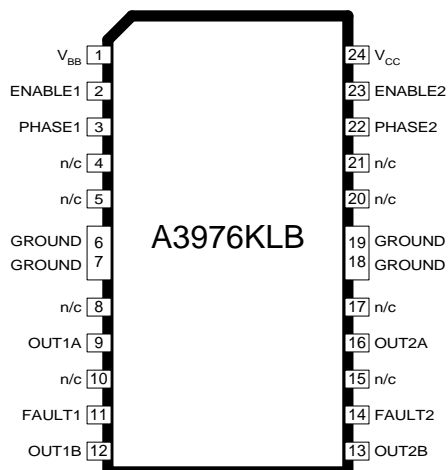


# 3976

ADVANCED DATASHEET - 02/19/99  
(Subject to change without notice)

## DUAL FULL BRIDGE PROTECTED MOTOR DRIVER



### ABSOLUTE MAXIMUM RATINGS at $T_A = +25^\circ\text{C}$

Operating Supply Voltage, $V_{BB}$ .....	30 V
Non-Operating Supply Voltage.....	35 V
Output Current, $I_{OUT}$ .....	$\pm 500$ mA*
Logic Supply Voltage, $V_{CC}$ .....	7.0 V
Fault Output Voltage .....	7.0 V
Logic Input Voltage Range, $V_{IN}$ .....	-0.3 V to $V_{CC} + 0.3$ V
Package Power Dissipation ( $T_A = +25^\circ\text{C}$ ), $P_D$	
A3976KLB .....	2.2 W
A3976KB .....	2.9 W
Operating Temperature Range, $T_A$ .....	-40°C to +125°C
Junction Temperature, $T_J$ .....	+150°C
Storage Temperature Range, $T_S$ .....	-55°C to +150°C

\* Output current rating may be limited by duty cycle, ambient temperature, and heat sinking. Under any set of conditions, do not exceed the specified current rating or a junction temperature of 150°C.

The A3976 is designed to drive both windings of a bipolar stepper motor or bidirectionally control two DC Motors. Both H-Bridges are capable of continuous output currents of up to  $\pm 500$  mA and operating voltages to 30V. Free wheeling, substrate isolated diodes are included for output transient suppression when switching motors or other inductive loads. For each bridge the PHASE input controls load current polarity by selecting the appropriate source and sink driver pair. The ENABLE input, when held high, enables the respective output H-bridge. When both ENABLE pins are held low the device will enter SLEEP mode and consume less than 100 $\mu$ A.

The 3976 is protected to ensure safe operation in harsh operating environments and was designed specifically for automotive applications. Protection circuitry will check for open or shorted load, motor lead short to ground or supply, VBB overvoltage, VCC undervoltage, and thermal shutdown. If any of these conditions are detected the outputs will be disabled and fault information will be output to diagnostic pins FAULT1 and FAULT2.

The 3976 is supplied in a choice of two power packages, a 16-lead plastic DIP with a copper batwing tab (suffix 'B'), and a 24-lead plastic SOIC with a copper batwing tab (suffix 'LB'). In both cases, the power tab is at ground potential and needs no electrical isolation.

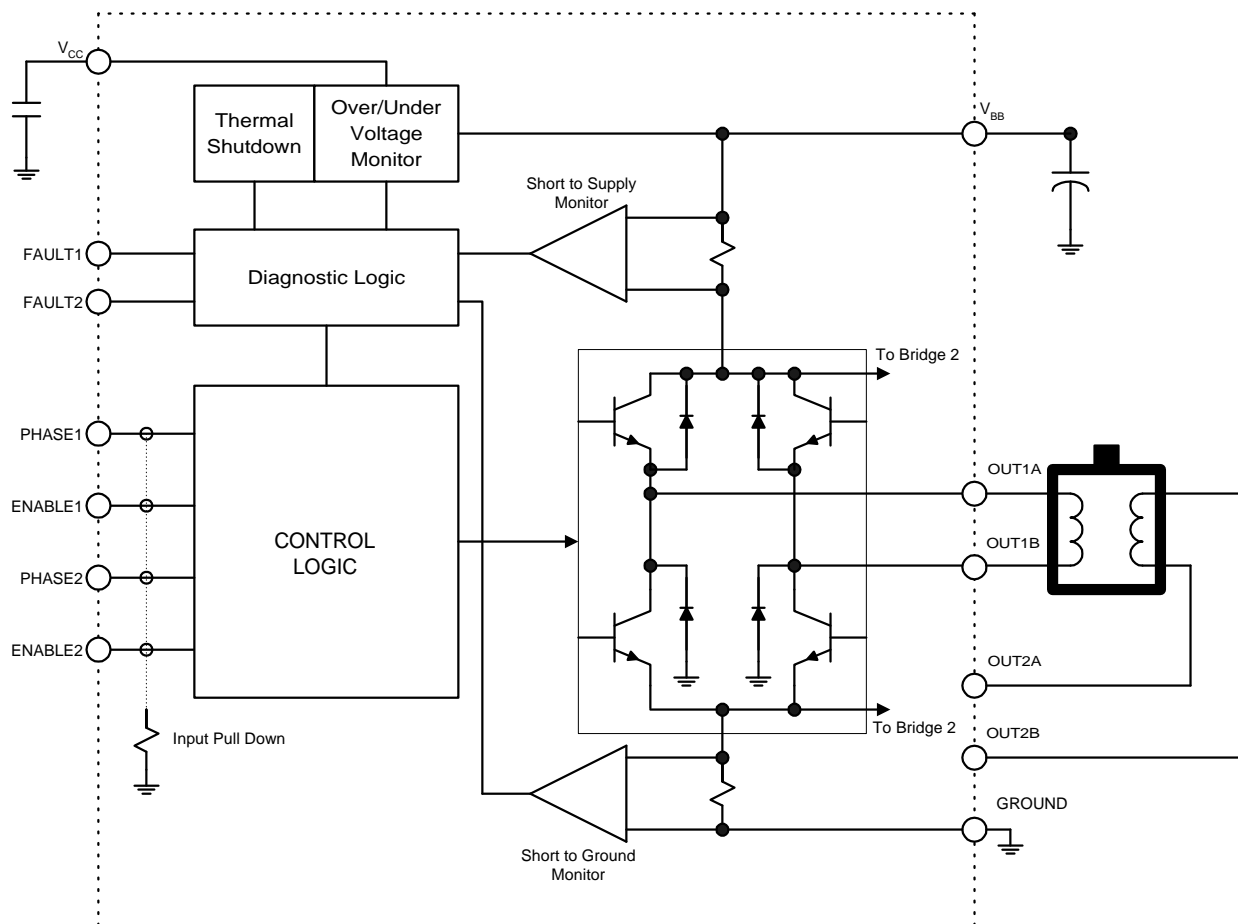
### FEATURES

- 30 V ,  $\pm 500$  mA Continuous Output Rating
- 35V Load Dump Survival
- Output Short Circuit Protection
- Coded Fault Diagnostic Outputs
- Low Current Standby Mode
- Open Load Monitor
- Low Current Standby Mode
- VBB Over Voltage Shutdown
- Internal Thermal Shutdown Circuitry
- Internal Low Parasitic Free Wheeling Diodes
- Crossover Current Protection

PART NUMBER	PACKAGE	$R_{\theta JA}$	$R_{\theta JT}$
A3976KLB	24 Lead SOIC	56°C/W	6°C/W
A3973KB	16 Lead DIP	43°C/W	6°C/W

# 3976 Dual Protected PWM Motor Driver

**Functional Block Diagram**  
(one of two bridges shown)



## Input Logic

PHASE	ENABLE	OUTA	OUTB
X	0	Off	Off
0	1	Low	High
1	1	High	Low

## Fault Logic

Fault Condition	FAULT1	FAULT2
Thermal Shutdown	Low	Low
Short to Battery or Open Load	Low	High
Short to Ground	High	Low
Normal Operation	High	High

# 3976 Dual Protected PWM Motor Driver

**ELECTRICAL CHARACTERISTICS at  $T_A = -40\text{ }^{\circ}\text{C}$  to  $+125\text{ }^{\circ}\text{C}$ ,  $V_{BB} = 30\text{ V}$ ,  $V_{CC} = 5.0\text{ V}$  (Unless noted otherwise)**

Characteristics	Symbol	Test Conditions	Limits			
			Min.	Typ.	Max.	Units

## Output Drivers

Load Supply Voltage Range	$V_{BB}$	Operating	6	-	30	V
Logic Supply Range	$V_{CC}$	Operating	4.5		5.5	V
Output Current Limit	$I_{CL}$	Outputs A or B = GROUND	0.7	1.1	-	A
		Outputs A or B = $V_{BB}$	0.7	1.1	-	A
Output Leakage Current	$I_{CEX}$	$V_{OUT} = V_{BB}$	-	<1.0	50	$\mu\text{A}$
		$V_{OUT} = 0\text{ V}$	-	<1.0	-50	$\mu\text{A}$
Output Saturation Voltage	$V_{CE(SAT)}$	Source Driver, $I_{OUT} = -350\text{ mA}$	-	1.0	1.2	V
		Source Driver, $I_{OUT} = -500\text{ ma}$	-	1.2	1.3	
		Sink Driver, $I_{OUT} = +350\text{ mA}$	-	0.2	0.4	V
		Sink Driver, $I_{OUT} = +500\text{ ma}$	-	0.4	0.6	V
Clamp Diode Forward Voltage (Flyback or Ground Clamp)	$V_F$	$I_F = 500\text{ mA}$ (Sink / Ground Clamp)	-	1.2	1.5	V
		$I_F = 500\text{ mA}$ (Source / Flyback)	-	1.55	2.0	V

## Control Logic

Motor Supply Current (No Load)	$I_{BB}$	ENABLE1 = ENABLE2 = High	-	7	10	mA
		Sleep Mode ENABLE1 = ENABLE2 = Low	-	-	25	$\mu\text{A}$
Logic Supply Current	$I_{CC}$	ENABLE1 = ENABLE2 = High	-	45	50	MA
		Sleep Mode, ENABLE1 = ENABLE2 = Low	-	-	75	$\mu\text{A}$
Logic Input Voltage	$V_{IN(1)}$		$0.7V_{CC}$	-	-	V
	$V_{IN(0)}$		-	-	$.3V_{CC}$	V
Logic Input Current	$I_{IN(1)}$	$V_{IN} = 5\text{ V}$	-	50	100	$\mu\text{A}$
	$I_{IN(0)}$	$V_{IN} = 0\text{V}$	-	-1.0	-2.0	$\mu\text{A}$

# 3976 Dual Protected PWM Motor Driver

**ELECTRICAL CHARACTERISTICS at  $T_A = -40^{\circ}\text{C}$   $+125^{\circ}\text{C}$ ,  $V_{BB} = 30\text{ V}$ ,  $V_{DD} = 5.0\text{ V}$  (unless noted otherwise)**

Characteristics	Symbol	Test Conditions	Limits			
			Min.	Typ.	Max.	Units

## Fault Circuitry

Fault Output Leakage	$I_{F-LEAK}$	$V_F = 5\text{ Volts}$ , No Faults	-	-	10	$\mu\text{A}$
Fault Output Low	$V_{FL}$	Fault Condition Asserted, $I_F = 25\ \mu\text{A}$	-	-	0.8	V
Fault Output Current	$I_F$	$V_F = 5\text{ Volts}$ , $ENABLE = 3.5\text{V}$	25	50	75	$\mu\text{A}$
Output Open Load Current	$I_{OUT-O.L.}$	$V_{BB} = 12\text{ V}$	-	2	-	mA
Thermal Fault Temp.	$T_F$		-	170	-	$^{\circ}\text{C}$
Thermal Fault Hysteresis	$T_{FHYS}$		-	10	-	$^{\circ}\text{C}$
OVLO Enable Threshold		$V_{bb}$ rising	27	30	33	V
OVLO Hysteresis				1.5		V
UVLO Enable Threshold		$V_{cc}$ falling	3.5	4	4.5	V
UVLO Hysteresis			-	400	-	mV

## Timing

Open Fault to Reset Delay	$t_{rs}$	$V_{BB} = 12\text{ V}$	-	-	25	$\mu\text{s}$
PHASE_X Delay to OPEN Fault	$t_{of}$	$V_{BB} = 12\text{ V}$	-	30	-	$\mu\text{s}$
PHASE_X Delay to S.C. Fault	$t_{sc}$	$V_{BB} = 12\text{ V}$	-	5	-	$\mu\text{s}$
ENABLE_X Delay to Fault	$t_{of}$	$V_{BB} = 12\text{ V}$	-	5	-	$\mu\text{s}$
Propagation Delay Times	$t_{pd}$	$I_{OUT} = \pm 0.35\text{A}$ , 50% TO 90%				
		ENABLE ON TO SOURCE ON	-	0.3	-	$\mu\text{s}$
		ENABLE OFF TO SOURCE OFF	-	0.4	-	$\mu\text{s}$
		ENABLE ON TO SINK ON	-	0.3	-	$\mu\text{s}$
		ENABLE OFF TO SINK OFF	-	0.2	-	$\mu\text{s}$
		PHASE CHANGE TO SINK ON	-	4.0	-	$\mu\text{s}$
		PHASE CHANGE TO SINK OFF	-	0.3	-	$\mu\text{s}$
		PHASE CHANGE TO SOURCE ON	-	4.0	-	$\mu\text{s}$
PHASE CHANGE TO SOURCE OFF	-	0.4	-	$\mu\text{s}$		
Cross Over Dead Time	$t_{CODT}$	1K $\Omega$ (1k+1k) Load ( $V_{BB}$ to OUT to GND)	0.5	3.0	6.0	$\mu\text{s}$

# 3976 Dual Protected PWM Motor Driver

## APPLICATION NOTES

**Open Lead Protection.** During normal PWM operation diagnostic circuitry will look for a minimum source current level after a bridge is signalled on. Additionally, the diode flyback is monitored on the proper output. The logic will signal a fault and disable the outputs if it determines that the current is below the minimum level AND no flyback is occurring. If the inductive load is too large, the current would take too long to reach the minimal level and a false open load would be reported. It is recommended that the inductive load be less than 38mH.

**Short Circuit Protection.** Internal sense resistors in series with  $V_{BB}$  and ground will trip the fault circuitry if greater than 1.1A is detected. To prevent false overcurrent events due to reverse recovery spikes of the clamp diodes, the current monitor is blanked for 5us after a high side is signalled to turn on. If an additional input command follows after the initial fault, the selected pair of drivers will pulse on for the 5us blanking duration. The short circuit fault will remember the input state where the fault occurred and will

wait for that particular logic state after the short has been removed before normal operation is allowed to resume.

**Thermal Protection.** Circuitry turns OFF all drivers when the junction temperature reaches 170°C typically. It is intended only to protect the device from failures due to excessive junction temperatures and has a hysteresis of approximately 15°C.

**Layout.** The printed wiring board should use a heavy ground plane. For optimum electrical and thermal performance, the driver should be soldered directly onto the board. The load supply pin,  $V_{BB}$ , should be decoupled with an electrolytic capacitor (> 47  $\mu$ F is recommended) placed as close to the device as possible.

## Terminal List

Pin Name	Pin Description	24 Lead SOIC	16 Lead DIP
$V_{BB}$	Motor Supply Voltage	1	1
ENABLE1	Control Logic – Bridge 1	2	2
PHASE1	Control Logic – Bridge 1	3	3
GROUND	Power Ground Return	18,19,6,7	4,5,12,13
OUT1A	Bridge 1 Output	9	6
FAULT1	Diagnostic Output	11	7
OUT1B	Bridge 1 Output	12	8
OUT2B	Bridge 2 Output	13	9
FAULT2	Diagnostic Output	14	10
OUT2A	Bridge 2 Output	16	11
PHASE2	Control Logic – Bridge 2	22	14
ENABLE2	Control Logic – Bridge 2	23	15
$V_{CC}$	Logic Supply	24	16
NC	No Connect	3,4,5,8,15,17,20,21	