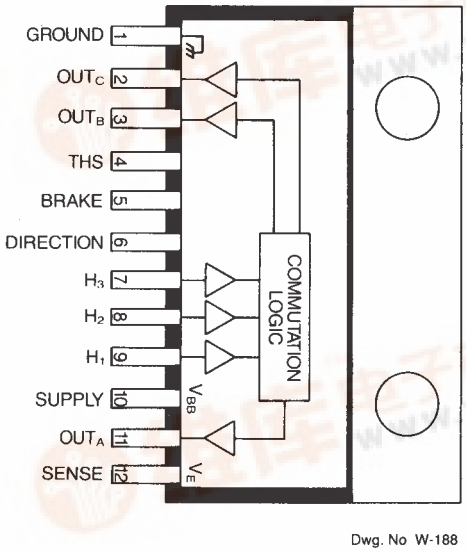
2936

Data Sheet
29318.20A*

3-PHASE BRUSHLESS DC MOTOR CONTROLLER/DRIVERS



Dwg. No W-188

ABSOLUTE MAXIMUM RATINGS
at $T_J \le +150°C$

Supply Voltage, V_{BB} . . . . . **45 V**
Output Current, I_{OUT}
(continuous) . . . . . **±2.0 A**
(peak) . . . . . **±3.0 A**
Input Voltage Range, V_{IN} . . . **-0.3 V to 15 V**
Threshold Voltage, V_{THS} . . . . . **15 V**
Package Power Dissipation,
P_D . . . . . **See Graph**
Operating Temperature Range,
T_A . . . . . **-20°C to +85°C**
Storage Temperature Range,
T_S . . . . . **-55°C to +150°C**

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

Combining logic and power, the UDN2936W and UDN2936W-120 provide commutation and drive for three-phase brushless dc motors. Each of the three outputs are rated at 45 V and ±2 A (±3 A peak), and include internal ground clamp and flyback diodes. These drivers also feature internal commutation logic, PWM current control, and thermal shutdown protection.

The UDN2936W and UDN2936W-120 are compatible with single-ended digital or linear Hall effect sensors. The commutating logic is programmed for 60° (UDN2936W) or 120° (UDN2936W-120) electrical separation. Current control is accomplished by sensing current through an external sense resistor and pulse-width modulating the source drivers. Voltage thresholds and hysteresis can be externally set by the user. If desired, internal threshold and hysteresis defaults (300 mV, 7.5 percent) can be used. The UDN2936W/W-120 also include braking and direction control. Internal protection circuitry prevents crossover current when braking or changing direction.

Both devices are also available for operation between -40°C and +85°C. To order, change the prefix from 'UDN' to 'UDQ'.

For maximum power-handling capability, the UDN2936W and UDN2936W-120 are supplied in 12-pin single in-line power-tab packages. An external heat sink may be required for high-current applications. The tab is at ground potential and needs no insulation.

FEATURES

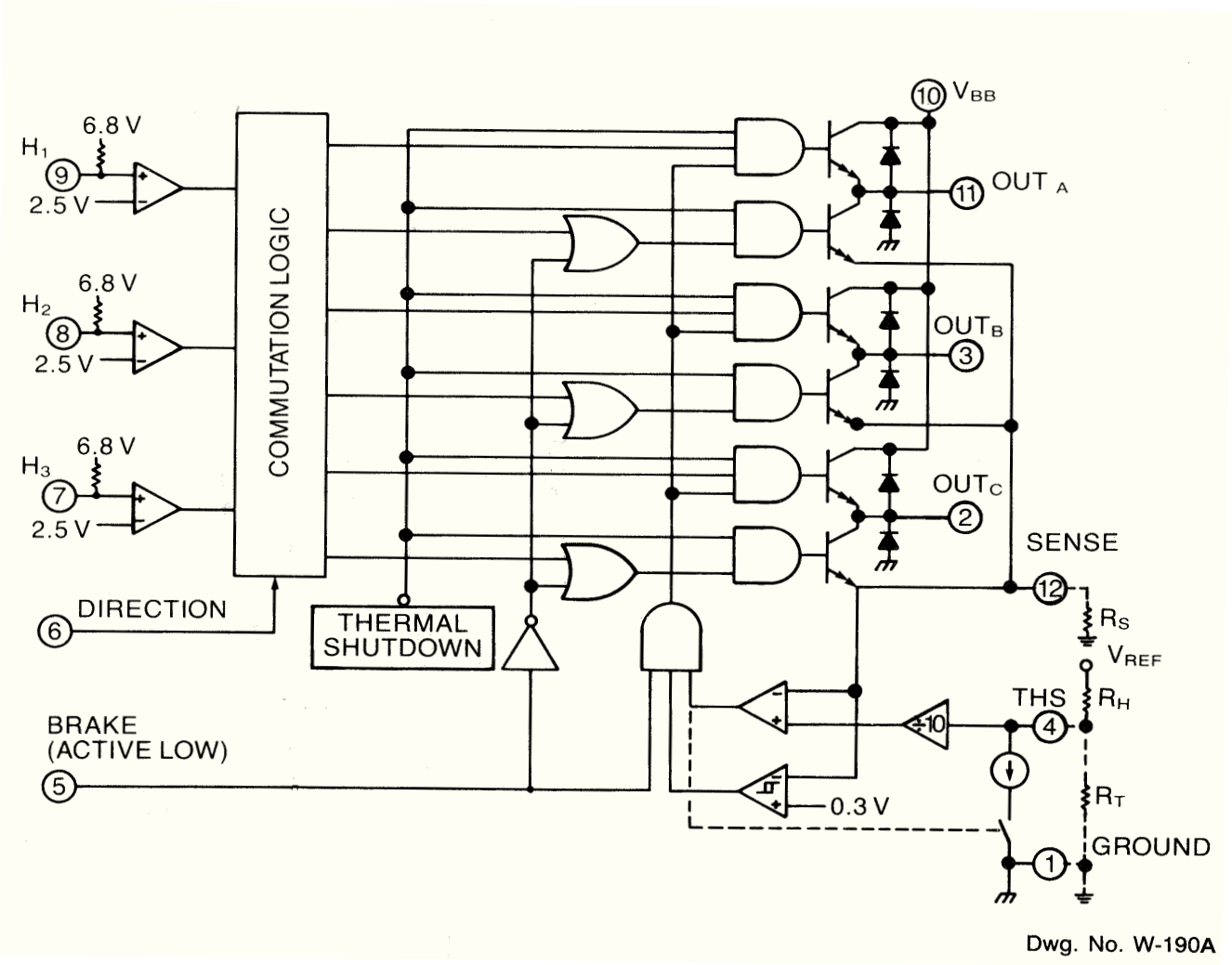
- 10 V to 45 V Operation
- ±3 A Peak Output Current
- Internal Clamp Diodes
- Internal PWM Current Control
- 60° or 120° Commutation Decoding Logic
- Thermal Shutdown Protection
- Compatible with Single-Ended or Differential Hall-Effect Sensors
- Braking and Direction Control

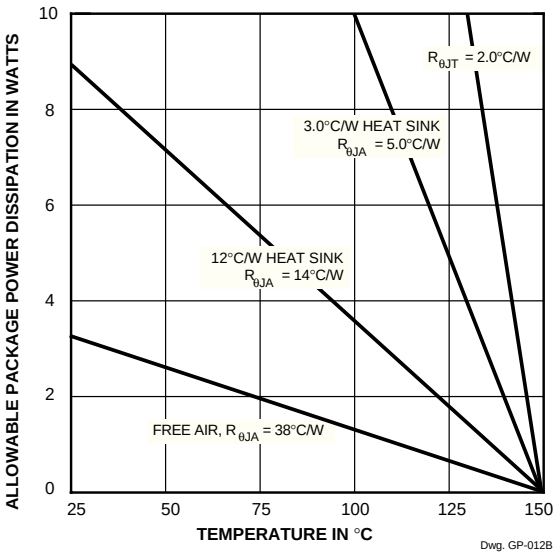
Always order by complete part number:

Part Number	Sensor Inputs
UDN2936W	Single-Ended, 60° Separation
UDN2936W-120	Single-Ended, 120° Separation

2936
3-PHASE BRUSHLESS DC MOTOR CONTROLLER/DRIVERS

FUNCTIONAL BLOCK DIAGRAM





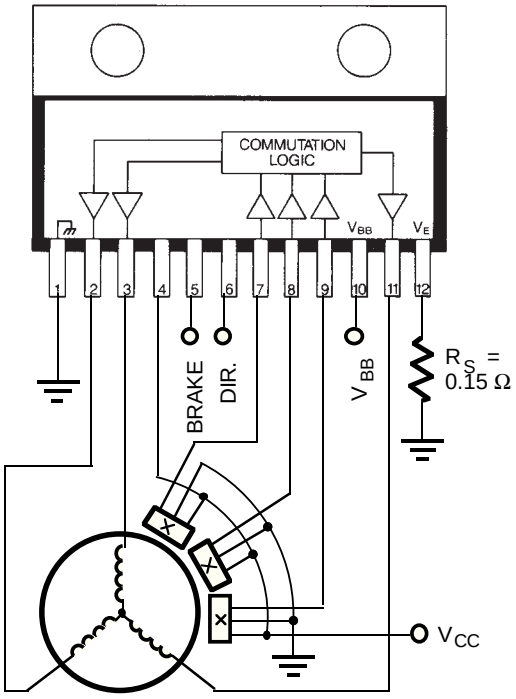
COMMUTATION TRUTH TABLE
UDN2936W

Hall Sensor Inputs					Outputs		
H_1	H_2	H_3	DIRECTION	BRAKE	OUT_A	OUT_B	OUT_C
High	High	High	Low	High	Z	Low	High
High	High	Low	Low	High	High	Low	Z
High	Low	Low	Low	High	High	Z	Low
Low	Low	Low	Low	High	Z	High	Low
Low	Low	High	Low	High	Low	High	Z
Low	High	High	Low	High	Low	Z	High
High	High	High	High	High	Z	High	Low
High	High	Low	High	High	Low	High	Z
High	Low	Low	High	High	Low	Z	High
Low	Low	Low	High	High	Z	Low	High
Low	Low	High	High	High	High	Low	Z
Low	High	High	High	High	High	Z	Low
X	X	X	X	Low	Low	Low	Low

X= Irrelevant

Z = High Impedance

TYPICAL APPLICATION



Dwg. EP-033

COMMUTATION TRUTH TABLE
UDN2936W-120

Hall Sensor Inputs					Outputs		
H_1	H_2	H_3	DIRECTION	BRAKE	OUT_A	OUT_B	OUT_C
High	Low	High	Low	High	Z	Low	High
High	Low	Low	Low	High	High	Low	Z
High	High	Low	Low	High	High	Z	Low
Low	High	Low	Low	High	Z	High	Low
Low	High	High	Low	High	Low	High	Z
Low	Low	High	Low	High	Low	Z	High
High	Low	High	High	High	Z	High	Low
High	Low	Low	High	High	Low	High	Z
High	High	Low	High	High	Low	Z	High
Low	High	Low	High	High	Z	Low	High
Low	High	High	High	High	High	Low	Z
Low	Low	High	High	High	High	Z	Low
X	X	X	X	Low	Low	Low	Low

X= Irrelevant

Z = High Impedance

ELECTRICAL CHARACTERISTICS at T_A = +25°C, $T_J \leq$ +150°C, V_{BB} = 45 V

Characteristic	Symbol	Test Conditions	Limits			
			Min.	Typ.	Max.	Units
Supply Voltage Range	V_{BB}	Operating	10	—	45	V
Supply Current	I_{BB}	Outputs Open	—	32	40	mA
		V_{BRAKE} = 0.8 V	—	42	50	mA
Thermal Shutdown Temp.	T_J		—	165	—	°C
Thermal Shutdown Hysteresis	ΔT_J		—	25	—	°C
Output Drivers						
Output Leakage Current	I_{CEX}	$V_{OUT} = V_{BB}$	—	—	50	µA
		V_{OUT} = 0 V	—	—	-50	µA
Output Saturation Voltage	$V_{CE(SAT)}$	I_{OUT} = -1 A	—	1.7	1.9	V
		I_{OUT} = +1 A	—	1.1	1.3	V
		I_{OUT} = -2 A	—	1.9	2.1	V
		I_{OUT} = +2 A	—	1.4	1.6	V
Output Sustaining Voltage	$V_{CE(sus)}$	I_{OUT} = ±2 A, L = 2 mH	45	—	—	V
Clamp Diode Forward Voltage	V_F	I_F = 2 A	—	1.8	2.0	V
Clamp Diode Leakage Current	I_R	V_R = 45 V	—	—	50	µA
Output Switching Time	t_r	I_{OUT} = ±2 A, Resistive Load	—	2.0	—	µs
	t_f	I_{OUT} = ±2 A, Resistive Load	—	2.0	—	µs
Turn-ON Delay (Resistive Load)	t_{on}	Source Drivers, 0 to -2 A	—	1.25	—	µs
		Sink Drivers, 0 to +2 A	—	1.9	—	µs
Turn-OFF Delay (Resistive Load)	t_{off}	Source Drivers, -2 A to 0	—	1.7	—	µs
		Sink Drivers, +2 A to 0	—	0.9	—	µs

Continued next page...

ELECTRICAL CHARACTERISTICS at T_A = +25°C, $T_J \leq$ +150°C, V_{BB} = 45 V continued

Characteristic	Symbol	Test Conditions	Limits			Units
			Min.	Typ.	Max.	
Control Logic						
Logic Input Voltage	$V_{IN(1)}$	V_{DIR} or V_{BRAKE}	2.0	—	—	V
	$V_{IN(0)}$	V_{DIR} or V_{BRAKE}	—	—	0.8	V
Sensor Input Voltage Threshold	V_{IN}	H_1, H_2, or H_3	—	2.5	—	V
Input Current	$I_{IN(1)}$	V_{DIR} = 2 V	—	150	200	µA
		V_{BRAKE} = 2 V	—	<1.0	5.0	µA
		V_H = 5 V	—	-190	-220	µA
	$I_{IN(0)}$	V_{DIR} = 0.8 V	—	35	50	µA
		V_{BRAKE} = 0.8 V	—	-5.0	-20	µA
		V_H = 0.8 V	—	-0.64	-1.0	mA
	I_{THS}	$V_{THS} \geq$ 3.0 V	—	-8.0	-15	µA
		V_{THS} < 3.0 V, $V_{SENSE} < V_{THS}/10.5$	—	-15	-30	µA
		V_{THS} < 3.0 V, $V_{SENSE} > V_{THS}/9.5$	190	250	310	µA
Current Limit Threshold	—	V_{THS}/V_{SENSE} at trip point, V_{THS} < 3.0 V	9.5	10	10.5	—
Default Sense Trip Voltage	V_{SENSE}	$V_{THS} \geq$ 3.0 V	270	300	330	mV
Default Hysteresis	—	$V_{THS} \geq$ 3.0 V	—	7.5	—	%
Deadtime	t_d	BRAKE or DIRECTION	—	2.0	—	µs

APPLICATIONS INFORMATION

The UDN2936W and UDN2936W-120 power drivers provide commutation logic and power outputs to drive three-phase brushless dc motors.

The UDN2936W and UDN2936W-120 are designed to interface with single-ended linear or digital Hall-effect devices (HEDs). Internal pull-up resistors allow for direct use with open-collector digital HEDs. The H_N inputs have 2.5 V thresholds.

The commutation logic provides decoding for HEDs with 60° (UDN2936W) or 120° (UDN2936W-120) electrical separation. At any one step in the logic sequencing, one half-bridge driver is sourcing current, one driver is sinking current, and one driver is in a high-impedance state (see Truth Table).

A logic low on the BRAKE pin turns ON the three sink drivers and turns OFF the three source drivers, essentially shorting the motor windings to ground. During braking, the back-electromotive force generated by the motor produces a current that dynamically brakes the motor. Depending upon the rotational velocity of the motor, this current can approach the locked rotor current level (which is limited only by the motor winding resistance). During braking, the output current-limiting circuitry is disabled and care should be taken to ensure that the back-EMF generated brake current does not exceed the maximum rating (3 A peak) of the sink drivers and ground clamp diodes.

Changing the logic level of the DIRECTION pin inverts the output states, thus reversing the direction of the motor. Changing the direction of a rotating motor produces a back-EMF current similar to when braking the motor. The load current should not be allowed to exceed the maximum rating (±3 A peak) of the drivers.

An internally generated dead time (t_d) of approximately 2 µs prevents potentially destructive crossover currents that can occur when changing direction or braking.

Motor current is internally controlled by pulse-width modulating the source drivers with a preset hysteresis format. Load current through an external sense resistor (R_S) is constantly monitored. When the current reaches the set trip point (determined by an external reference voltage or internal default), the source driver is disabled. Current recirculates through the ground clamp diode, motor winding, and sink driver. An internal constant-current sink reduces the trip point (hysteresis). When the decaying current reaches this lower threshold, the source driver is enabled again and the cycle repeats.

Thresholds and hysteresis can be set with external resistors, or internal defaults can be used. With V_{THS} > 3.0 V, the trip point is internally set at 300 mV with 7.5% hysteresis. Load current is then determined by the equation:

$$I_{TRIP} = 0.3 / R_S$$

With V_{THS} < 3.0 V, the threshold, hysteresis percentage, and peak current are set with external resistors according to the equations:

$$\text{threshold voltage } (V_{THS}) = V_{REF} \bullet R_T / (R_H + R_T)$$

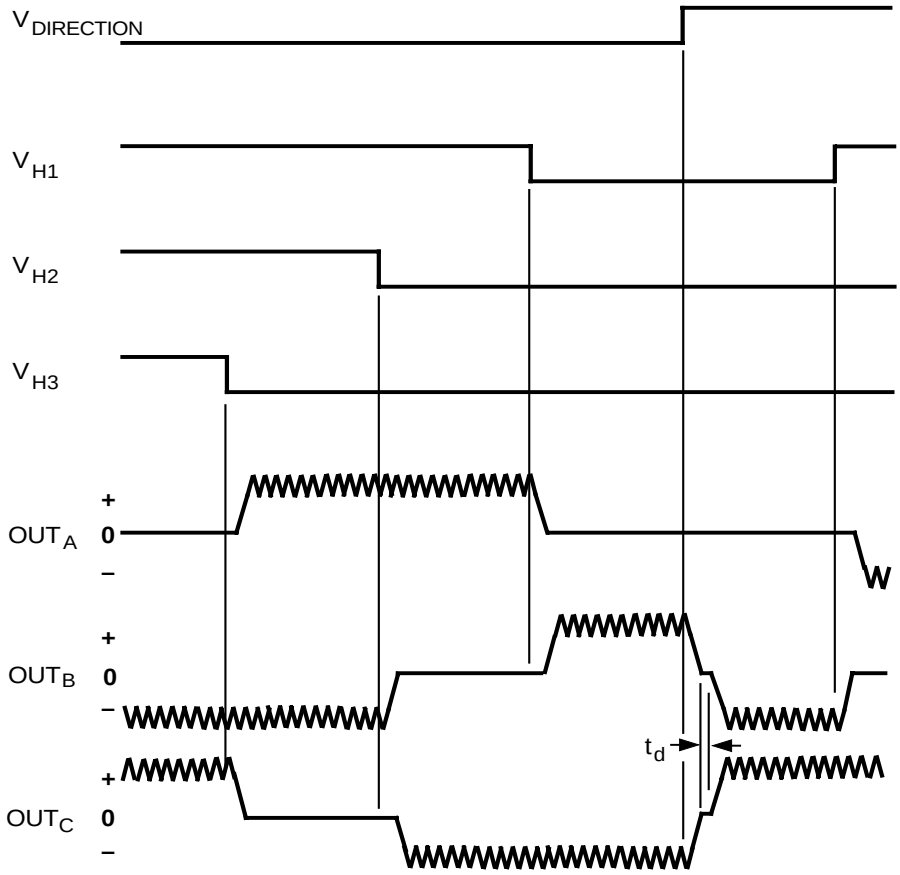
$$\text{hysteresis percentage} = R_H / 50\ V_{REF}$$

$$\text{load trip current } (I_{TRIP}) = V_{THS} / 10\ R_S$$

Percentage hysteresis is a fixed value independent of load current. The chopping frequency is a function of circuit parameters including load inductance, load resistance, supply voltage, hysteresis, and switching speed of the drivers.

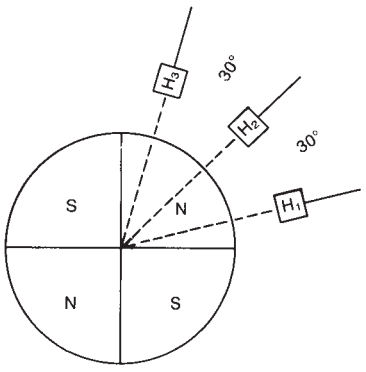
The UDN2936W and UDN2936W-120 outputs are rated for normal operating currents of up to ±2 A and startup currents to ±3 A (see cautions above regarding braking and changing of motor direction). Internal power ground-clamp and flyback diodes protect the outputs from the voltage transients that occur when switching inductive loads. All devices also feature thermal protection circuitry. If the junction temperature reaches +165°C, the thermal shutdown circuitry turns OFF all output drivers. The outputs are re-enabled when the junction cools down to approximately +140°C. This protection is only intended to protect the device from failures due to excessive junction temperature or loss of heat sinking and should not imply that output short circuits are permitted.

As with all high-power integrated circuits, the printed wiring board should utilize a heavy ground plane. For optimum performance, the drivers should be soldered directly into the board. The power supply should be decoupled with an electrolytic capacitor (>10 µF) as close as possible to the device supply pin (V_{BB}).



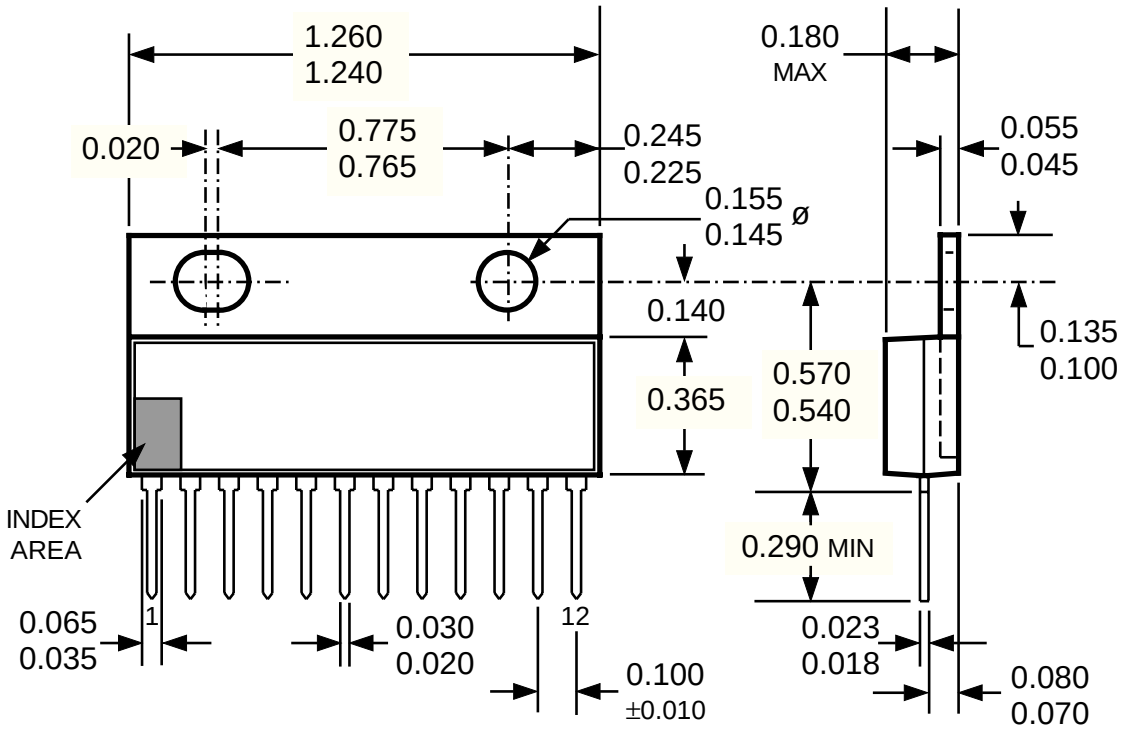
Dwg. WM-002-1

TYPICAL HALL EFFECT SENSOR LOCATIONS



Dwg. No. W-193

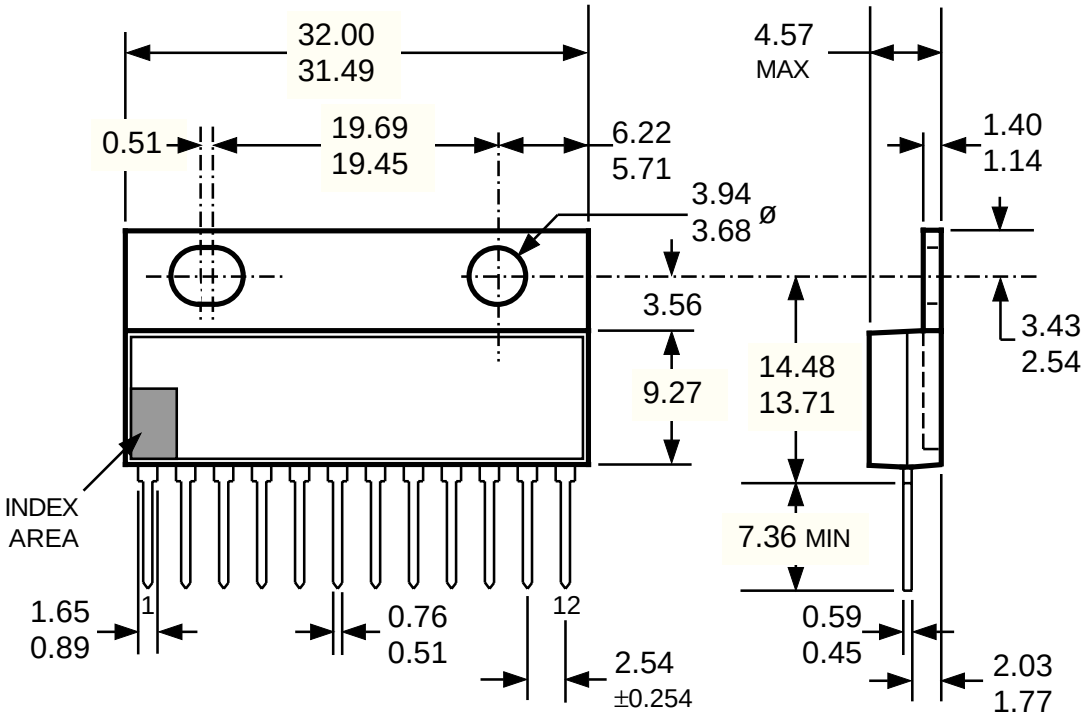
Dimensions in Inches
(controlling dimensions)



Dwg. MP-007 in

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

Dimensions in Millimeters
(for reference only)



Dwg. MP-007 mm

NOTES: 1. Lead thickness is measured at seating plane or below.
2. Lead spacing tolerance is non-cumulative
3. Exact body and lead configuration at vendor's option within limits shown.
4. Lead gauge plane is 0.762 mm below seating plane.

2936
3-PHASE BRUSHLESS DC MOTOR CONTROLLER/DRIVERS

MOTOR DRIVERS SELECTION GUIDE

Function	Output Ratings *		Part Number †
INTEGRATED CIRCUITS FOR BRUSHLESS DC MOTORS			
3-Phase Controller/Drivers	±2.0 A	45 V	2936 and 2936-120
Hall-Effect Latched Sensors	10 mA	24 V	3175 and 3177
2-Phase Hall-Effect Sensor/Controller	20 mA	25 V	3235
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	400 mA	26 V	3626
Hall-Effect Complementary-Output Sensor/Driver	300 mA	60 V	5275
3-Phase Back-EMF Controller/Driver	±900 mA	14 V	8902–A
3-Phase Controller/DMOS Driver	±4.0 A	14 V	8925
3-Phase Back-EMF Controller/Driver	±1.0 A	7 V	8984
INTEGRATED BRIDGE DRIVERS FOR DC AND BIPOLAR STEPPER MOTORS			
PWM Current-Controlled Dual Full Bridge	±750 mA	45 V	2916
PWM Current-Controlled Dual Full Bridges	±1.5 A	45 V	2917 and 2918
PWM Current-Controlled Dual Full Bridge	±750 mA	45 V	2919
Dual Full-Bridge Driver	±2.0 A	50 V	2998
PWM Current-Controlled Full Bridge	±2.0 A	50 V	3952
PWM Current-Controlled Full Bridge	±1.3 A	50 V	3953
PWM Current-Controlled Microstepping Full Bridges	±1.5 A	50 V	3955 and 3957
PWM Current-Controlled Dual Full Bridge	±800 mA	33 V	3964
PWM Current-Controlled Dual Full Bridge	±650 mA	30 V	3966 and 3968
PWM Current-Controlled Dual Full Bridge	±750 mA	45 V	6219
OTHER INTEGRATED CIRCUIT & PMCM MOTOR DRIVERS			
Unipolar Stepper-Motor Quad Driver	1.8 A	50 V	2544
Unipolar Stepper-Motor Translator/Driver	1.25 A	50 V	5804
Unipolar Stepper-Motor Quad Drivers	1 A	46 V	7024 and 7029
Unipolar Microstepper-Motor Quad Driver	1.2 A	46 V	7042
Voice-Coil Motor Driver	±500 mA	6 V	8932–A
Voice-Coil Motor Driver	±800 mA	16 V	8958
Voice-Coil (and Spindle) Motor Driver	±350 mA	7 V	8984

* 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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