National Semiconductor

July 2006

LM4570
Single-Ended Input Motor Driver

General Description

The LM4570 is a single supply motor driver for improved sensory experience in mobile phones and other handheld devices. The LM4570 is capable of driving up to 192mA while operating from a 3V supply. Near rail-to-rail output swing under load ensures sufficient voltage drive for most DC motors, while the differential output drive allows the voltage polarity across the motor to be reversed quickly. Reversing the voltage gives the LM4570 the ability to drive a motor both clock-wise and counter clock-wise from a single supply.

The LM4570 features fast turn on time, and a wide input voltage range for precise speed control. A low power shutdown mode minimizes power consumption.

Thermal and output short circuit protection prevents the device from being damaged during fault conditions.

Key Specifications

■ High Output Current @ V_{DD} = 3V	192mA
■ Fast Turn On Time @ 3V	2.4ms
■ Quiescent Power Supply Current @ 3V	1.9mA
■ Shutdown Current	0.1µA (typ)

Features

- Output Short Circuit Protection
- High Output Current Capability
- Wide Output Voltage Range
- Fast Turn on Time
- Output Short Circuit Protection
- Low Power Shutdown Mode
- Minimum external components
- Available in space-saving LLP package

Applications

- Mobile Phones
- PDAs
- Video Game Systems

Typical Application

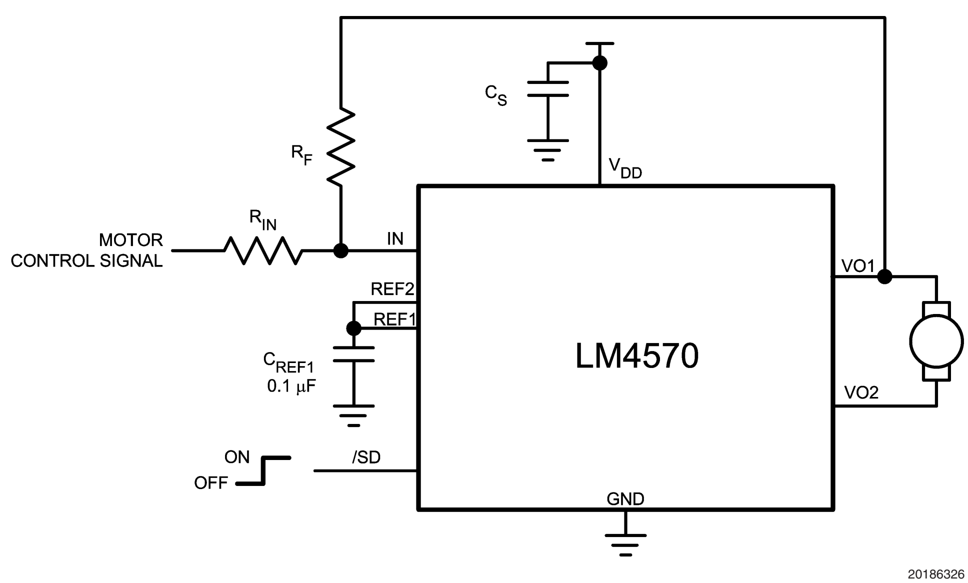
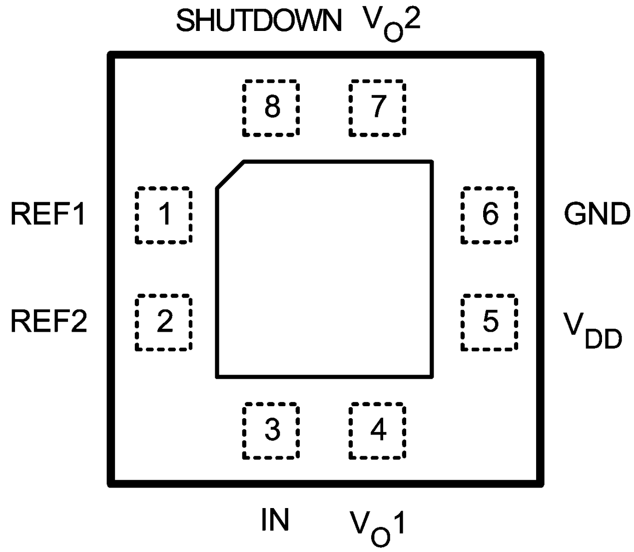


FIGURE 1. Typical Motor Driver Application Circuit

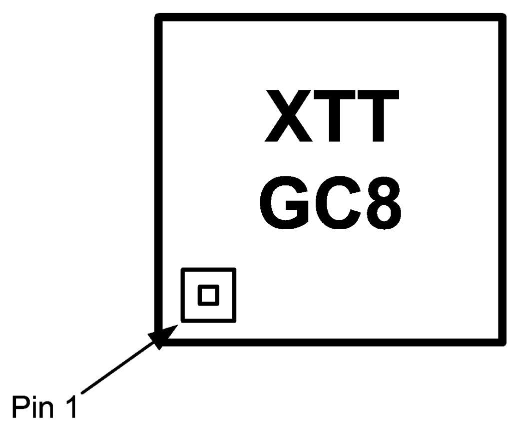
Connection Diagrams

Leadless Leadframe Package (LLP)
LQ Package



Top View
Order Number LM4570LQ
See NS Package Number LQB08A

LLP Marking



Top View
X - One digit date code
TT - Lot traceability
G - Boomer Family
C8 - LM4570LQ

Absolute Maximum Ratings (Note 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage (Note 1)	6.0V
Storage Temperature	−65˚C to +150˚C
Voltage at Any Input Pin	−0.3V ≥ to V_{DD} +0.3V
Power Dissipation (Note 3)	Internally Limited
ESD Susceptibility (Note 4)	2000V
ESD Susceptibility (Note 5)	200V
Junction Temperature (T_{JMAX})	150˚C
Thermal Resistance	
θ_{JA} (LLP)	140˚C/W

Operating Ratings

Temperature Range	
$T_{MIN} \leq T_A \leq T_{MAX}$	−40˚C ≤ T_A ≤ 85˚C
Supply Voltage	2.4V ≤ V_{DD} ≤ 5.5V

Electrical Characteristics V_{DD} = 5V (Notes 1, 2)

The following specifications apply for V_{DD} = 5V, A_{V-BTL} = 6dB unless otherwise specified. Limits apply for T_A = 25˚C.

Symbol	Parameter	Conditions	LM4570		Units (Limits)
			Typical	Limit	
			(Note 6)	(Notes 7, 8)	
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0V, I_L = 0A, No Load	2.5	5.5	mA (max)
		V_{IN} = 0V, I_L = 0A, R_L = 30Ω	2.6	5.5	
I_{SD}	Shutdown Current	V_{SD} = GND	0.1	1.5	µA (max)
V_{IH}	Logic Input High			1.4	V (min)
V_{IL}	Logic Input Low			0.4	V (max)
V_{OS}	Output Offset Voltage		5	±35	mV (max)
I_{OUT}	Output Current	V_{OH}, V_{OL} ≤ 250mV	268		mA
T_{WU}	Wake-up time		2.5		ms (max)
V_{OH}	Output High Voltage	R_L = 30Ω specified as $\|V_{DD}$ - $V_{OH}\|$	146	200	mV (max)
V_{OL}	Output Low Voltage	R_L = 30Ω specified as $\|GND + V_{OH}\|$	106	200	mV (max)

Electrical Characteristics V_{DD} = 3V (Notes 1, 2)

The following specifications apply for V_{DD} = 3V, A_{V-BTL} = 6dB unless otherwise specified. Limits apply for T_A = 25˚C.

Symbol	Parameter	Conditions	LM4570		Units (Limits)
			Typical	Limit	
			(Note 6)	(Notes 7, 8)	
I_{DD}	Quiescent Power Supply Current	V_{IN} = 0V, I_L = 0A, No Load	1.9	4	mA (max)
		V_{IN} = 0V, I_L = 0A, R_L = 30Ω	1.95	4	
I_{SD}	Shutdown Current	V_{SD} = GND	0.1	1.0	µA (max)
V_{IH}	Logic Input High			1.4	V (min)
V_{IL}	Logic Input Low			0.4	V (max)
V_{OS}	Output Offset Voltage		5	±35	mV (max)
I_{OUT}	Output Current	V_{OH}, V_{OL} ≤ 200mV	192		mA
T_{WU}	Wake-up time		2.4		ms (max)
V_{OH}	Output High Voltage	R_L = 30Ω specified as $\|V_{DD}$ - $V_{OH}\|$	90	110	mV (max)
V_{OL}	Output Low Voltage	R_L = 30Ω specified as $\|V_{DD}$ - $V_{OH}\|$	63	110	mV (max)

Note 1: All voltages are measured with respect to the ground pin, unless otherwise specified.

Note 2: *Absolute Maximum Ratings* indicate limits beyond which damage to the device may occur. *Operating Ratings* indicate conditions for which the device is functional, but do not guarantee specific performance limits. *Electrical Characteristics* state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not guaranteed for parameters where no limit is given; however, the typical value is a good indication of device performance.

Note 3: The maximum power dissipation must be de-rated at elevated temperatures and is dictated by T_{JMAX}, θ_{JC}, and the ambient temperature T_A. The maximum allowable power dissipation is $P_{DMAX} = (T_{JMAX} - T_A) / \theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is lower. For the LM4570, T_{JMAX} = 150˚C and the typical θ_{JA} for the LLP package is 140˚C/W.

Note 4: Human body model, 100pF discharged through a 1.5kΩ resistor.

Note 5: Machine Model, 220pF–240pF discharged through all pins.

Note 6: Typicals are measured at 25˚C and represent the parametric norm.

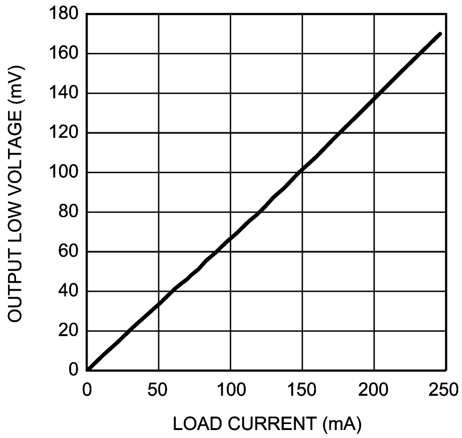
Note 7: Limits are guaranteed to National's AOQL (Average Outgoing Quality Level).

Note 8: Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

Note 9: Shutdown current is measured in a normal room environment. Exposure to direct sunlight will increase I_{SD} by a maximum of 2µA.

Typical Performance Characteristics

Output Low Voltage vs Load Current
V_{DD} = 3V



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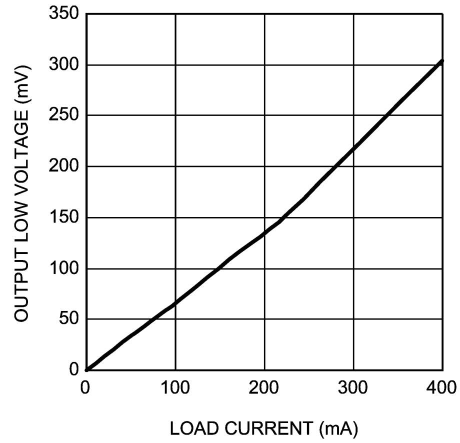
Output Low Voltage vs Load Current
V_{DD} = 5V



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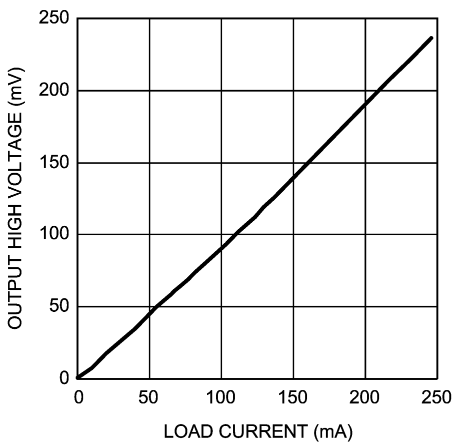
Output High Voltage vs Load Current
V_{DD} = 3V



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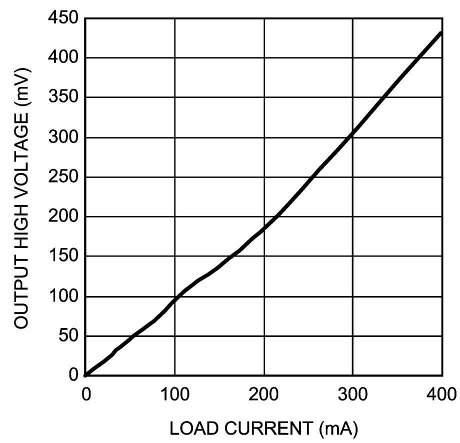
Output High Voltage vs Load Current
V_{DD} = 5V



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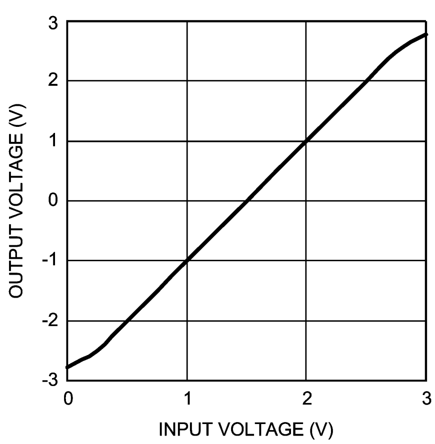
Output Voltage vs Input Voltage
V_{DD} = 3V, R_L = 20Ω



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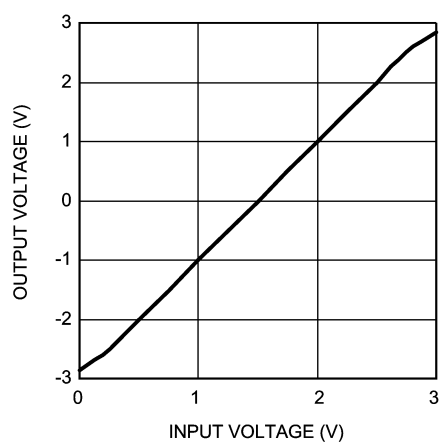
Output Voltage vs Input Voltage
V_{DD} = 3V, R_L = 30Ω



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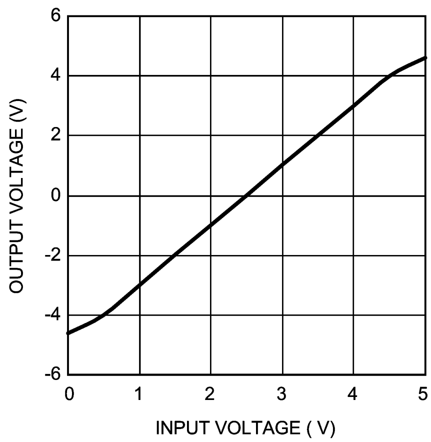
Typical Performance Characteristics (Continued)

Output Voltage vs Input Voltage
V_{DD} = 5V, R_L = 20Ω



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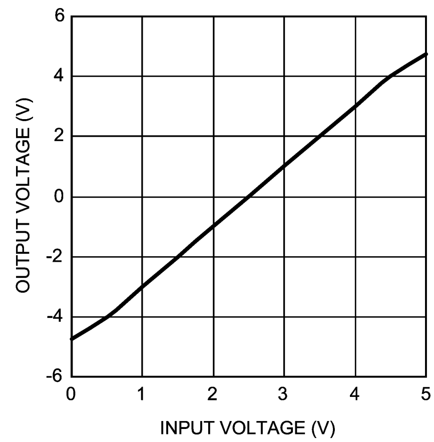
Output Voltage vs Input Voltage
V_{DD} = 5V, R_L = 30Ω



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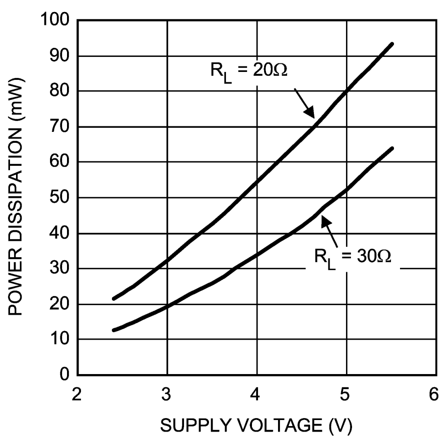
Power Dissipation vs Supply Voltage



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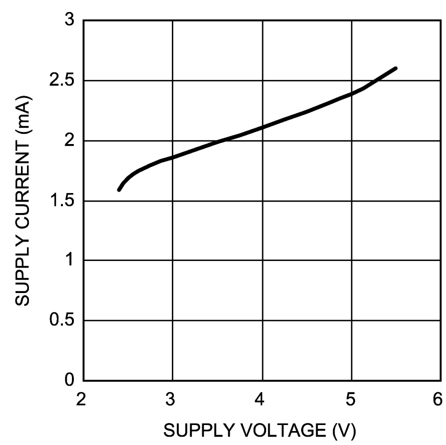
Supply Current vs Supply Voltage



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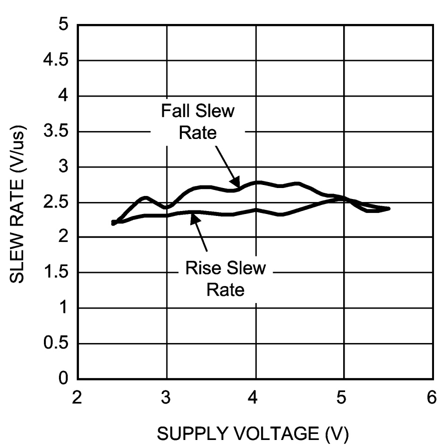
Slew Rate vs Supply Voltage
R_L = 30Ω



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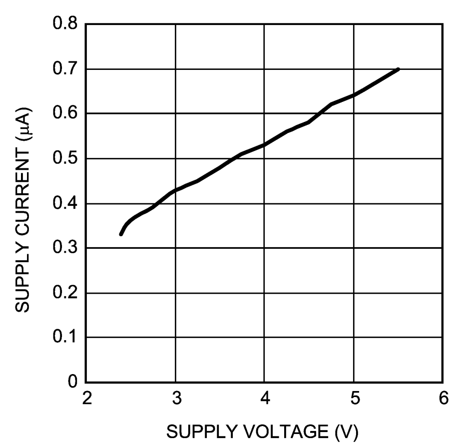
Shutdown Supply Current vs Supply Voltage



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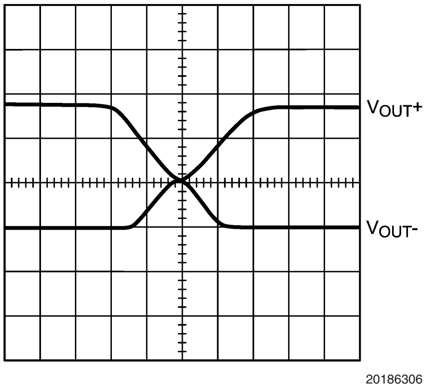
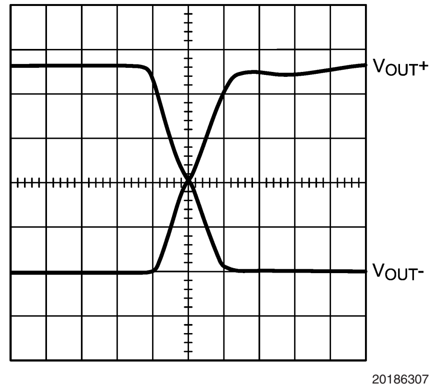
Typical Performance Characteristics (Continued)

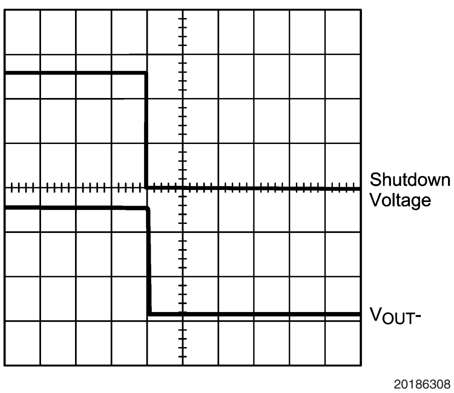
Output Transition High to Low, Low to High
V_{DD} = 3V, 1V/div, 400ns/div



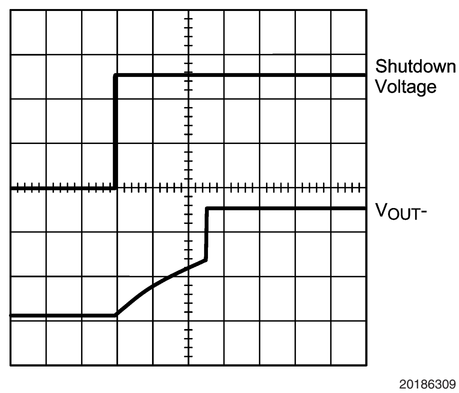
Output Transition High to Low, Low to High
V_{DD} = 5V, 1V/div, 1µs/div



Turn-Off Time
V_{DD} = 5V, 2V/div, 1ms/div



Turn-On Time
V_{DD} = 5V, 2V/div, 1ms/div



Application Information

BRIDGE CONFIGURATION EXPLANATION

The LM4570 uses a bridged architecture that drives a load differentially. The BTL design offers several advantages over a single-ended design. The the device outputs, V_O1 and V_O2, both source and sink current, which means that the polarity of the voltage across the motor can be reversed quickly (Figure 2). A single-ended device would need to operate from split supplies to achieve this behavior. The ability to reverse the voltage polarity is necessary in applications where a negative (reverse polarity) pulse is used to quickly stop the motor. If the drive voltage is just removed from the motor (not reversed) then the motor will continue to spin until the residual energy stored in the windings has dissipated.

The output voltage of the LM4570 is determined by the difference between the input voltage and V_{REF1} , as well as the differential gain of the device. The output voltage is given by the following:

$$V_O1 - V_O2 = A_{VD}(V_{IN} - V_{REF1})$$

For input voltages that are less than the reference voltage, the differential output voltage is negative. For input voltages that are greater than the reference voltage, the differential output voltage is positive. For example, when operating from a 5V supply (V_{REF1} = 2.5V) and with a differential gain of 6dB, with a 1V input, the voltage measured across V_O1 and V_O2 is -3V, with a 4V input, the differential output voltage is +3V.

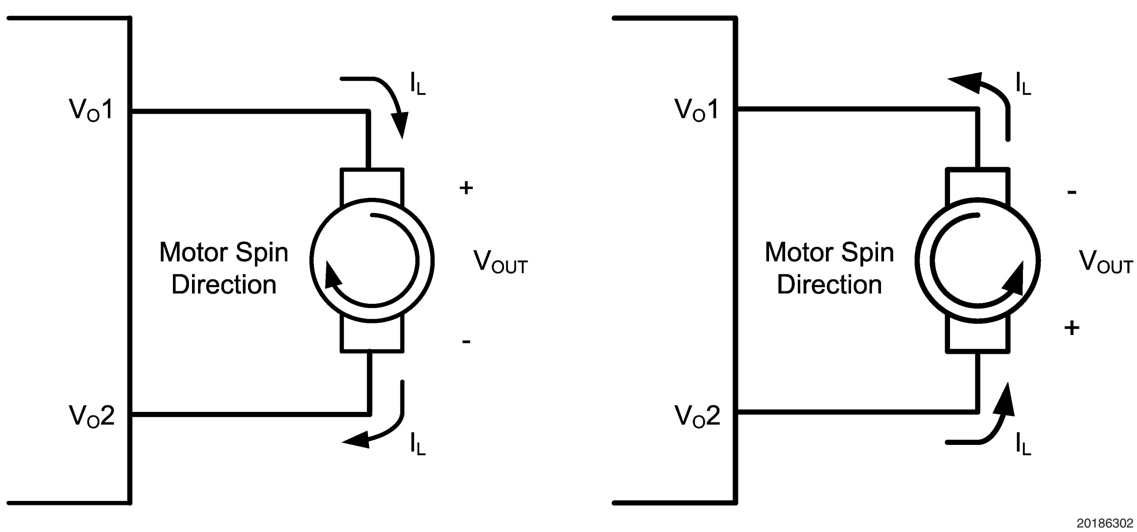


FIGURE 2. Voltage Polarity and Motor Direction

Application Information (Continued)

GAIN SETTING

The resistors R_{IN} and R_F set the gain of the LM4570, given by:

$$V_{VD} = 2 \times (R_F / R_{IN})$$

Where A_{VD} is the differential gain. A_{VD} differs from single-ended gain by a factor of 2. This doubling is due to the differential output architecture of the LM4570. Driving the load differentially doubles the output voltage compared to a single-ended output amplifier under the same conditions.

POWER DISSIPATION

The Power Dissipation vs. Supply Voltage graph in the Operating Curves section shows the power dissipation of the LM4570 with the input equal to the supply voltage, meaning the outputs swing rail-to-rail. This configuration results in the output devices of the LM4570 operating in the linear region, essentially very small resistors determined by the $R_{DS(ON)}$ of the output devices. Under these conditions, the power dissipation is dominated by the I*R drop associated with the output current across the $R_{DS(ON)}$ of the output transistors, thus the power dissipation is very low (60mW for a 800mW output).

When the input voltage is not equal to GND or V_{DD}, the power dissipation of the LM4570 increases (Figure 3). Under these conditions, the output devices operate in the saturation region, where the devices consume current in addition to the current being steered to the load, increasing the power dissipation. Power dissipation for typical motor driving applications should not be an issue since the most of the time the device outputs will be driven rail-to-rail.

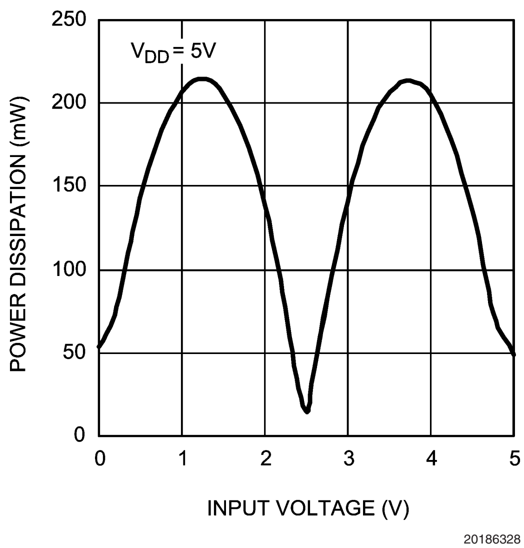


FIGURE 3. Power Dissipation vs. Input Voltage

EXPOSED-DAP MOUNTING CONSIDERATIONS

The LM4570 is available in an 8-pin LLP package which features an exposed DAP (die attach paddle). The exposed DAP provides a direct thermal conduction path between the die and the PCB, improving the thermal performance by reducing the thermal resistance of the package. Connect the exposed DAP to GND through a large pad beneath the device, and multiple vias to a large unbroken GND plane. For best thermal performance, connect the DAP pad to a GND plane on an outside layer of the PCB. Connecting the DAP to a plane on an inner layer will result in a higher thermal resistance. Ensure efficient thermal conductivity by plugging and tenting the vias with plating and solder mask, respectively.

POWER SUPPLY BYPASSING

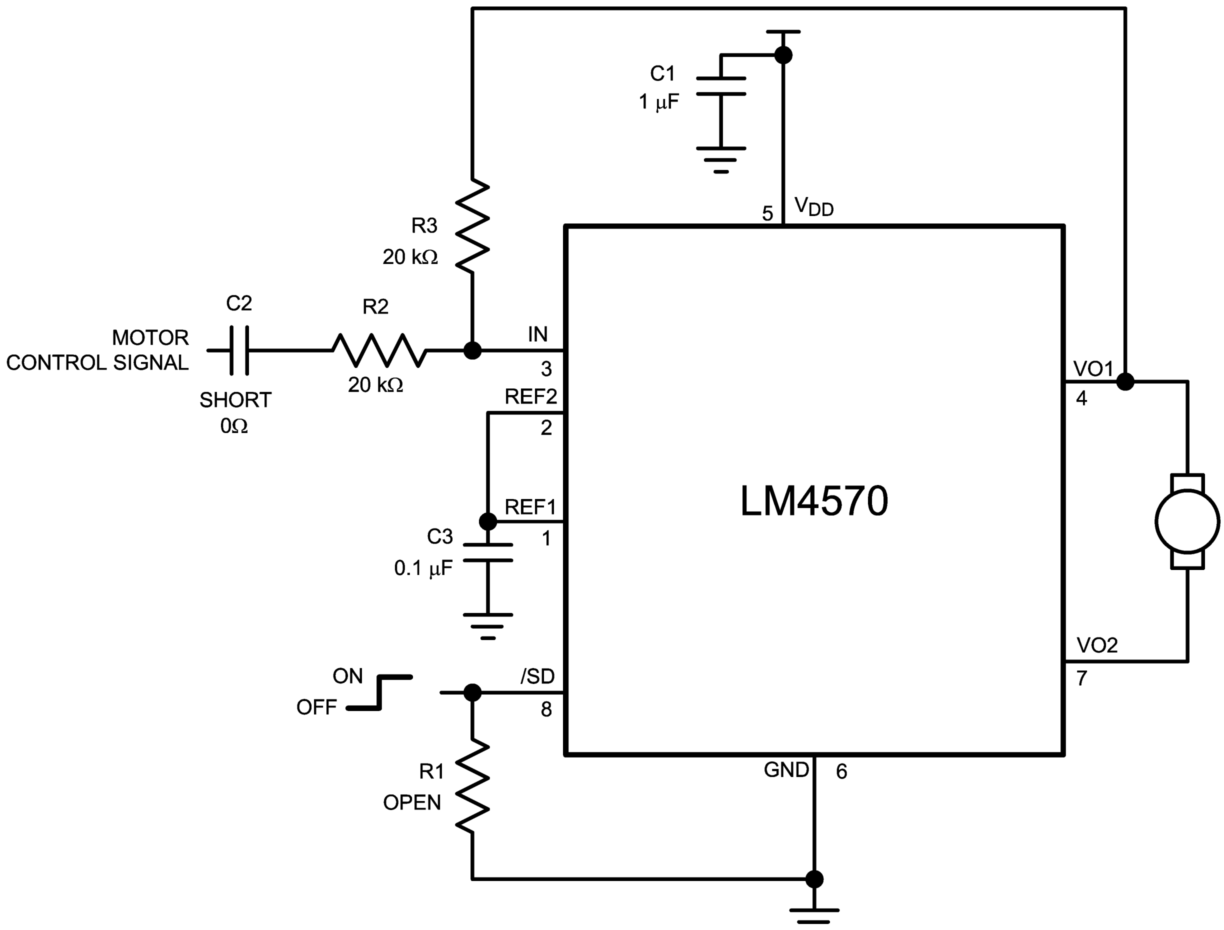
Good power supply bypassing is critical for proper operation. Locate both the REF1 and V_{DD} bypass capacitors as close to the device as possible. Typical applications employ a regulator with a 10µF tantalum or electrolytic capacitor and a ceramic bypass capacitor which aid in supply stability. This does not eliminate the need for bypass capacitors near the LM4570. Place a 1µF ceramic capacitor as close to V_{DD} as possible. Place a 0.1µF capacitor as close to REF1 as possible. Smaller values of C_{REF1} may be chosen for decreased turn on times.

SHUTDOWN FUNCTION

The LM4570 features a low power shutdown mode that disables the device and reduces quiescent current consumption to 0.1µA. Driving /SD Low disables the amplifiers and bias circuitry, and drives $V_{REF1}$and the outputs to GND. Connect /SD to V_{DD} for normal operation.

Application Information (Continued)

DEMO BOARD LAYOUT



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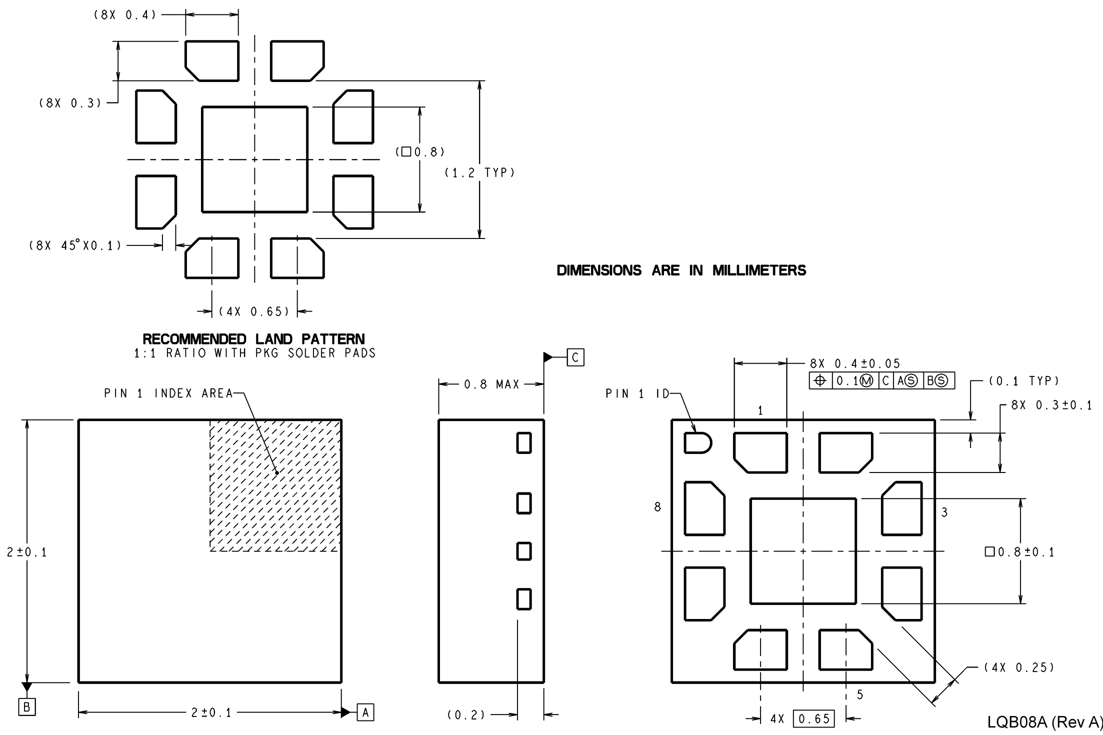
Revision History

Rev	Date	Description
1.0	04/13/06	Initial release.

Physical Dimensions inches (millimeters) unless otherwise noted



LLP Package
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NS Package Number LQB08A

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