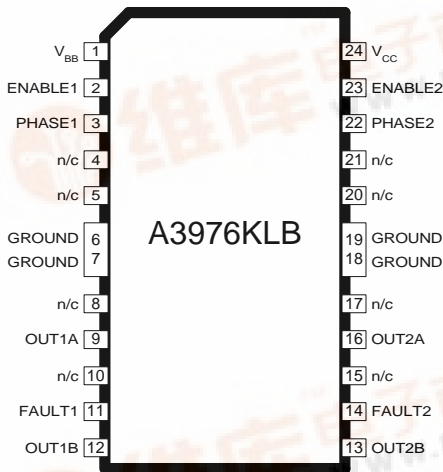


3976

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

DUAL FULL BRIDGE PROTECTED MOTOR DRIVER



ABSOLUTE MAXIMUM RATINGS at T_A = +25°C

Operating Supply Voltage, V_{BB} **30 V**
 Non-Operating Supply Voltage..... **35 V**
 Output Current, I_{OUT} **±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°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 +/- 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 100µA.

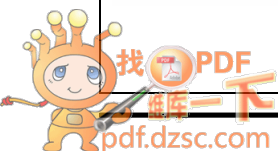
The 3976 is protected to ensure safe operation in harsh operating environments and was designed specifically for automotive applications. Protection circuitry will check for open or shorted load, motor lead short to ground or supply, VBB overvoltage, VCC undervoltage, and thermal shutdown. If any of 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

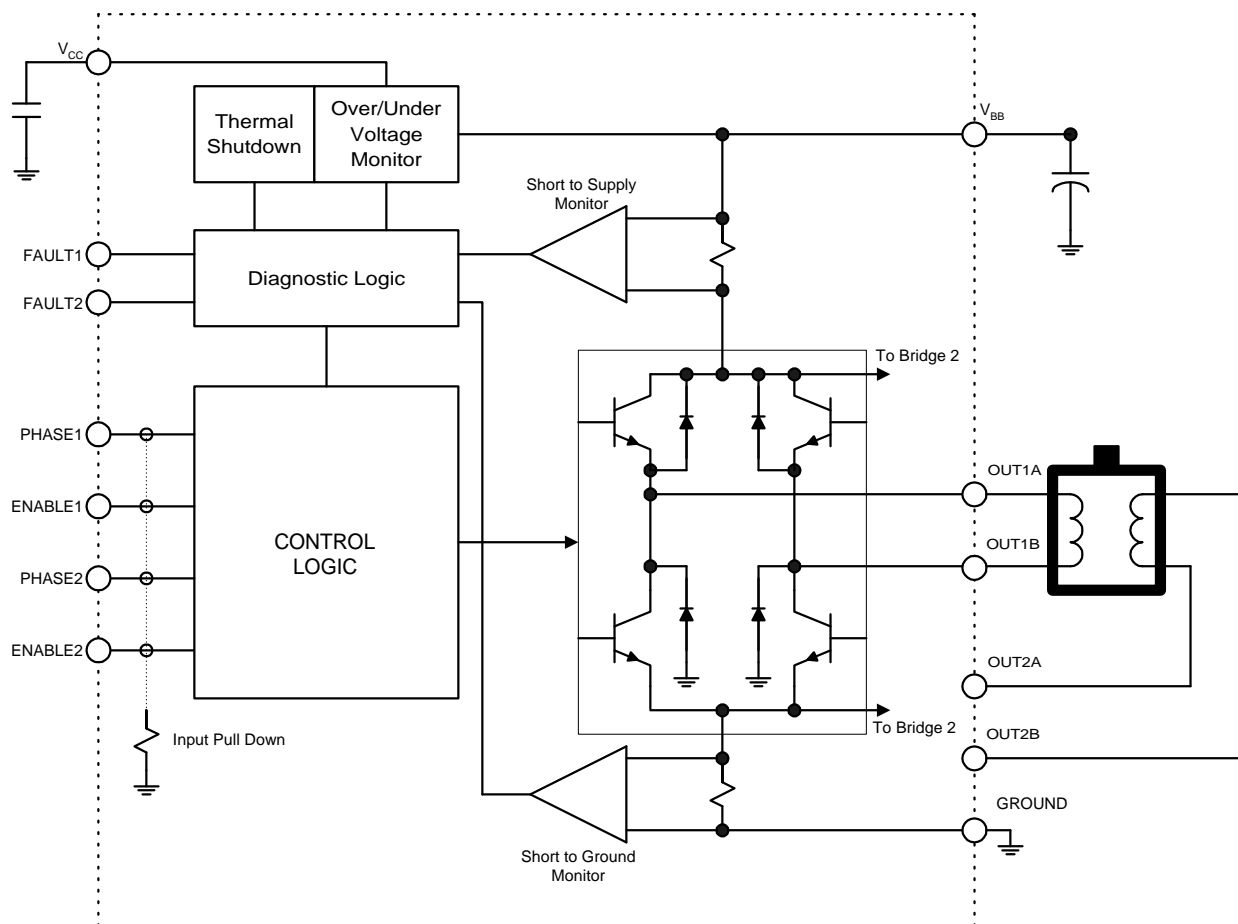
- 30 V , ±500 mA Continuous Output Rating
- 35V Load Dump Survival
- Output Short Circuit Protection
- Coded Fault Diagnostic Outputs
- Low Current Standby Mode
- Open Load Monitor
- Low Current Standby Mode
- VBB Over Voltage Shutdown
- Internal Thermal Shutdown Circuitry
- Internal Low Parasitic Free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

| PART NUMBER | PACKAGE | R _{ΘJA} | R _{ΘJT} |
|-------------|--------------|------------------|------------------|
| 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 | μA |
| | | $V_{OUT} = 0\text{ V}$ | – | <1.0 | -50 | μA |
| 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 | μA |
| Logic Supply Current | I_{CC} | ENABLE1 = ENABLE2 = High | – | 45 | 50 | MA |
| | | Sleep Mode, ENABLE1 = ENABLE2 = Low | – | – | 75 | μA |
| 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 | μA |
| | $I_{IN(0)}$ | $V_{IN} = 0\text{V}$ | – | -1.0 | -2.0 | μA |

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 | $I_{F\text{-LEAK}}$ | $V_F = 5\text{ Volts}$, No Faults | - | - | 10 | μA |
| Fault Output Low | V_{FL} | Fault Condition Asserted, $I_F=25\ \mu\text{A}$ | - | - | 0.8 | V |
| Fault Output Current | I_F | $V_F = 5\text{ Volts}$, $\text{ENABLE}=3.5\text{V}$ | 25 | 50 | 75 | μA |
| Output Open Load Current | $I_{\text{OUT-O.L.}}$ | $V_{BB} = 12\text{ V}$ | - | 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 | μs |
| PHASE_X Delay to OPEN Fault | t_{of} | $V_{BB} = 12\text{ V}$ | - | 30 | - | μs |
| PHASE_X Delay to S.C. Fault | t_{SC} | $V_{BB} = 12\text{ V}$ | - | 5 | - | μs |
| ENABLE_X Delay to Fault | t_{of} | $V_{BB} = 12\text{ V}$ | - | 5 | - | μs |
| Propagation Delay Times | t_{pd} | $I_{\text{OUT}} = \pm 0.35\text{A}$, 50% TO 90% | | | | |
| | | ENABLE ON TO SOURCE ON | - | 0.3 | - | μs |
| | | ENABLE OFF TO SOURCE OFF | - | 0.4 | - | μs |
| | | ENABLE ON TO SINK ON | - | 0.3 | - | μs |
| | | ENABLE OFF TO SINK OFF | - | 0.2 | - | μs |
| | | PHASE CHANGE TO SINK ON | - | 4.0 | - | μs |
| | | PHASE CHANGE TO SINK OFF | - | 0.3 | - | μs |
| | | PHASE CHANGE TO SOURCE ON | - | 4.0 | - | μs |
| PHASE CHANGE TO SOURCE OFF | - | 0.4 | - | μs | | |
| Cross Over Dead Time | t_{CODT} | 1K Ω (1k+1k) Load (V_{BB} to OUT to GND) | 0.5 | 3.0 | 6.0 | μs |

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 μ 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 | |