

# 2953 AND 2954

## FULL-BRIDGE PWM MOTOR DRIVERS

The UDN2953B and UDN2954W are designed for bidirectional control of dc or stepper motors with continuous output currents to 2 A and peak start-up currents as high as 3.5 A. For pulse-width modulated (chopped-mode) operation, the output current is determined by the user's selection of a reference voltage and sensing resistor while the OFF pulse duration is set by an external RC timing network. PWM operation is characterized by maximum efficiency and low power-dissipation levels. Extensive internal circuit protection includes thermal shutdown with hysteresis, transient-suppression diodes, and crossover current protection.

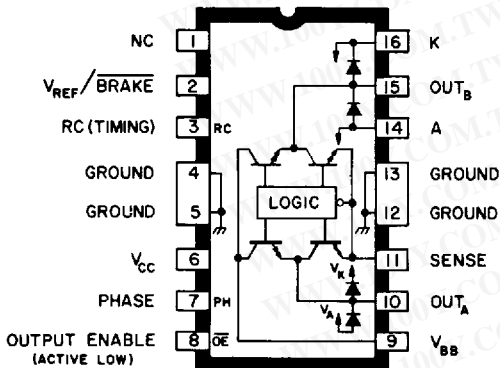
When the  $V_{REF}/\overline{BRAKE}$  pin is low (<0.8 V), the braking function is enabled. This turns both sink drivers OFF and the source drivers are turned ON. When  $V_{REF}/\overline{BRAKE}$  is set above 2.4 V, that voltage (and the current sensing resistor) determines the load current trip point. An RC TIMING pin is available to use for an internal one-shot to control load current decay time.

The UDN2953B driver is supplied in a 16-pin dual-in-line plastic package with copper heat-sink contact tabs. The lead configuration enables easy attachment of a heat sink while fitting a standard integrated circuit socket or printed wiring board layout. The UDN2954W, for higher package power dissipation requirements, is supplied in a 12-pin single in-line power-tab package. In any package style, the heat sink is at ground potential and needs no insulation.

### FEATURES

- 50 V Output Voltage Rating
- 2 A Continuous Output Rating
- Internal Flyback Diode
- Thermal Shutdown
- Crossover Current Protection
- BRAKE, ENABLE, and Current-Limit Functions

### UDN2953B



Dwg. No. A-13,024

### ABSOLUTE MAXIMUM RATINGS at $T_J \leq +150^\circ\text{C}$

Motor Supply Voltage, $V_{BB}$	50 V
Output Current, $I_{OUT}$	
(Peak)	$\pm 3.5$ A
(Continuous)	$\pm 2.0$ A
Flyback Diode Voltage, $V_K$	$V_{BB}$
Minimum Clamp Diode Voltage, $V_A$	Ground
Logic Supply Voltage, $V_{CC}$	7.0 V
Logic Input Voltage, $V_{PHASE}, V_{ENABLE}$	$V_{BB}$
Sense Voltage, $V_{SENSE}$	1.5 V
Reference Voltage, $V_{REF}/\overline{BRAKE}$	1.5 V
Package Power Dissipation, $P_D$	See Graphs
Operating Temperature Range, $T_A$	$-20^\circ\text{C}$ to $+85^\circ\text{C}$
Storage Temperature Range, $T_S$	$-55^\circ\text{C}$ to $+150^\circ\text{C}$

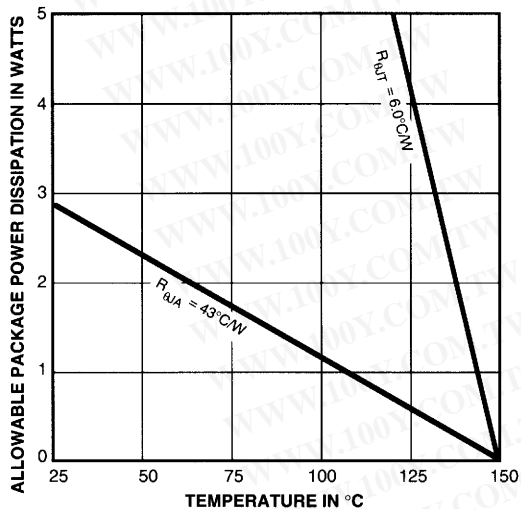
Always order by complete part number:

Part Number	Package
UDN2953B	16-Pin DIP
UDN2954W	12-Pin Power-Tab SIP

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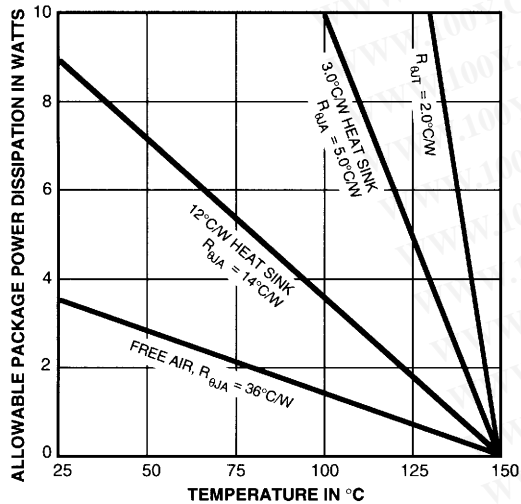
# 2953 AND 2954 FULL-BRIDGE PWM MOTOR DRIVERS

## UDN2953B



Dwg. GP-010B

## UDN2954W



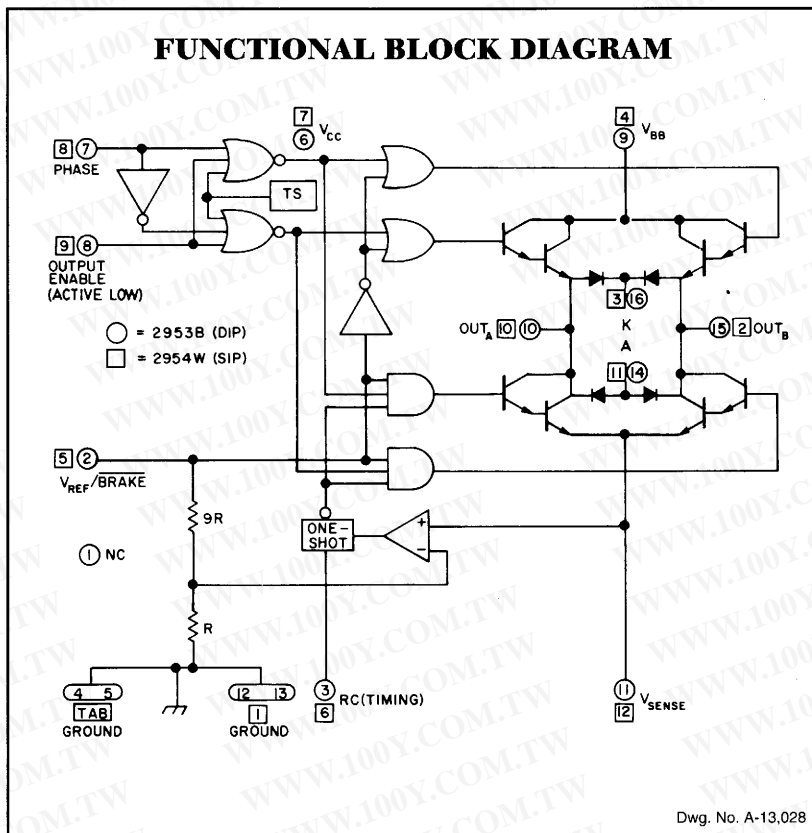
Dwg. GP-012A

### TRUTH TABLE

Output Enable	Phase	$V_{REF}/BRAKE$	Out <sub>A</sub>	Out <sub>B</sub>
Low	High	> 2.4 V	High	Low
Low	Low	> 2.4 V	Low	High
High	X	> 2.4 V	Open	Open
X	X	< 0.8 V	High	High

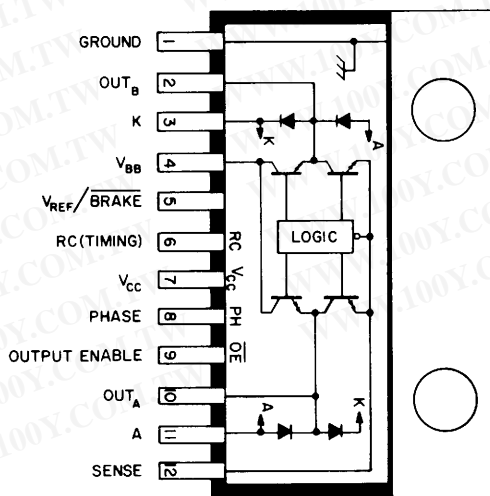
X = Irrelevant

### FUNCTIONAL BLOCK DIAGRAM



Dwg. No. A-13,028

## UDN2954W



Dwg. No. A-13,023

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**ELECTRICAL CHARACTERISTICS at  $T_A = +25^\circ\text{C}$ ,  $T_J \leq +150^\circ\text{C}$ ,  $V_{BB} = 50\text{ V}$ ,  $V_{CC} = 5\text{ V}$ ,  
 $V_{SENSE} = 0\text{ V}$ ,  $R_C = 20\text{ k}\Omega/470\text{ pF}$  to Ground.**

Characteristic	Symbol	Test Conditions	Limits			
			Min.	Typ.	Max.	Units
<b>Output Drivers (OUT<sub>A</sub> or OUT<sub>B</sub>)</b>						
Output Supply Range	$V_{BB}$		6.5	—	50	V
Output Leakage Current	$I_{CEX}$	$V_{ENABLE} = 5\text{ V}$ , $V_{OUT} = V_{BB}$ , (note)	—	—	50	$\mu\text{A}$
		$V_{ENABLE} = 5\text{ V}$ , $V_{OUT} = 0\text{ V}$ , (note)	—	—	-50	$\mu\text{A}$
Output Sustaining Voltage	$V_{CE(sus)}$	$I_{OUT} = \pm 2\text{ A}$ , $L = 2\text{ mH}$	50	—	—	V
Output Saturation Voltage	$V_{CE(SAT)}$	$V_{ENABLE} = 0\text{ V}$ , $I_{OUT} = \pm 0.5\text{ A}$	—	1.0	1.2	V
		$V_{ENABLE} = 0\text{ V}$ , $I_{OUT} = \pm 1.0\text{ A}$	—	1.2	1.4	V
		$V_{ENABLE} = 0\text{ V}$ , $I_{OUT} = \pm 2.0\text{ A}$	—	1.5	1.8	V
Clamp Diode Leakage Current	$I_R$	$V_R = 50\text{ V}$	—	—	50	$\mu\text{A}$
Clamp Diode Forward Voltage	$V_F$	$I_F = 2\text{ A}$	—	1.8	2.2	V
Motor Supply Current	$I_{BB(ON)}$	$V_{ENABLE} = 0.8\text{ V}$ , $V_{REF} = 2.4\text{ V}$ , No Load	—	20	30	mA
	$I_{BB(OFF)}$	$V_{ENABLE} = V_{REF} = 2.4\text{ V}$ , No Load	—	2.5	3.5	mA
		$V_{ENABLE} = 5\text{ V}$ , $V_{REF} = 0.8\text{ V}$ , No Load	—	40	60	mA
<b>Control Logic</b>						
Logic Supply Range	$V_{CC}$		4.5	5.0	5.5	V
Logic Input Current	$I_{IN(1)}$	All Inputs = 2.4 V	—	<-1.0	-10	$\mu\text{A}$
	$I_{IN(0)}$	All Inputs = 0.8 V	—	-50	-200	$\mu\text{A}$
Logic Input Voltage	$V_{IN(1)}$	All Inputs	2.4	—	—	V
	$V_{IN(0)}$	All Inputs	—	—	0.8	V
$V_{REF}$ Open-Circuit Voltage	$V_{REF(OPEN)}$	$I_{REF} = 0$	—	$V_{CC}/2$	—	V
Current Limit Threshold		$V_{REF}/V_{SENSE}$ at Trip Point	9.5	10	10.5	—
Turn-On Delay	$t_{on}$	All Drivers	—	1.0	—	$\mu\text{s}$
Turn-Off Delay	$t_{off}$	All Drivers	—	1.0	—	$\mu\text{s}$
Thermal Shutdown Temp.	$T_J$		—	165	—	$^\circ\text{C}$
Logic Supply Current	$I_{CC}$	$V_{ENABLE} = V_{REF} = 2.4\text{ V}$	—	15	20	mA
		$V_{ENABLE} = 0.8\text{ V}$ , $V_{REF} = 2.4\text{ V}$	—	22	30	mA

NOTE: Tests performed at OUT<sub>B</sub> with  $V_{PHASE} = 0.8\text{ V}$  and at OUT<sub>A</sub> with  $V_{PHASE} = 2.4\text{ V}$

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# 2953 AND 2954 FULL-BRIDGE PWM MOTOR DRIVERS

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## APPLICATIONS INFORMATION

The UDN2953B and UDN2954W full-bridge motion control ICs are designed for pulse-width-modulated (PWM) bidirectional interface to many types of dc (brush) servo, brushless dc, and 2-phase stepper motors. These power ICs permit various techniques of direct motor interface and offer internally and externally programmed current control. Pulse-width-modulated output current can be regulated by an (external) PWM control signal or use of an external sensing resistor ( $R_{SENSE}$ ) in combination with an RC network and/or voltage reference.

The output current trip point or sense resistor formulas are:

$$I_{TRIP} = \frac{V_{REF}}{10 R_{SENSE}}$$

$$R_{SENSE} = \frac{V_{REF}}{10 I_{TRIP}}$$

The allowable reference voltage range is from 2.4 V to 15 V. If unconnected, the reference input ( $V_{REF}$ ) defaults to  $V_{CC}/2$  (refer to Figure 1) and  $I_{TRIP} = 0.5$  A (per typical application where  $R_S = 0.5 \Omega$ ).

When the motor current attains the specified design value, the internal comparator triggers the monostable ('one-shot') multivibrator, which disables (switches OFF) the sink (lower) output. The actual load current may vary slightly, and the difference is (chiefly) related to the circuit propagation delays between comparator (trip point) command and power output switching. Applications involving very-low inductance windings may necessitate specific consideration; typical circuit delays ( $t_d$ ) are about 2  $\mu$ s.

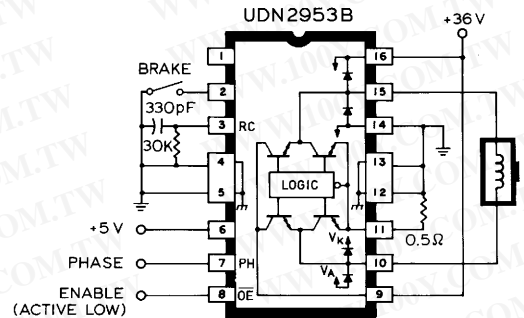
After the sink ('low-side') output is switched OFF, motor current starts to decay, and the circulation path is through the ON source (upper) drive output and the flyback diode protecting the sink (lower) output. The output OFF interval is set by an external RC timing network connected to the monostable. The magnitude of the current decay is directly related to the OFF period and the duration should allow the current level to drop below the trip point before reactivating the sink output. This ON-OFF PWM cycle repeats, sustaining the desired average current to the motor winding, and continues free-running until a new input command switches the output state. The RC network values range from 20 k $\Omega$  to 100 k $\Omega$  for resistors, and capacitor values from 200 pF to 500 pF. The parallel RC network establishes the  $t_{off}$  interval and directly affects the decaying motor current.

Internal timing circuitry is an alternative to the external RC timing network. However, with internal timing the logic supply current rises approximately 6 mA. Connecting the RC input to the logic supply activates internal circuitry;  $t_{off} = 12 \mu$ s with  $V_{CC} = +5$  V and  $T_A = +25$  C, and increases with temperature.

The sink (lower) output is repeatedly re-enabled until the motor is reversed, braked, or stopped. Current control via pulse modulating the lower outputs is based on the dynamic characteristics of the much faster NPN Darlington outputs.

Another method of controlling motor current involves external circuitry to pulse modulate the OUTPUT ENABLE pin. Switching

## TYPICAL APPLICATION



Dwg. No. A-12,649B

NOTE: Pin 3 must be connected to an RC network as shown, or to  $V_{CC}$ . It must **NOT** be left unconnected.

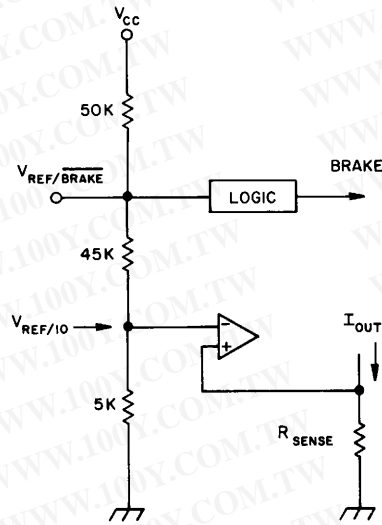
(toggling) the OUTPUT ENABLE affects both the sink (low-side) and upper (high-side) outputs. Both lower and upper transient-protection diodes conduct during the OFF interval. This method of operation produces very rapid current decay. The sink driver parallel diodes (common anode pin) are connected to ground; the source output flyback diodes (common cathode pin) are connected to the motor supply ( $V_{BB}$ ). The RC input pin is to be terminated to ground through 20 k $\Omega$  (minimum).

The motor is braked by simultaneously activating both source driver outputs and disabling both sink outputs. Basically, this shorts both terminals of the motor winding to the supply. The back EMF (electromotive force) of the motor develops current which functions as a dynamic brake. Typically, the braking current approaches the values related to a locked rotor (or stall) condition. Fundamentally, locked rotor (or stall) current is dependent upon the motor winding impedance and driver output ON characteristics. Internal current control circuitry is not operational during braking. Therefore, designers should exercise caution to ensure that the current produced by the back EMF does not exceed the absolute maximum ratings of the power outputs.

# 2953 AND 2954 FULL-BRIDGE PWM MOTOR DRIVERS

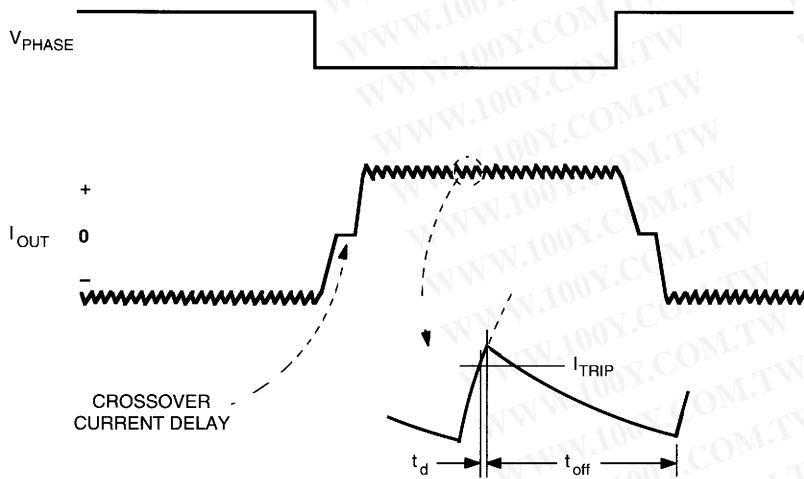
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**Figure 1**



Dwg. No. A-13,025

**Figure 2**



Dwg. WM-003-1

## CURRENT CONTROL OPTIONS

Control Option	Circuit Terminal			
	V <sub>REF/BRAKE</sub>	RC (TIMING)	V <sub>SENSE</sub>	OUTPUT ENABLE
No PWM	V <sub>CC</sub> or High	≥20 kΩ to Ground	Ground	Low
PWM with Internal Timing	V <sub>CC</sub> or High	V <sub>CC</sub>	R <sub>SENSE</sub>	Low
PWM with External Timing	2.4 V or 15 V* or V <sub>CC</sub>	20-100 kΩ/200-500 pF	R <sub>SENSE</sub>	Low
External PWM	V <sub>CC</sub> or High	≥20 kΩ to Ground	R <sub>SENSE</sub> †	Toggle†

\* Programmed reference, i.e., A/D converter.

† Primarily, closed-loop speed and/or current control applications. I<sub>TRIP</sub> can be peak (or default) limit for protecting motor and/or driver IC.

In bidirectional drive applications, especially dc (brush) servos, the PHASE input is utilized for direction control. The current generated by back EMF at reversal is comparable to that of dynamic braking, and should be limited to the absolute maximum output current rating.

An internally generated deadtime (approximately 3 μs) precludes the high crossover (or 'shoot-through') currents associated with momentary, overlapping conduction of both upper and lower outputs. This very abrupt, coincident-ON mode occurs with change of direction (PHASE reversal) and/or dynamic braking.

Integrated thermal shutdown protection circuitry switches OFF all power outputs should the junction temperature exceed +165°C (typical). The thermal protection is designed to avoid power IC failures stemming from extreme, excessive junction heating. Thermal shutdown self protection does not afford a proper safeguard from shorted load and/or shorted output conditions, and should not be operated as such. The thermal self-protection circuitry has a (typical) hysteresis of 8°C.

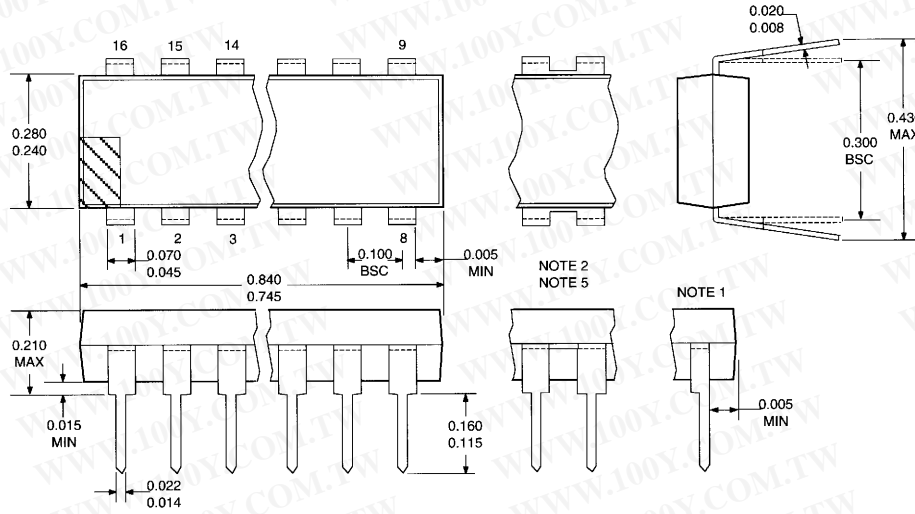
The printed wiring board should utilize a large, heavy ground plane. To optimize power IC performance, the package should be soldered directly into the circuit board. The ground side of R<sub>S</sub> should have an individual path to the ground terminal(s) of the device. Also, the load supply (V<sub>BB</sub>) should be closely decoupled with an electrolytic capacitor of between 10 μF and 100 μF (typically ≥47 μF) depending on printed wiring board layout.

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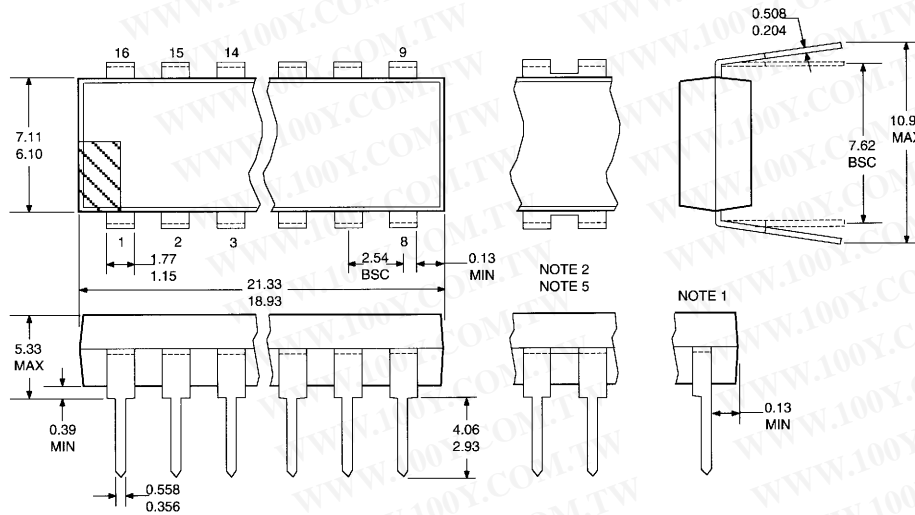
## UDN2953B

### Dimensions in Inches



Dwg. MA-001-17 in

### Dimensions in Millimeters (Based on 1" = 25.4 mm)



Dwg. MA-001-17 mm

- NOTES:
1. Leads 1, 8, 9, and 16 may be half leads at vendor's option.
  2. Webbed lead frame. Leads indicated are internally one piece.
  3. Lead thickness is measured at seating plane or below.
  4. Lead spacing tolerance is non-cumulative.
  5. Exact body and lead configuration at vendor's option within limits shown.



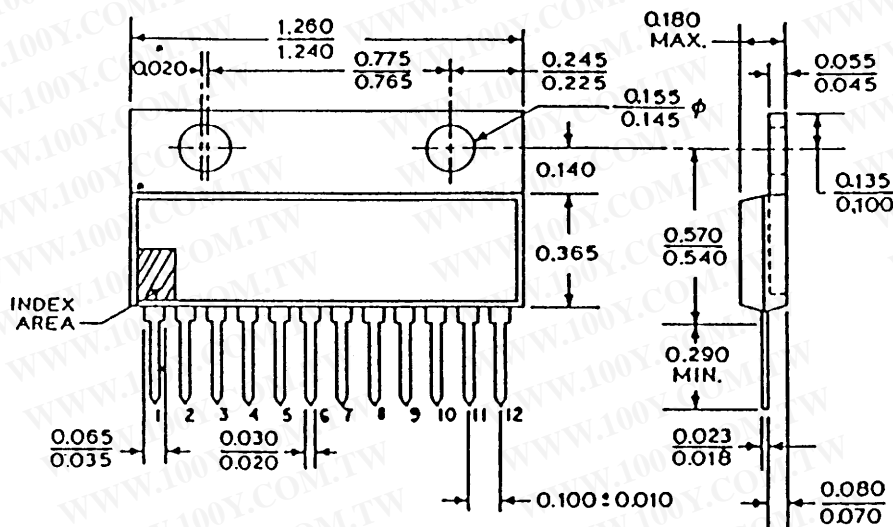
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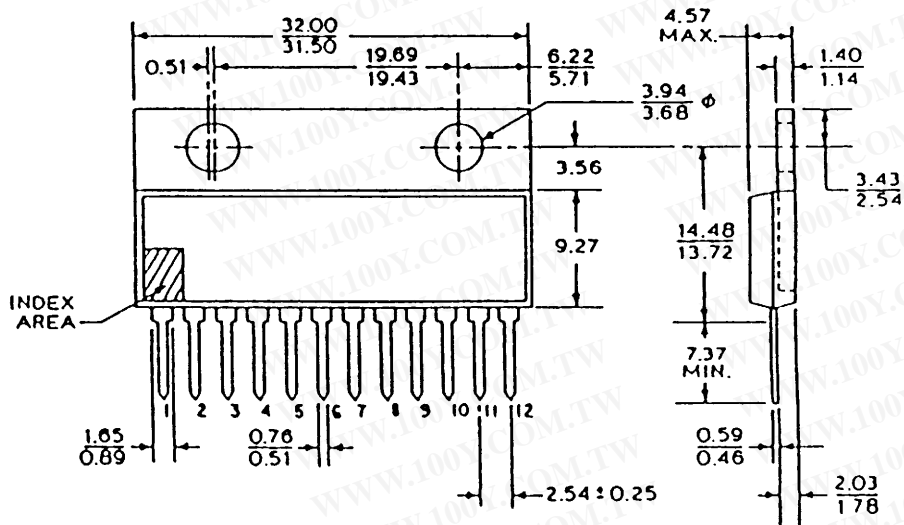
## UDN2954W

Dimensions in Inches



Dwg. No. A-13,652 in

Dimensions in Millimeters  
(Based on 1" = 25.4 mm)



Dwg. No. A-13,652 mm

- NOTES:
- Lead thickness is measured at seating plane or below.
  - Lead spacing tolerance is non-cumulative.
  - Exact body and lead configuration at vendor's option within limits shown.
  - Lead gauge plane is 0.030" (0.762 mm) below seating plane.

# 2953 AND 2954 FULL-BRIDGE PWM MOTOR DRIVERS

## MOTOR DRIVERS SELECTION GUIDE

Function	Output Ratings *		Part Number †
<b>INTEGRATED CIRCUITS FOR BRUSHLESS DC MOTORS</b>			
3-Phase Controller/Drivers	±2.0 A	45 V	2936 and 2936-120
2-Phase Hall-Effect Sensor/Controller	20 mA	25 V	3235
Hall-Effect Latched Sensors	10 mA	24 V	3175 and 3177
Hall-Effect Complementary Output Sensor	20 mA	25 V	3275
2-Phase Hall-Effect Sensor/Driver	900 mA	14 V	3625
2-Phase Hall-Effect Sensor/Driver	900 mA	26 V	3626
Hall-Effect Comp. Output Sensor/Driver	300 mA	60 V	5275
3-Phase Back-EMF Controller/Driver	±900 mA	7 V	8901
3-Phase Back-EMF Controller/Driver	±900 mA	14 V	8902
3-Phase Controller/DMOS Driver	±4.0 A	14 V	8925
3-Phase Back-EMF Controller/Driver	±1.0 A	7 V	8980
<b>FULL-BRIDGE DRIVERS FOR DC AND BIPOLAR STEPPER MOTORS</b>			
PWM Current Controlled Dual Full Bridge	±750 mA	45 V	2916
PWM Current Controlled Dual Full Bridge	±1.5 A	45 V	2917
PWM Current Controlled Dual Full Bridge	±1.5 A	45 V	2918
PWM Current Controlled Full Bridges	±2.0 A	50 V	2953 and 2954
Dual Full Bridge	±500 mA	40 V	2993
Dual Full Bridge	±2.0 A	50 V	2998
<b>OTHER MOTOR DRIVERS</b>			
Unipolar Stepper Motor Driver	1.8 A	50 V	2544
Linear Servo Motor Driver	±1.0 A	28 V	3751
Unipolar Stepper-Motor Translator/Driver	1.25 A	50 V	5804
Voice-Coil Motor Driver	±500 mA	6 V	8932-A
Voice-Coil Motor Driver	±500 mA	6 V	8936
Servo Controller System	—	—	8951
Servo Loop Compensator	—	—	8952
Voice-Coil Motor Driver	±800 mA	16 V	8958
Voice-Coil Motor Driver	±350 mA	7 V	8980

\* Current is maximum specified test condition, voltage is maximum rating.  
See specification for sustaining voltage limits or over-current protection voltage limits.  
Negative current is defined as coming out of (sourcing) the output.

† Complete part number includes additional characters to indicate operating temperature range and package style.

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