	V_{DD} rising		3.3	3.8	4.3	V
Undervoltage Lockout Threshold Hysteresis	V_{UVLO_HYST}				400		mV
DRIVER (M1, M2)							
Driver Output Resistance (High-Side + Low-Side)	R_{ON}	COM1 = COM2 = GND, $I_{M\_}$ = 2.5A	T_J = 25°C		280	395	mΩ
			T_J = 125°C		410	580	
Driver Overload Current Limit	I_{M_OL}			3			A
M1, M2 Leakage Current	I_{M_LKG}	EN_ = low $V_{M\_}$ = 0V or V_{DD}		-1		+1	µA
COM1, COM2 Voltage Range	V_{COM}			-0.25		+1	V
COM1, COM2 Off Leakage Current	$I_{COM\_LKG\_OFF}$	EN_ = low, $V_{COM\_}$ = 0V or 1V, M_ unconnected		-3		0	µA
COM1, COM2 On Leakage Current	$I_{COM\_LKG\_ON}$	EN_ = high, IN_ = high or low, $V_{COM\_}$ = 0V or 1V, M_ unconnected		-3		0	µA

Electrical Characteristics (continued)

(V_{DD} = 4.5V to 36V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V_{DD} = 12V, T_A = +25°C)(Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
M1, M2 Body Diode Forward-Voltage	V_{BF}	Low-side diode, EN_ = low, I_F = 2.5A			1.5	V
		High-side diode, EN_ = low, I_F = 2.5A			1.5	
LOGIC SIGNALS (IN1, IN2, EN1, EN2, $\overline{\text{FAULT}}$)						
Input Logic-High Voltage	V_{IH}	IN1, IN2, EN1, EN2	2			V
Input Logic-Low Voltage	V_{IL}	IN1, IN2, EN1, EN2			0.8	V
Input Leakage Current	I_{IL}	IN1, IN2, EN1, EN2, V_{INPUT} = 5.5V or 0V	-1		+1	µA
$\overline{\text{FAULT}}$ Output Low Voltage	V_{OL}	$\overline{\text{FAULT}}$ asserted, I_{SINK} = 5mA			0.5	V
$\overline{\text{FAULT}}$ Off Leakage Current	I_{F_LKG}	$\overline{\text{FAULT}}$ deasserted, $V_{\overline{FAULT}}$ = 5.5V	-1		+1	µA
PROTECTION						
Thermal-Shutdown Threshold	T_{SHDN}	Temperature rising, $\overline{\text{FAULT}}$ asserted		+160		°C
Thermal-Shutdown Hysteresis	T_{SHDN_HYST}			10		°C

AC Electrical Characteristics

(V_{DD} = 4.5V to 36V, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at V_{DD} = 12V, T_A = +25°C)(Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Switching Frequency	f_{SW}	EN_ = high, Switching signal applied at IN_			50	kHz
Dead Time	t_{DEAD}			140		ns
M1, M2 Slew Rate	SR			200		V/µs
M1, M2 High-Side Propagation Delay	t_{PR}	R_L = 1kΩ, C_L = 50pF, IN_ rising, Figure 1		620		ns
M1, M2 Low-Side Propagation Delay	t_{PF}	R_L = 1kΩ, C_L = 50pF, IN_ falling, Figure 1		583		ns
Overcurrent Blanking Time	t_{OC_BL}	M1/M2 is shorted to V_{DD} or GND, Figure 2		1		µs
Overcurrent Autoretry Timeout	t_{OC_TO}	IN_ = high, EN_ = high, $I_{M\_}$ > I_{M_OL}, Figure 2		2		ms
Enable Turn-on Delay	t_{EN_ON}	IN_ = high, R_L = 1kΩ, C_L = 50pF, EN_ rising, M_ rising to 10%, Figure 3		1		µs
Enable Turn-off Delay	t_{EN_OFF}	IN_ = high, R_L = 1kΩ, C_L = 50pF, EN_ falling, M_ falling to 90%, Figure 3		1		µs

Note 2: All units are production tested at T_A = +25°C. Specifications over temperature are guaranteed by design.

Test Circuits/Timing Diagrams

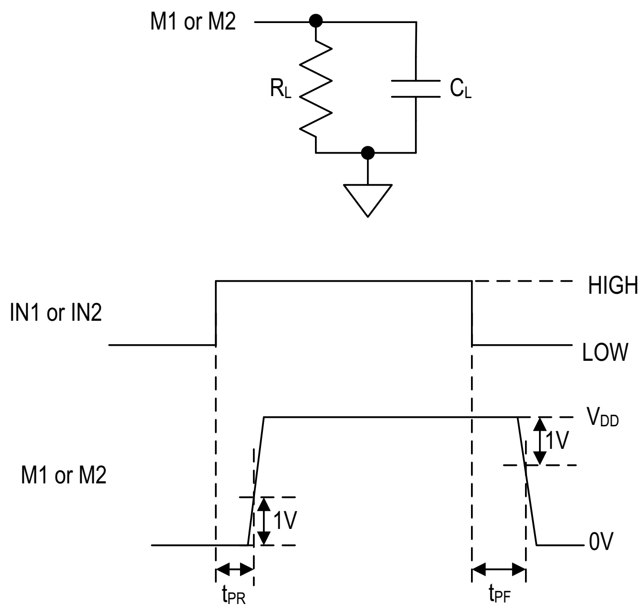


Figure 1. M1/M2 Propagation Delays

Test Circuits/Timing Diagrams (continued)

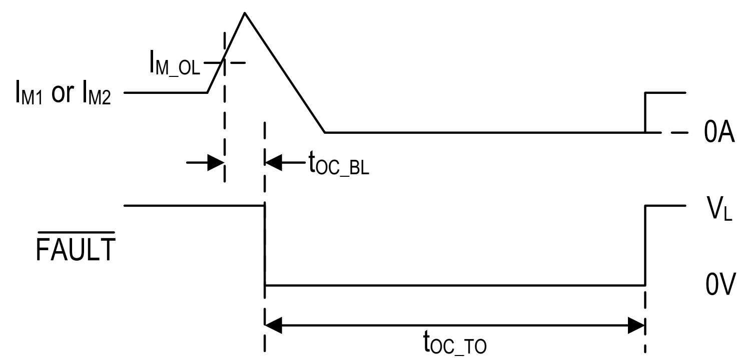


Figure 2. Overcurrent Autoretry Timeout

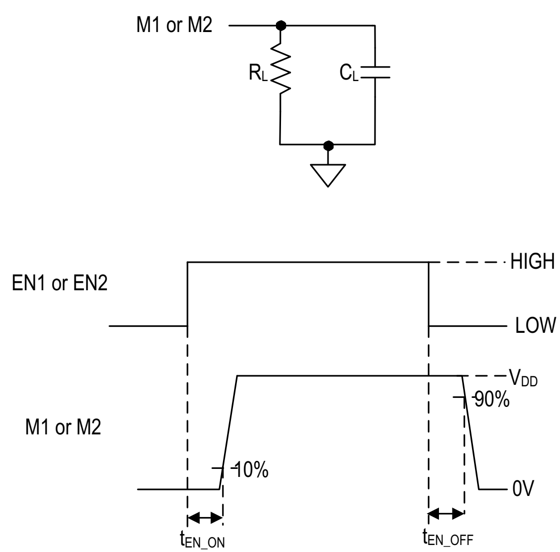
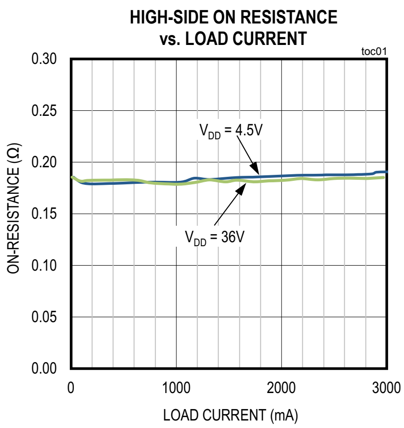
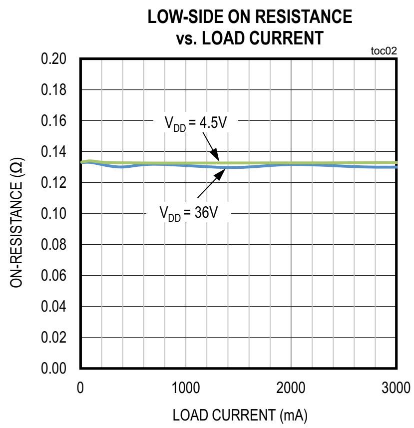


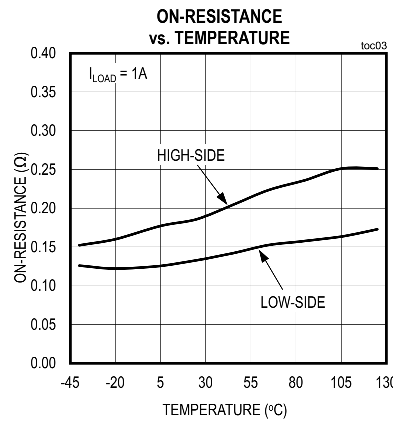
Figure 3. Enable/Disable Delays

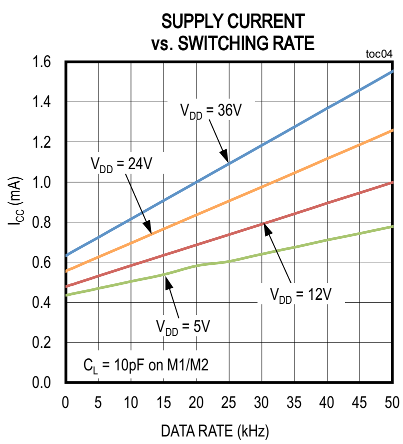
Typical Operating Characteristics

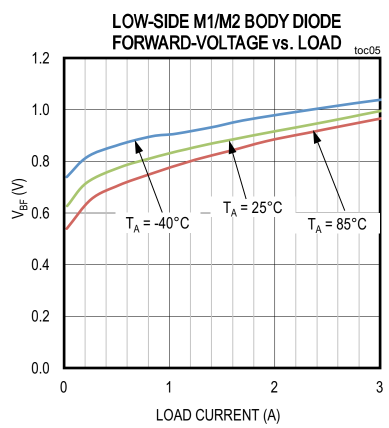
(V_{DD} = 24V, T_A = +25°C, unless otherwise noted.)

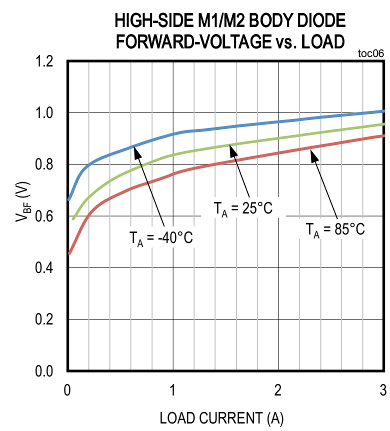




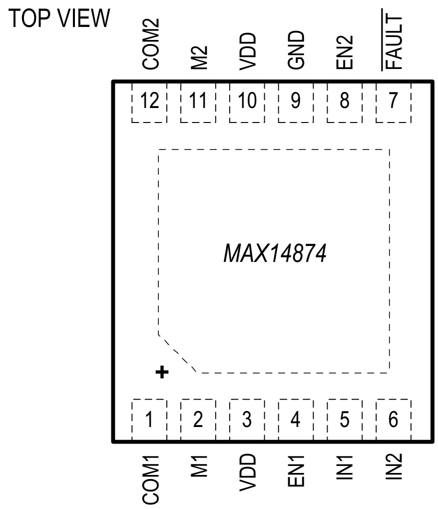








Pin Configuration



TDFN-EP
3mm x 3mm

Pin Description

PIN	NAME	FUNCTION
1	COM1	COM1 Current Output. Connect COM1 to GND or connect a sense resistor, R_{SENSE1}, from COM1 to GND to monitor the current flowing into/out of COM1.
2	M1	Driver Output 1. See the *Function Table* for more information.
3, 10	V_{DD}	Power Supply Input. Bypass V_{DD} to GND with a 1μF ceramic capacitor as close to the device as possible. Connect both V_{DD} pins together.
4	EN1	Active-High Enable Input 1. Drive EN1 high to enable the M1 driver output. M1 is high impedance when EN1 is low.
5	IN1	Control Logic Input 1. Pull IN1 high to drive M1 high. Pull IN1 low to drive M1 low. See the *Function Table* for more information.
6	IN2	Control Logic Input 2. Pull IN2 high to drive M2 high. Pull IN2 low to drive M2 low. See the *Function Table* for more information.
7	$\overline{\text{FAULT}}$	Open-Drain Active-Low Fault Output. $\overline{\text{FAULT}}$ goes low during a short circuit or overcurrent condition and thermal shutdown.
8	EN2	Active-High Enable Input 2. Drive EN2 high to enable the M2 driver output. M2 is high impedance when EN2 is low.
9	GND	Ground
11	M2	Driver Output 2. See the *Function Table* for more information.
12	COM2	COM2 Current Output. Connect COM2 to GND or connect a sense resistor, R_{SENSE2}, from COM1 to GND to monitor the current flowing into/out of COM2.
—	EP	Exposed Pad. Connect to ground.

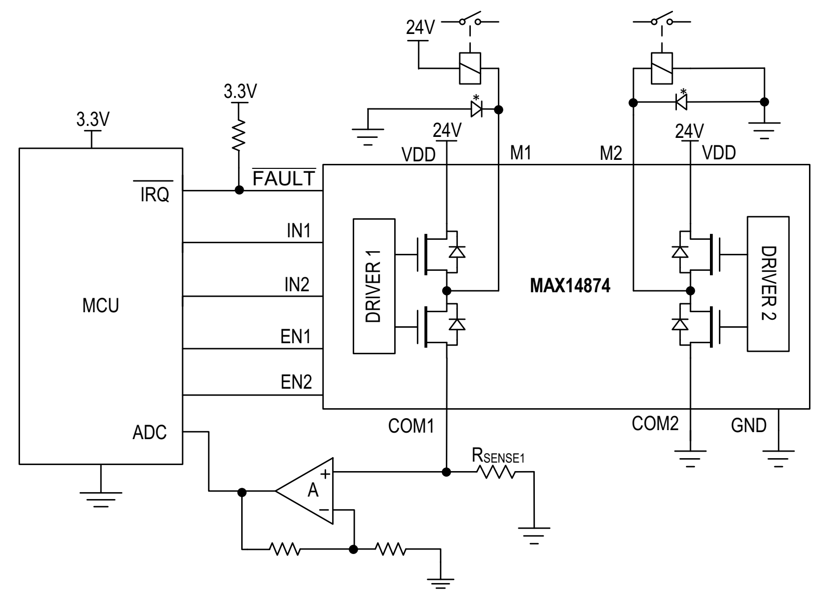
Function Table

EN_/IN_Control Logic

INPUTS		M_ OUTPUT
EN_	IN_	
0	X	High-Impedance
1	0	GND
1	1	V_{DD}

X = Don't care

Functional Diagram



Detailed Description

The MAX14874 relay/valve driver, which can also be used as a DC brushed motor driver, provides a low-power and flexible solution for driving and controlling loads with voltages between 4.5V and 36V. Peak currents of up to 2.8A ensure for large force/torque that is controllable by an external PWM signal.

Charge-pump-less design ensures for minimal external components and low supply current.

Shoot-through protection with a 140ns (typ) dead time ensures low operating current. Internal free-wheeling diodes absorb inductive motor currents. The $\overline{\text{FAULT}}$ output signals thermal overload and overcurrents.

Overcurrent Protection

The MAX14874 is protected against shorts on M1/M2 to V_{DD} and between M1 and M2 via overcurrent limiting. When a current above 6A (typ) flows through M1 or M2 for longer than 1μs, an overcurrent condition is detected and the H-bridge drivers are automatically disabled and the $\overline{\text{FAULT}}$ output asserts.

If the overcurrent condition continues for longer than the overcurrent autoretry timeout (2ms, typ) the MAX14874 enters autoretry mode. In autoretry mode, the M1 and M2 outputs are re-enabled for 1μs (typ) and $\overline{\text{FAULT}}$ goes high impedance. The drivers are disabled again and $\overline{\text{FAULT}}$ is re-asserted if the overcurrent condition persists.

Short Circuit Protection

The M1 and M2 outputs are safe against all short circuits, if the $R_{SENSE\_}$ resistors on COM1 and/or COM2 have a value of less than 50mΩ.

When using a larger sense resistor, protect the part against shorts to GND by connecting a silicon diode (for example MURA205T3) between the M_ driver output and ground. These protection diodes are not needed if the maximum operating supply voltage (V_{DD}) is less than 24V, and the sense resistor, $R_{SENSE\_}$, on COM_ is 100mΩ or less.

Driver Control

The IN_ input is used for motor speed/torque control. Increasing or decreasing the duty cycle at IN_ sets the effective (average) voltage across the motor terminals and allows current control.

When IN_ is logic-high, the motor is driven high (see Function Table). When IN_ is logic low, M_ pin is driven low.

Slope Control

The MAX14874 drivers turn-on and turn-off with active slope control during the M1/M2 transition times. This integrated slew rate limiting reduces EMC, like conducted and radiated EMI, associated with high di/dt and dv/dt rates.

Thermal Shutdown

The MAX14874 includes integrated protection against thermal overload. When the junction temperature exceeds 160°C (typ), the M1 and M2 outputs are tri-stated and $\overline{\text{FAULT}}$ asserted.

M1 and M2 are automatically re-enabled when the junction temperature falls to 150°C (typ).

Current Sensing with R_{SENSE}

Connect a sense resistor ($R_{SENSE\_}$) between COM_ and GND to monitor the load current through that driver during operation. Select R_{SENSE} such that the voltage at COM_ does not exceed 1V.

Applications Information

Layout Considerations

Connect VDD pins together with low-resistance traces. Place a bypass capacitor next to each VDD pin, as close to the device as possible.

Power Considerations

The MAX14874 driver can generate more internal heat/ power than the package for the device can safely dissipate. Total power dissipation for the device is calculated using the following equation:

$$P_{TOTAL} = P_{DRIVER} + P_{SW} + P_D$$

The power dissipated inside of the driver is calculated as:

$$P_{DRIVER} = I_{M\_LOAD}^2 \times R_{ON}$$

where I_{M_LOAD} is the load current and R_{ON} is the on-resistance of the high and low-side FETs.

P_{SW} is the power generated by the driver during the rise/ fall times in switching, and includes both arms of the bridge. Calculate P_{SW} using the following equation:

$$P_{SW} = I_{M\_LOAD} \times 2 \times V_{DS}$$

$$= I_{M\_LOAD} \times 2 \times (1/2 \times V_{DD} \times f_{SW} \times t_R)$$

where I_{M_LOAD} is the load current, t_R is the 200ns (typ) rise or fall time of the driver output, and f_{SW} is the switching frequency.

The internal diodes dissipate power during switching, as well. Calculate the power dissipated in the diodes as:

$$P_D = I_{M\_LOAD} \times 2 \times V_{BF} \times t_{DEAD} \times f_{SW}$$

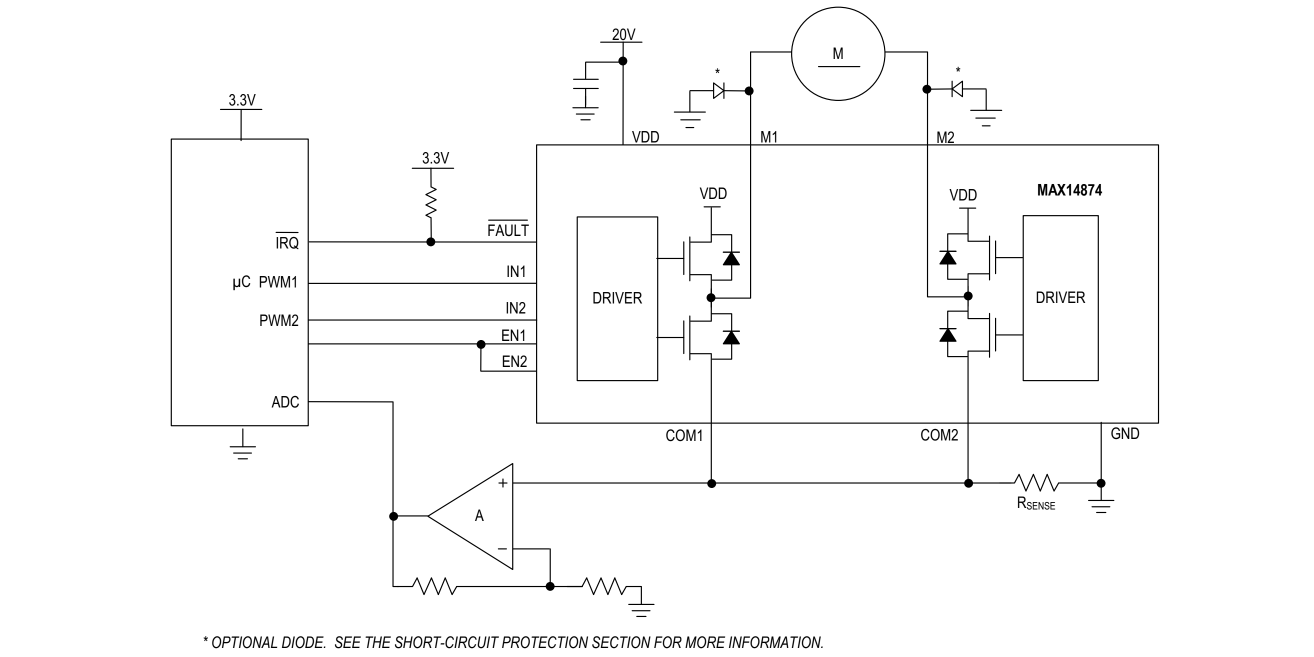


Figure 4. Motor Control Operation with External Current Regulation

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX14874ETC+	-40°C to +85°C	12 TDFN-EP

+Denotes a lead(Pb)-free/RoHS-compliant package.

**EP = Exposed pad*

Chip Information

PROCESS: BiCMOS

Package Information

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
12 TDFN-EP	TD1233-1	**21-0664**	**90-0397**

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	4/17	Initial release	—

