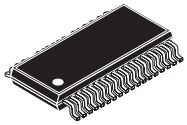
Document Number: MPC17550
Rev. 2.0, 7/2006

RoHS

Quad H-Bridge Micromotor Driver with DC/DC Boost Converter

17550

H-BRIDGE MOTOR DRIVER



EV SUFFIX (Pb-FREE)
98ASA10591D
36-TERMINAL VMFP

The 17550 is a monolithic quad H-Bridge power IC ideal for portable electronic applications containing tiny bipolar stepper motors and/or brush DC-motors powered by two-to-four cell NiCd/NiMH batteries.

The 17550 operates from 2.5 V to 5.5 V, with independent control of each H-Bridge via parallel 3.0 V or 5.0 V logic-compatible I/O. The device features an on-board DC/DC boost converter that allows motor operation all the way down to 1.6 V (the boost converter supplies the gate-drive voltage for each of the four independent H-bridge output stages). Each output bridge has its own gate-drive and logic circuitry with built-in shoot-through current protection.

The 17550 has four operating modes: Forward, Reverse, Brake, and Tri-Stated (High Impedance). The 17550 has a low total $R_{DS(ON)}$ of 1.2 Ω max @ 25°C. In addition, it can be set into a very low current-drain standby mode.

The H-Bridge outputs can be independently PWM'ed at up to 200 kHz for speed/torque and current control. The 17550 can efficiently drive many types of micromotors owing to its low output resistance and high output slew rates.

ORDERING INFORMATION		
Device	**Temperature Range (T_A)**	**Package**
MPC17550EV/EL	-10°C to 60°C	36 VMFP

Features

- Low Total $R_{DS(ON)}$ 0.7 Ω (Typ), 1.2 Ω (Max) @ 25°C
- Output Current 700 mA (Continuous per Output)
- Shoot-Through Current Protection Circuit
- PWM Control Input Frequency up to 200 kHz
- Built-In DC/DC Boost Converter
- Low Power Consumption Standby Mode
- Undervoltage Detection and Shutdown Circuit
- Pb-Free Packaging Designated by Suffix Code EV

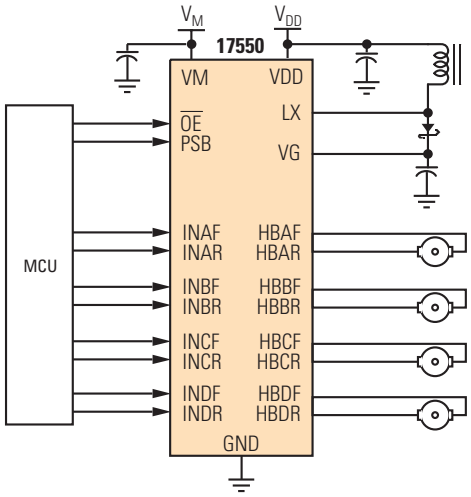


Figure 1. 17550 Simplified Application Diagram

ADVANCE INFORMATION*

* This document contains certain information on a new product.
Specifications and information herein are subject to change without notice.

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INTERNAL BLOCK DIAGRAM

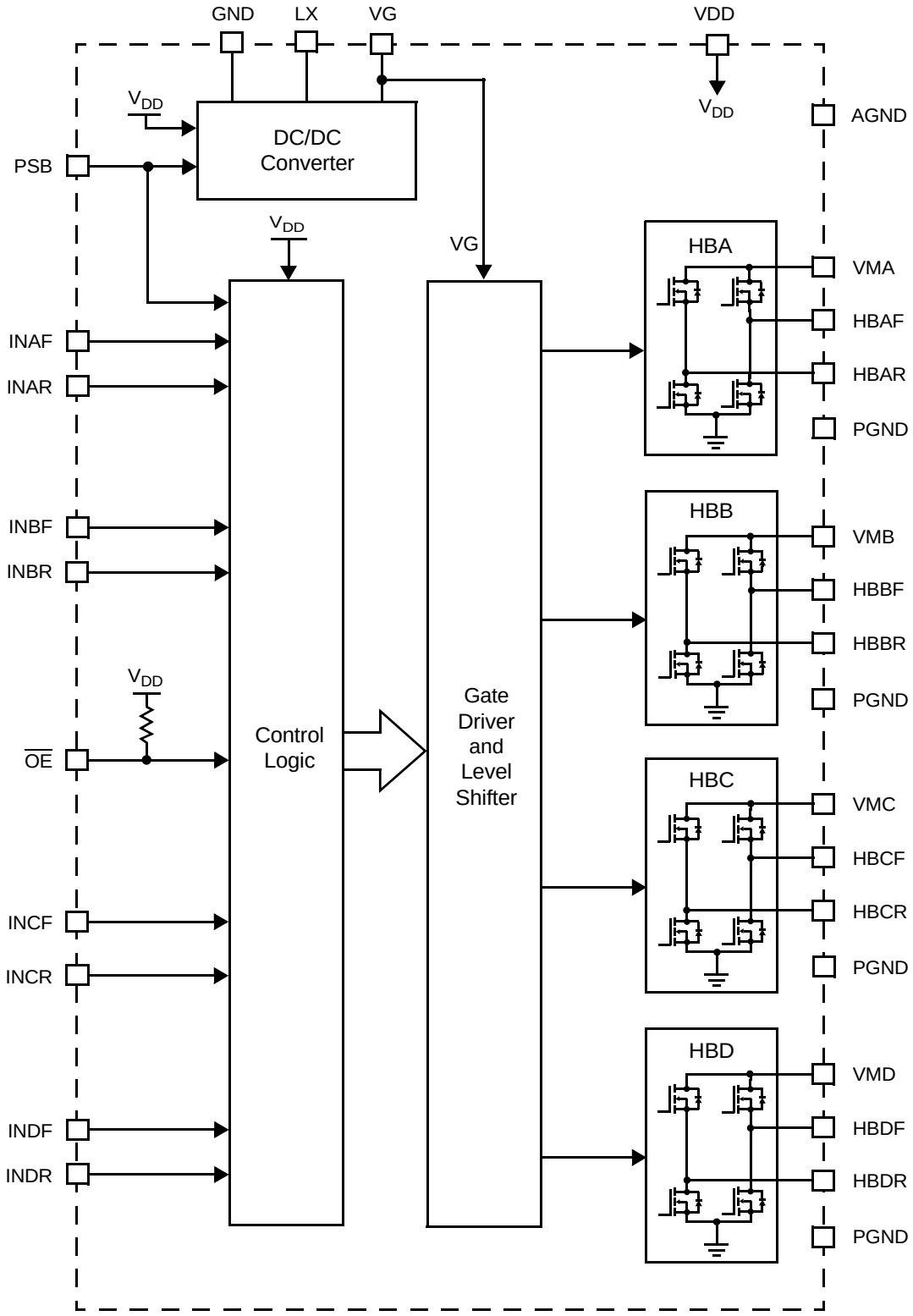


Figure 2. 17550 Simplified Internal Block Diagram

TERMINAL CONNECTIONS

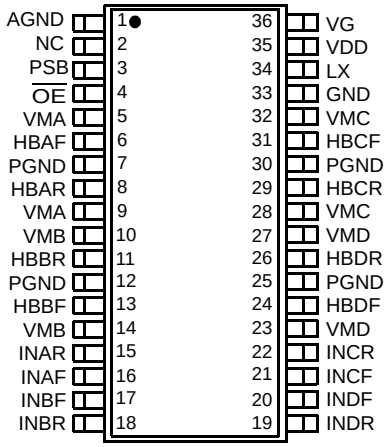


Figure 3. 17550 Terminal Connections

Table 1. Terminal Function Description

Terminal	Terminal Name	Formal Name	Definition
1	AGND	Analog Ground	Analog and logic signal ground reference terminal.
2	NC	No Connect	No connection to this terminal.
3	PSB	Power Standby	Power standby mode control terminal.
4	$\overline{OE}$	Output Enable	Logic output Enable control of H-Bridges (Low = True).
5, 9	VMA	Motor Drive Power Supply A	Power supply voltage connection for Motor “A” (top of HBA).
6	HBAF	HBA Forward Output	Forward output of H-Bridge A.
8	HBAR	HBA Reverse Output	Reverse output of H-Bridge A.
10, 14	VMB	Motor Drive Power Supply B	Power supply voltage connection for Motor “B” (top of HBB).
11	HBBR	HBB Reverse Output	Reverse output of H-Bridge B.
7, 12, 25, 30	PGND	Power Ground	Power ground connection.
13	HBBF	HBB Forward Output	Forward output of H-Bridge B.
15	INAR	Input Control HBA Reverse	Control signal input for H-Bridge A reverse.
16	INAF	Input Control HBA Forward	Control signal input for H-Bridge A forward.
17	INBF	Input Control HBB Forward	Control signal input for H-Bridge B forward.
18	INBR	Input Control HBB Reverse	Control signal input for H-Bridge B reverse.
19	INDR	Input Control HBD Reverse	Control signal input for H-Bridge D reverse.
20	INDF	Input Control HBD Forward	Control signal input for H-Bridge D forward.
21	INCF	Input Control HBC Forward	Control signal input for H-Bridge C forward.
22	INCR	Input Control HBC Reverse	Control signal input for H-Bridge C reverse.
23, 27	VMD	Motor Drive Power Supply D	Power supply voltage connection for Motor “D” (top of HBD).
24	HBDF	HBD Forward Output	Forward output of H-Bridge D.
26	HBDR	HBD Reverse Output	Reverse output of H-Bridge D.
28, 32	VMC	Motor Drive Power Supply C	Power supply voltage connection for Motor “C” (top of HBC).

Table 1. Terminal Function Description (continued)

Terminal	Terminal Name	Formal Name	Definition
29	HBCR	HBC Reverse Output	Reverse Output of H-Bridge C.
31	HBCF	HCB Forward Output	Forward Output of H-Bridge C.
33	GND	Ground	Control circuit ground terminal for DC/DC circuit ground.
34	LX	DC/DC Converter Switching Transistor Output	Open-drain output of the internal DC/DC converter circuit.
35	VDD	Logic Supply	Control circuit power supply terminal.
36	VG	Gate-Driver Circuit Power Supply	Input terminal for the gate-drive voltage.

ELECTRICAL CONNECTIONS

MAXIMUM RATINGS

Table 2. Maximum Ratings

All voltages are with respect to ground unless otherwise noted. Exceeding the ratings may cause a malfunction or permanent damage to the device.

Rating	Symbol	Value	Unit
Motor Supply Voltage	V_M	-0.5 to 9.0	V
Gate-Driver Circuit Power Supply Voltage	V_G	V_{DD} -0.5 to 14	V
Logic Supply Voltage	V_{DD}	-0.5 to 6.0	V
Signal Input Voltage (1)	V_{IN}	-0.5 to V_{DD} +0.5	V
Driver Output Current			A
Continuous (2)	I_O	0.7	
Peak (3)	I_{OPK}	2.0	
ESD Voltage (4)			V
Human Body Model	V_{ESD1}	±2000	
Machine Model	V_{ESD2}	±100	
Storage Temperature Range	T_{STG}	-65 to 150	°C
Operating Ambient Temperature	T_A	-10 to 60	°C
Operating Junction Temperature	T_J	-10 to 150	°C
Thermal Resistance (5)	$R_{\theta JA}$	TBD	°C/W
Power Dissipation (6)	P_D	1500	mW
Soldering Temperature (7)	T_{SOLDER}	260	°C

Notes

1. V_{IN} is the voltage level applied to any input terminal.
2. I_O is measured as the load current flowing through the H-bridge.
3. T_A = 25°C, pulse width < 10 ms at intervals > 0.2 seconds.
4. ESD1 testing is performed in accordance with the Human Body Model (C_{ZAP} = 100 pF, R_{ZAP} = 1500 Ω), ESD2 testing is performed in accordance with the Machine Model (CZAP = 200 pF, RZAP = 0 Ω).
5. Mounted on 37 x 50 Cu area (1.6 mm FR-4 PCB).
6. Maximum at T_A = 25°C.
7. Soldering temperature limit is for 10 seconds maximum duration. Not designed for immersion soldering. Exceeding these limits may cause malfunction or permanent damage to the device.

STATIC ELECTRICAL CHARACTERISTICS

Table 3. STATIC ELECTRICAL CHARACTERISTICS

Characteristics noted under conditions T_A = 25°C, V_{DD} = 3.0 V, V_M = 2.5 V, GND = 0 V, f_{IN} = 176 kHz unless otherwise noted. Typical values noted reflect the approximate parameter means at T_A = 25°C under nominal conditions unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
POWER					
Motor Supply Voltage	V_M	1.6	2.5	5.5	V
Logic Supply Voltage	V_{DD}	2.5	3.0	5.5	V
Standby Power Supply Current [8]					µA
Motor Supply Standby Current	I_{VMSTBY}	–	–	1.0	
Logic Supply Standby Current	$I_{VDDSTBY}$	–	–	1.0	
Logic Supply Current	I_{VDD}	–	0.3	1.0	mA
Gate Driver Circuit Power Supply Current [9]					
Standby (PSB = “L”)	I_{DDC0}	–	–	1.0	µA
No Signal Operating	I_{DDCN}	–	1.0	3.0	µA
Input Signal Operating [10]	I_{DDC}	–	19	25	mA
Driver Output ON Resistance [11]	$R_{DS(ON)}$	–	0.7	1.2	Ω
GATE DRIVE					
Gate Driver Circuit Power Supply Voltage [12]	V_G	10	11.5	13	V
CONTROL LOGIC					
Logic Input Voltage [13]	V_{IN}	0	–	V_{DD}	V
Logic Input (F, R, PSB, $\overline{OE}$)					
High-Level Input Voltage	V_{IH}	V_{DD} x 0.7	–	–	V
Low-Level Input Voltage	V_{IL}	–	–	V_{DD} x 0.3	V
High-Level Input Current	I_{IH}	–	–	1.0	µA
Low-Level Input Current	I_{IL}	-1.0	–	–	µA

Notes

8. Applies individually to each H-Bridge.
9. Average inductor current for DC/DC converter (connected between V_{DD} and LX [L = 1.0 mH, C = 2.2 µF]).
10. Full drive (input signal to all input control terminals).
11. The total H-bridge ON resistance when V_G is 11.5 V.
12. When voltage is supplied externally without built-in DC/DC.
13. V_{IN} is the voltage level applied to any input.

DYNAMIC ELECTRICAL CHARACTERISTICS

Table 4. DYNAMIC ELECTRICAL CHARACTERISTICS

Characteristics noted under conditions T_A = 25°C, V_{DD} = 3.0 V, V_M = 2.5 V, GND = 0 V, f_{IN} = 176 kHz unless otherwise noted. Typical values noted reflect the approximate parameter means at T_A = 25°C under nominal conditions unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
INPUT					
Pulse Input Frequency (14)	f_{IN}	–	–	200	kHz
Internal Oscillator Frequency	f_{OSC}	–	100	200	kHz
OUTPUT					
Gate Driver Circuit Power Supply Wake-Up Time	t_{VGON}	–	10	20	ms
Propagation Delay Time					µs
Turn-ON Time	t_{PLH}	–	0.2	1.0	
Turn-OFF Time	t_{PHL}	–	0.2	1.0	

Notes

14. f_{IN} is the signal frequency applied to an input terminal (F, R).

TIMING DIAGRAMS

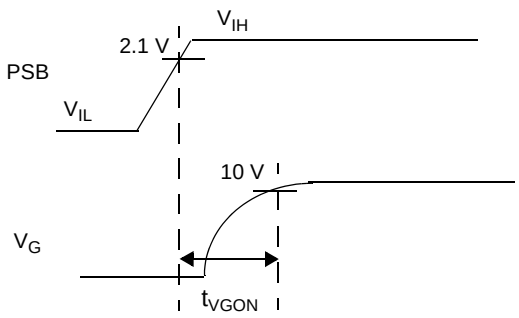


Figure 4. DC/DC Converter Output Waveform

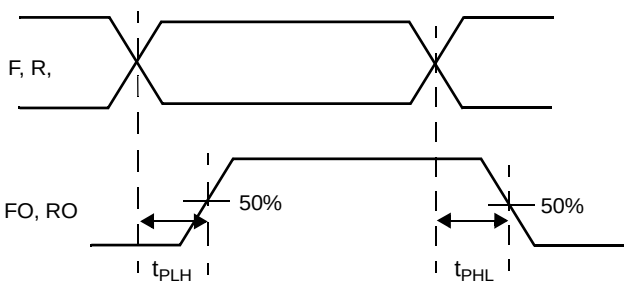


Figure 5. H-Bridge Output Waveform

Table 5. Truth Table

PSB, $\overline{OE}$		INA/INB/INC/IND		HBA/HBB/HBC/HBC	
PSB	**OE**	**IN*F**	**IN*R**	**HB*F**	**HB*R**
H	L	L	L	L	L
H	L	L	H	L	H
H	L	H	L	H	L
H	L	H	H	Z	Z
H	H	X	X	Z	Z
L	X	X	X	Z	Z

H = High.
L = Low.
Z = High impedance.
X = Don't care.
***** = A, B, C, or D.

FUNCTIONAL DESCRIPTION

INTRODUCTION

The 17550 is a monolithic quad H-Bridge ideal for portable electronic applications containing multiple bipolar stepper motors and/or brush DC motors. The device features an on-board DC/DC converter to provide gate-drive voltages, as well as level-shifting circuitry. The control logic translates the input signals to the gate-driver circuitry while providing cross-conduction suppression.

The 17550 has four operating modes: Forward, Reverse, Brake, and Tri-Stated (High Impedance). The MOSFETs comprising the output bridge have a total source+sink $R_{DS(ON)} \leq 1.2\ \Omega$.

The 17550 can simultaneously drive four brush DC motors or two bipolar stepper motors. The drivers are designed to be PWM'ed at frequencies up to 200 kHz.

FUNCTIONAL TERMINAL DESCRIPTION

LOGIC SUPPLY (VDD)

The VDD terminal carries the logic supply voltage and current into the logic sections of the IC. V_{DD} has an undervoltage threshold. If the supply voltage drops below the undervoltage threshold, the output power stage switches to a tri-state condition. When the supply voltage returns to a level that is above the threshold, the power stage automatically resumes normal operation according to the established condition of the input control terminals.

CONTROL SIGNAL INPUT FOR H-BRIDGE, F=FORWARD, R= REVERSE (INAF, INAR, INBF, INBR, INCF, INCR, INDF, INDR)

These logic input control terminals control each H-Bridge output; e.g., IN*F logic HIGH = HB*F HIGH; likewise, IN*R logic HIGH = HB*R HIGH. However, if both "F" and "R" inputs are taken HIGH, the associated bridge's outputs are both tri-stated (refer to Table 5, Truth Table, page 8).

OUTPUT ENABLE ($\overline{OE}$)

$\overline{OE}$ terminal is a LOW = TRUE enable input. When $\overline{OE}$ = HIGH, all H-Bridge outputs are tri-stated (high impedance) regardless of logic inputs states.

OUTPUT OF H-BRIDGE, R=REVERSE, F=FORWARD (HBAF, HBAR, HBBF, HBBR, HBCF, HBCR, HBDF, HBDR)

These terminals provide connection to the outputs of each of the internal H-Bridges (see Figure 2, 17550 Simplified Internal Block Diagram, page 2).

POWER SUPPLY VOLTAGE CONNECTION FOR MOTORS A, B, C, D (VMA, VMB, VMC, VMD)

The VM terminals carry the main supply voltage and current into the power sections of the 17550. This supply then becomes controlled and/or modulated by the 17550 as it delivers the power to the loads attached between the H-Bridge output terminals. All VM terminals must be connected together on the printed circuit board.

DC/ DC CONVERTER SWITCHING TRANSISTOR OUTPUT (LX)

The LX terminal is the open-drain output of the internal DC/DC converter circuit. It is the junction for the external inductor and the anode of the external Schottky diode.

GATE-DRIVER CIRCUIT POWER SUPPLY (VG)

The VG terminal is the input terminal for the gate-drive voltage. It can be supplied from the built-in DC/DC converter or from an external source.

GROUND TERMINALS (GND, AGND, PGND)

All ground terminals must be tied together on the PCB.

POWER STANDBY MODE CONTROL (PSB)

The PSB input controls the functioning of power output stages (the H-Bridges). When this input signal turns Low, the output stages and Internal DC/DC Converter which makes Gate Voltage are disabled and all the outputs are opened (High Impedance). When this input signal turns High, the output stages and Internal DC/DC Converter are enabled and the H-Bridges operate normally.

TYPICAL APPLICATIONS

INTRODUCTION

The 17550's built-in DC/DC converter must be connected to an external inductor, rectifier, and filter capacitor. This step-up converter generates the gate-drive voltage, V_G, required by the internal gate driver circuits. Although there is some latitude in selecting the values for the external component, care must be taken that V_G does not exceed 14 V. Additionally, too low an inductance will cause large instantaneous switching currents, which may damage the device.

Important Do not use an inductance lower than 330 µH.

To attain high-efficiency operation, the rectifier should be a Schottky diode, and the filter capacitor should be of the low Equivalent Series Resistance (ESR) type. Attention should be paid to proper switch mode power supply PCB layout practice. Some experimentation may be required to determine optimal external component values. The recommended starting values are L = 1.0 mH, C = 2.2 µF.

The DC/DC converter includes its own internal oscillator and does not require an external clock input.

TYPICAL APPLICATION

Two typical application schematics are shown in Figure 6. and Figure 7.

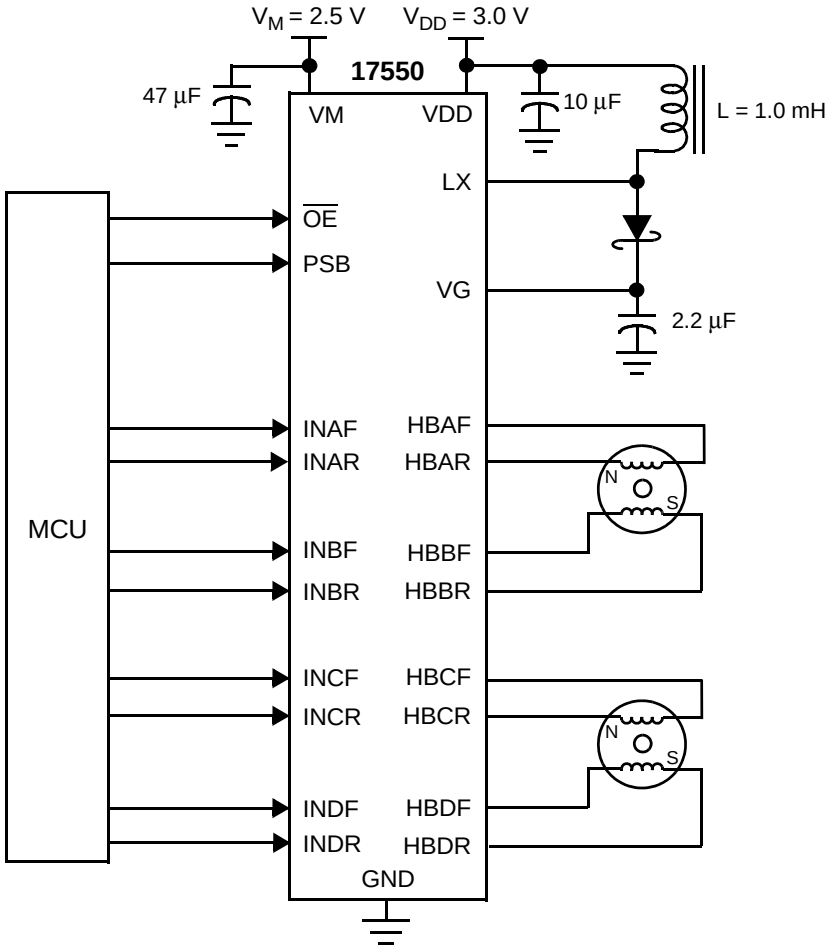


Figure 6. Typical 17550 Application - Controlling Stepper Motors

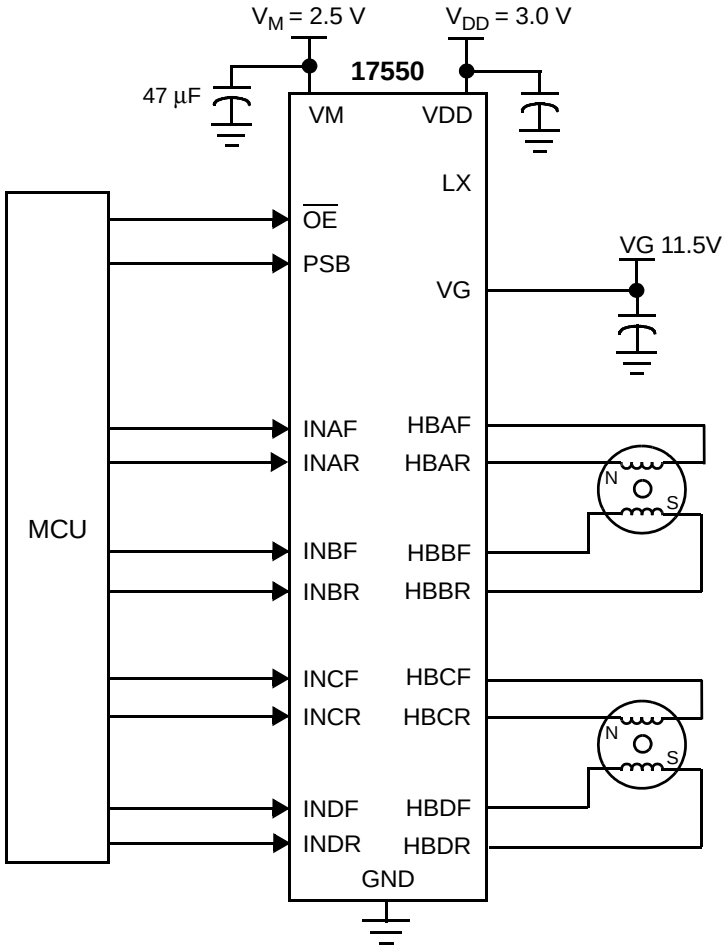


Figure 7. Typical 17550 Application - No Internal DC-DC Used

CEMF SNUBBING TECHNIQUES

Care must be taken to protect the IC from potentially damaging CEMF spikes induced when commuting currents in inductive loads. Typical practice is to provide snubbing of voltage transients by placing a capacitor or zener at the motor supply voltage terminal (VM) (see Figure 8).

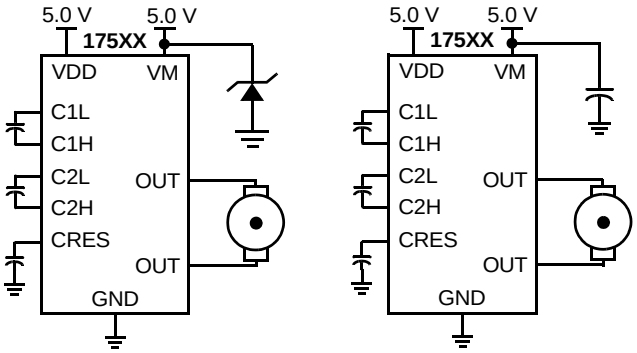
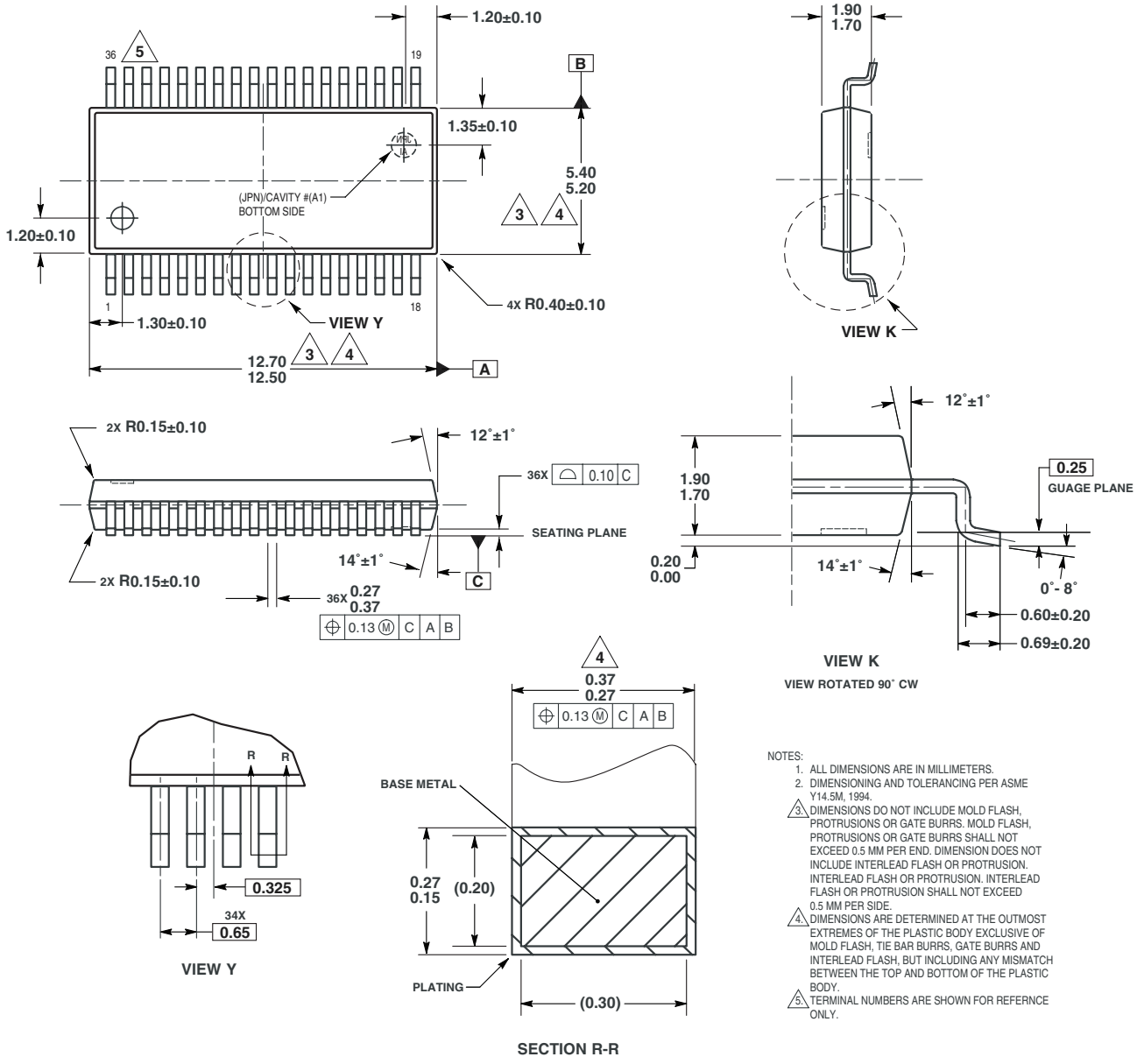


Figure 8. CEMF Snubbing Techniques

PACKAGING

PACKAGE DIMENSIONS

Important: For the most current revision of the package, visit www.freescale.com and perform a keyword search on the 98A number listed below.



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
3. DIMENSIONS DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.5 MM PER END. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.5 MM PER SIDE.
4. DIMENSIONS ARE DETERMINED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY EXCLUSIVE OF MOLD FLASH, TIE BAR BURRS, GATE BURRS AND INTERLEAD FLASH, BUT INCLUDING ANY MISMATCH BETWEEN THE TOP AND BOTTOM OF THE PLASTIC BODY.
5. TERMINAL NUMBERS ARE SHOWN FOR REFERNCE ONLY.

EV (Pb-FREE) SUFFIX
36-LEAD VMFP
PLASTIC PACKAGE
CASE 1522-01
ISSUE O

17550

REVISION HISTORY

REVISION	DATE	DESCRIPTION OF CHANGES
2.0	7/2006	• Converted to Freescale format and updated to the prevailing form and style • Added typical Application for non DC/DC use • Added RoHS compliance

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