

# DATA SHEET

**TDA5146T**

Brushless DC motor drive circuit

Product specification

1994 May 18

# Brushless DC motor drive circuit

# TDA5146T

## FEATURES

- Full-wave commutation (using push/pull drivers at the output stages) without position sensors
- Built-in start-up circuit
- Three push-pull outputs:
  - 2 A output current (Typical)
  - Built-in current limiter
- Thermal protection
- Soft switching outputs
- Flyback diodes
- Tacho output sensor
- Brake function
- Direction control input
- Reset function
- FET driver stage to be used in a buck converter

## APPLICATIONS

General purpose spindle driver (e.g., HDD, tape driver)

## GENERAL DESCRIPTION

The TDA5146T is a bipolar integrated circuit used to drive brushless DC motors in full-wave mode. The device senses the rotor position using an EMF –sensing technique and is ideally suited as a drive circuit for a hard disk drive motor or tape drive.

## QUICK REFERENCE DATA

Measured over full voltage and temperature ranges

Symbol	Parameter	Min.	Typ.	Max.	Unit
$V_P$	Supply voltage range (Note 1)	4	–	18	V
$V_{sup}$	Supply for the FET driver voltage range	4	–	18	V
$V_{VMOT}$	Input voltage to the output driver stages (see Fig. 1)	1.7	–	16	V
$V_{DO}$	Driver output voltage drop $I_O = 100$ mA	–	0.9	1.05	V
$I_{LIM}$	Current limiting	1.80	2.0	2.5	A

### NOTES:

1. An unstabilized supply can be used
2.  $V_{VMOT} = V_P$ ; all outputs  $I_O = 0$  mA

## ORDERING AND PACKAGE INFORMATION

Type number	Package		
	Name	Description	Version
TDA5146T	SO28	plastic small outline package; 28 leads; body width 7.5 mm	SOT136-1

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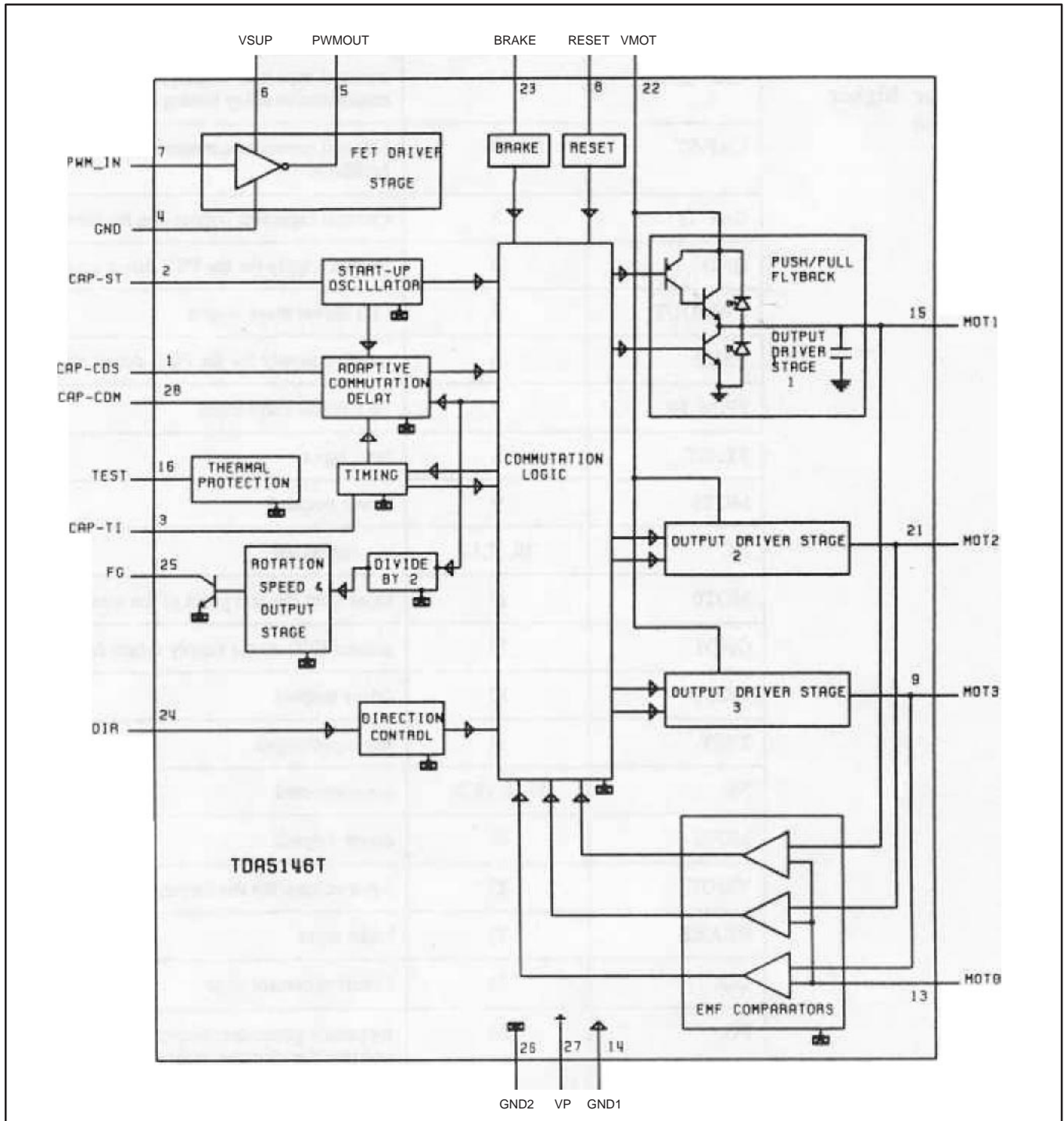


Figure 1. Block diagram

# Brushless DC motor drive circuit

# TDA5146T

## PINNING

Symbol	Pin	Description
CAP-CDS	1	external capacitor connection for adaptive commutation delay timing copy
CAP-ST	2	external capacitor connection for start-up oscillator
CAP-TI	3	external capacitor connection for timing
GND	4	ground supply for the FET driver stage
PWMOUT	5	FET driver stage output
V <sub>SUP</sub>	6	positive supply for the FET driver stage
PWM_IN	7	FET driver stage input
RESET	8	reset input
MOT3	9	driver output 3
NC	10,11,12	not connected
MOT0	13	input from the star point of the motor coils
GND1	14	ground (0 V) motor supply return for output stages
MOT1	15	driver output 1
TEST	16	test input/output
NC	17,18,19,20	not connected
MOT2	21	driver output 2
VMOT	22	input voltage for the output driver stages
BRAKE	23	brake input
DIR	24	direction control input
FG	25	frequency generator: output of the rotation speed and position detector stages (open collector digital output, negative – going edge is valid)
GND2	26	ground supply return for control circuits
V <sub>P</sub>	27	positive supply voltage
CAP-CDM	28	external capacitor connection for adaptive commutation delay timing

### NOTE:

1. Pins 10,11,12,17,18,19 have to be connected to the ground for higher dissipation

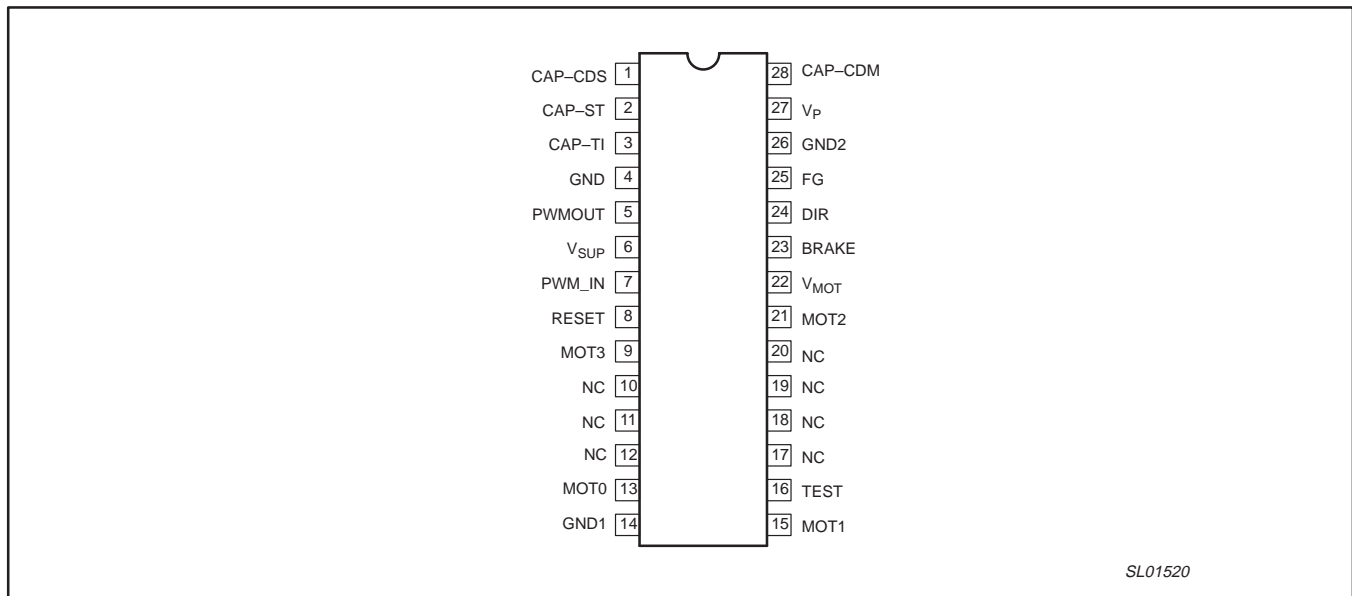


Figure 2. Pin configuration

## Brushless DC motor drive circuit

## TDA5146T

**FUNCTIONAL DESCRIPTION**

The TDA5146T offers a sensorless three phase motor drive function. It is unique in its combination of sensorless motor drive and full-wave drive.

The TDA5146T offers protected outputs capable of handling high currents and can be used with star or delta connected motors. It can easily be adapted for different motors and applications. The TDA5146T offers the following features:

- Sensorless commutation by using the motor EMF
- Built-in start-up circuit
- Optimum commutation, independent of motor type or motor loading
- Built-in flyback diodes
- Three phase full-wave drive
- High output current (1.8 A)
- Outputs protected by current limiting and thermal protection of each output transistor
- Low current consumption by adaptive base-drive
- Soft switching pulse output for low radiation.
- Accurate frequency generator (FG) by using the motor BMF
- Direction of rotation controlled by one pin.
- FET driver stage to be used in a buck converter

**LIMITING VALUES**

In accordance with the Absolute Maximum System (IEC 134).

Symbol	Parameter	Min	Max	Unit
$V_P, V_{sup}$	Supply voltage	–	18	V
$V_I$	Input voltage; all pins except VMOT ( $V_I < 18$ V)	–0.3	$V_P + 0.5$	V
$V_{VMOT}$	$V_{VMOT}$ input voltage	–0.5	17	V
$V_O$	Output voltage; PWM_OUT and PG/FG	GND	$V_P$	V
$V_O$	Output voltage MOT0, MOT1, MOT2 and MOT3	–1	$V_{VMOT} + V_D$	V
$V_I$	Input voltage CAP-ST, CAP-TI, CAP-CD and CAP-DC	–	2.5	V
$T_{stg}$	Storage temperature range	–55	+150	°C
$T_{amb}$	Operating ambient temperature range	0	70	°C
$P_{tot}$	Total power dissipation	–	–	–

**HANDLING**

Every pin withstands the ESD test according to MIL-STD-883C cross 1. Method 3015 (HBM 1500Ω, 100 pF 3 pulses + and 3 pulses – on each pin referenced to ground).

# Brushless DC motor drive circuit

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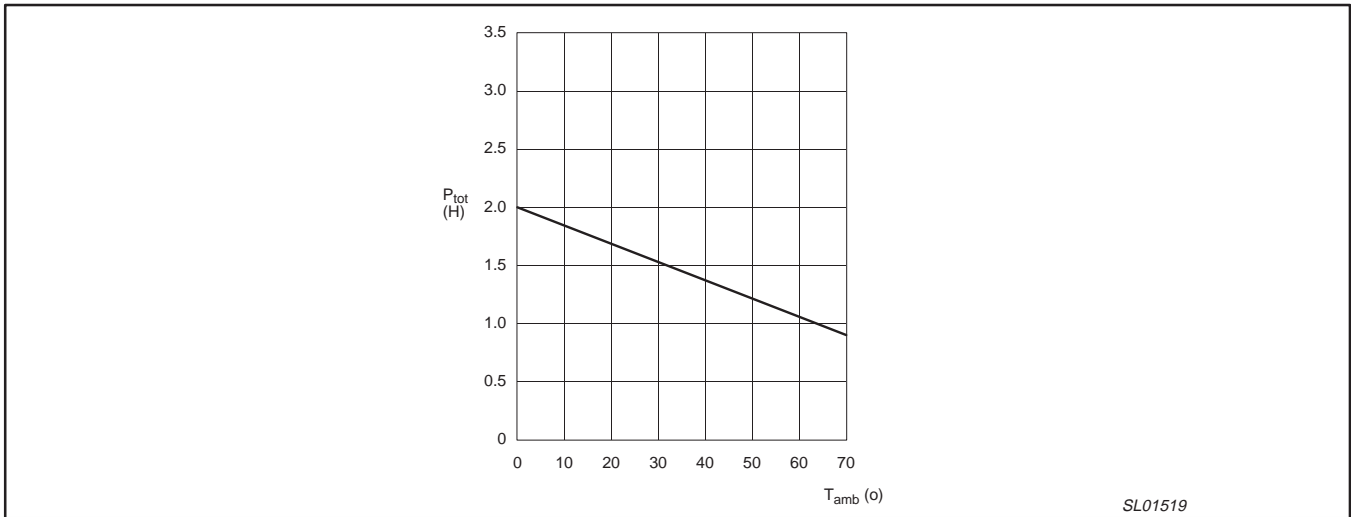


Figure 3. Power derating curve (SOT136-1)

## Brushless DC motor drive circuit

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**CHARACTERISTICS**

$V_P = 14.5\text{ V}$ ;  $T_{\text{amb}} = 25\text{ }^\circ\text{C}$ ; unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Supply</b>						
$V_P$	Supply voltage range	note 1	4	–	18	V
$I_P$	Input current range	note 2	–	5.9	7.5	mA
$V_{VMOT}$	Input voltage to the driver output stages range	see Figure 1	1.7	–	16	V
$I_{Vsup}$	$V_{sup}$ current range	$V_{sup} = 12\text{ V}$	–	1.2	2.0	mA
<b>Thermal protection</b>						
$T_{SD}$	Local temperature at temperature sensor causing shut-down		130	140	150	$^\circ\text{C}$
$\Delta T$	Reduction in temperature before switch-on	after shut-down	–	TSD–30	–	$^\circ\text{C}$
<b>MOT0 – CENTER TAPE</b>						
$V_I$	Input voltage range		–0.5	–	$V_{VMOT}$	V
$I_I$	Input bias current	$0.5\text{ V} < V_I < V_{VMOT} - 1.5\text{ V}$	–10	–	–	$\mu\text{A}$
$\pm V_{CSW}$	Comparator Switching Level	note 3	20	25	30	mV
$\Delta V_{CS}$	Variation in threshold voltage between comparators	note 3	–	–	3	mV
$V_H$	Comparator input hysteresis		–	75	–	$\mu\text{V}$
<b>MOT1, MOT2 AND MOT3</b>						
$V_{DO}$	Dropout Voltage	$I_O = 100\text{ mA}$ $I_O = 1000\text{ mA}$	–	0.9 1.6	1.05 1.85	V
$\Delta V_{OL}$	Variation in saturation voltage between lower transistors	$I_O = 100\text{ mA}$	–	–	180	mV
$\Delta V_{OH}$	Variation in saturation voltage between upper transistors	$I_O = -100\text{ mA}$	–	–	180	mV
$I_{LIM}$	Current limiting	$V_{VMOT} = 10\text{ V}$ $R_{out} = 1.2\ \Omega$	1.8	2.0	2.5	A
$T_r$	Rise time switching output	$V_{MOT} = 15\text{ V}$ note 6	5	10	15	$\mu\text{s}$
$T_f$	Fall time switching output	$V_{MOT} = 15\text{ V}$ note 6	10	15	20	$\mu\text{s}$
$V_{DHF}$	Diode forward voltage ( $D_H$ )	notes 4 and 5; see Fig. 1; $I_0 = -500\text{ mA}$	–	–	1.5	V
$V_{DLF}$	Diode forward voltage ( $D_L$ )	notes 4 and 5; see Fig. 1; $I_0 = 500\text{ mA}$	–1.5	–	–	V
$I_{DM}$	Peak diode current	note 5	–	–	2.5	A
<b>DIR</b>						
$V_{IH}$	Normal rotation voltage on pin 5	$4\text{ V} < V_P < 18\text{ V}$	2.0	–	–	V
$V_{IL}$	Reverse rotation voltage on pin 5	$4\text{ V} < V_P < 18\text{ V}$	–	–	0.8	V
$I_{IL}$	Reverse rotation current		–	–20	–	$\mu\text{A}$
$I_{IH}$	Normal rotation current		–	–20	–	$\mu\text{A}$
<b>RESET</b>						
$V_{IH}$	Input voltage HIGH in reset mode	$4\text{ V} < V_P < 18\text{ V}$	2.0	–	–	V
$V_{IL}$	Input voltage LOW in normal mode	$4\text{ V} < V_P < 18\text{ V}$	–	–	0.8	V
$I_{IH}$	Input current HIGH	$V_I = 2.0\text{ V}$	–	–20	–	$\mu\text{A}$
$I_{IL}$	Input current LOW	$V_I = 0.8\text{ V}$	–	–20	–	$\mu\text{A}$

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Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>BRAKE</b>						
V <sub>IH</sub>	Input voltage HIGH in brake mode	4V < V <sub>P</sub> < 18V	2.0	–	–	V
V <sub>IL</sub>	Input voltage LOW in normal mode	4V < V <sub>P</sub> < 18V	–	–	0.8	V
I <sub>IH</sub>	Input current HIGH	V <sub>I</sub> = 2.0 V	–	–20	–	μA
I <sub>IL</sub>	Input current LOW	V <sub>I</sub> = 0.8 V	–	–20	–	μA
<b>FG</b>						
V <sub>OL</sub>	Output voltage LOW	I <sub>O</sub> = 1.6 mA	–	–	0.4	V
V <sub>OHmax</sub>	Maximum output voltage HIGH		V <sub>P</sub>	–	–	V
t <sub>THL</sub>	Transition time	HIGH-to-LOW C <sub>L</sub> = 50 pF R <sub>L</sub> = 10 kΩ	–	0.5	–	μS
	Ratio of FG frequency and commutation frequency		–	1:2	–	
δ	Duty factor		–	50	–	%
<b>PWM_IN</b>						
V <sub>IH</sub>	High Level Input	4V < V <sub>P</sub> < 18V	2.0	–	–	V
V <sub>IL</sub>	Low Level Input	4V < V <sub>P</sub> < 18V	–	–	0.8	V
I <sub>IH</sub>	High Level Input Current	V <sub>I</sub> = 2.0V	–3	0	3	μA
I <sub>IL</sub>	Low Level Input Current	V <sub>I</sub> = 0.8V	–20	–3	–	μA
<b>PWMOUT</b>						
V <sub>OH</sub>	PWM Output HIGH	PWM IN <= 2.0V	V <sub>sup</sub> – 0.7	–	–	V
V <sub>OL</sub>	PWM Output LOW	PWM IN > –0.8V	–	–	0.7	V
I <sub>pwmoutsource</sub>	Sourcing capability	PWMOUT = 10 9.5V 9V	5 15 30			mA mA mA
I <sub>pwmoutsink</sub>	sinking capability	PWMOUT = 1V	25	–	–	mA
SR	PWM Output Slew Rate	R <sub>s</sub> = 51 Ω C <sub>1</sub> = 2nF	–	100	–	V/μS
<b>CAP-ST</b>						
I <sub>I</sub>	Output sink current		1.6	2.1	2.6	μA
I <sub>O</sub>	Output source current		–2.6	–2.1	–1.6	μA
V <sub>SWL</sub>	Lower switching level		–	0.20	–	V
V <sub>SWM</sub>	Middle switching level		–	0.30	–	V
V <sub>SWH</sub>	Upper switching level		–	2.20	–	V
<b>CAP-TI</b>						
I <sub>I</sub>	Output sink current		–	28	–	μA
I <sub>OH</sub>	Output source current HIGH		–	–57	–	μA
I <sub>OL</sub>	Lower source current LOW		–	–5	–	μA
V <sub>SWL</sub>	Lower switching level		–	50	–	mV
V <sub>SWM</sub>	Middle switching level		–	0.30	–	V
V <sub>SWH</sub>	Upper switching level		–	2.20	–	V



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Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>CAP-CDM</b>						
$I_I$	Output sink current		10.6	16.2	22	$\mu\text{A}$
$I_O$	Output source current		-5.3	-8.1	-11	$\mu\text{A}$
$I_I/I_O$	Ratio of sink to source current		1.85	2.05	2.25	
$V_{IL}$	Input voltage level LOW		0.85	-	0.9	V
$V_{IH}$	Input voltage level HIGH		2.3	2.4	2.55	V
<b>CAP-CDS</b>						
$I_I$	Output sink current		10.1	15.5	20.9	$\mu\text{A}$
$I_O$	Output source current		-20.9	-15.5	-10.1	$\mu\text{A}$
$I_I/I_O$	Ratio of sink to source current		0.9	1.025	1.15	$\mu\text{A}$
$V_{IL}$	Input voltage level LOW		0.85	-	0.9	V
$V_{IH}$	Input voltage level HIGH		2.3	2.4	2.55	V

**NOTES:**

1. An unstabilized supply can be used.
2.  $V_{MOT} = V_P$ , all other inputs at 0V; all outputs at  $V_P$  and  $I_O = 0\text{mA}$ .
3. Switching levels with respect to MOT1, MOT2 and MOT3. See Figure 4.
4. Drivers are in high impedance OFF-state.
5. The outputs are short-circuit protected by limiting the current and the IC temperature.
6. Output transition time measurement. See Figure 5.

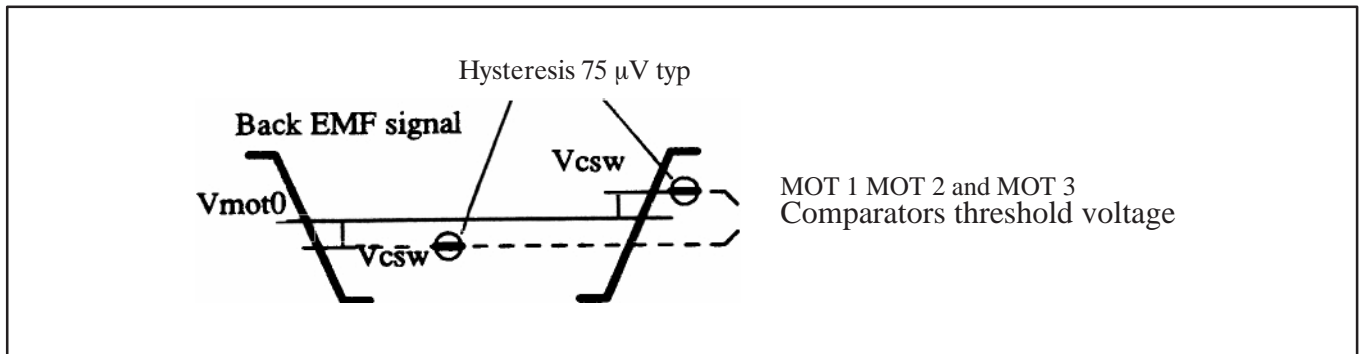


Figure 4.

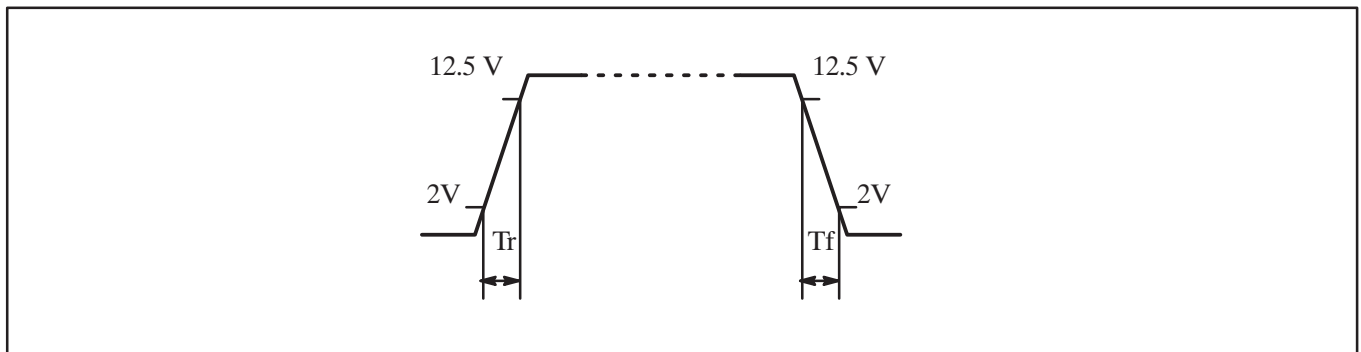
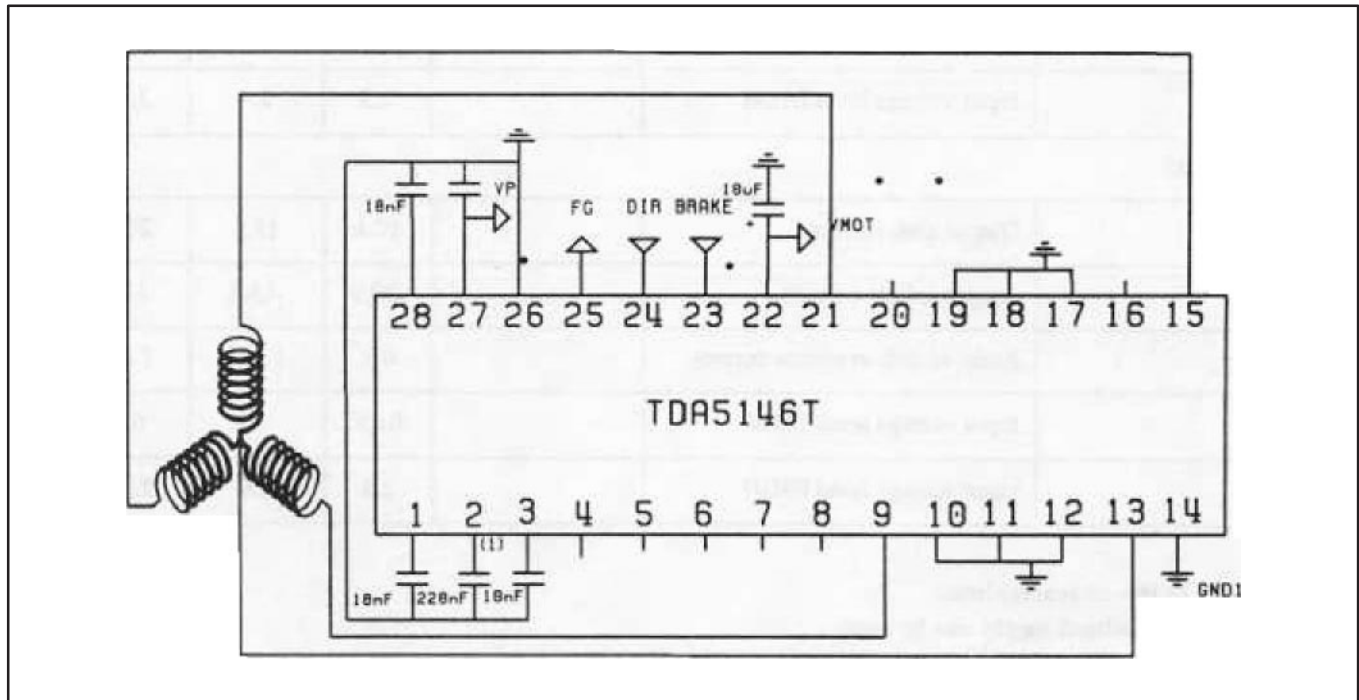


Figure 5.

# Brushless DC motor drive circuit

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1. Value selected for 3 HZ start-up oscillator frequency

**Figure 6. Application diagram without use of the FET driver stage**

## APPLICATION INFORMATION

### Introduction

Full-wave driving of a three phase motor requires three push-pull output stages. In each of the six possible states two outputs are active, one sourcing and one sinking current. The third output presents a high impedance to the motor which enables measurement of the motor EMF in the corresponding motor coil by the EMF comparator at each output. The commutation logic is responsible for control of the output transistors and selection of the correct EMF comparator.

The zero-crossing in the motor EMF (detected by the comparator selected by the commutation logic) is used to calculate the correct moment for the next commutation, that is, the change to the next output state. The delay is calculated (depending on the motor loading) by the adaptive commutation delay block.

Because of high inductive loading the output stages contain flyback diodes. The output stages are also protected by a current limiting circuit and by thermal protection of the six output transistors.

The zero-crossings can be used to provide speed information such as the tacho signal FG.

# Brushless DC motor drive circuit

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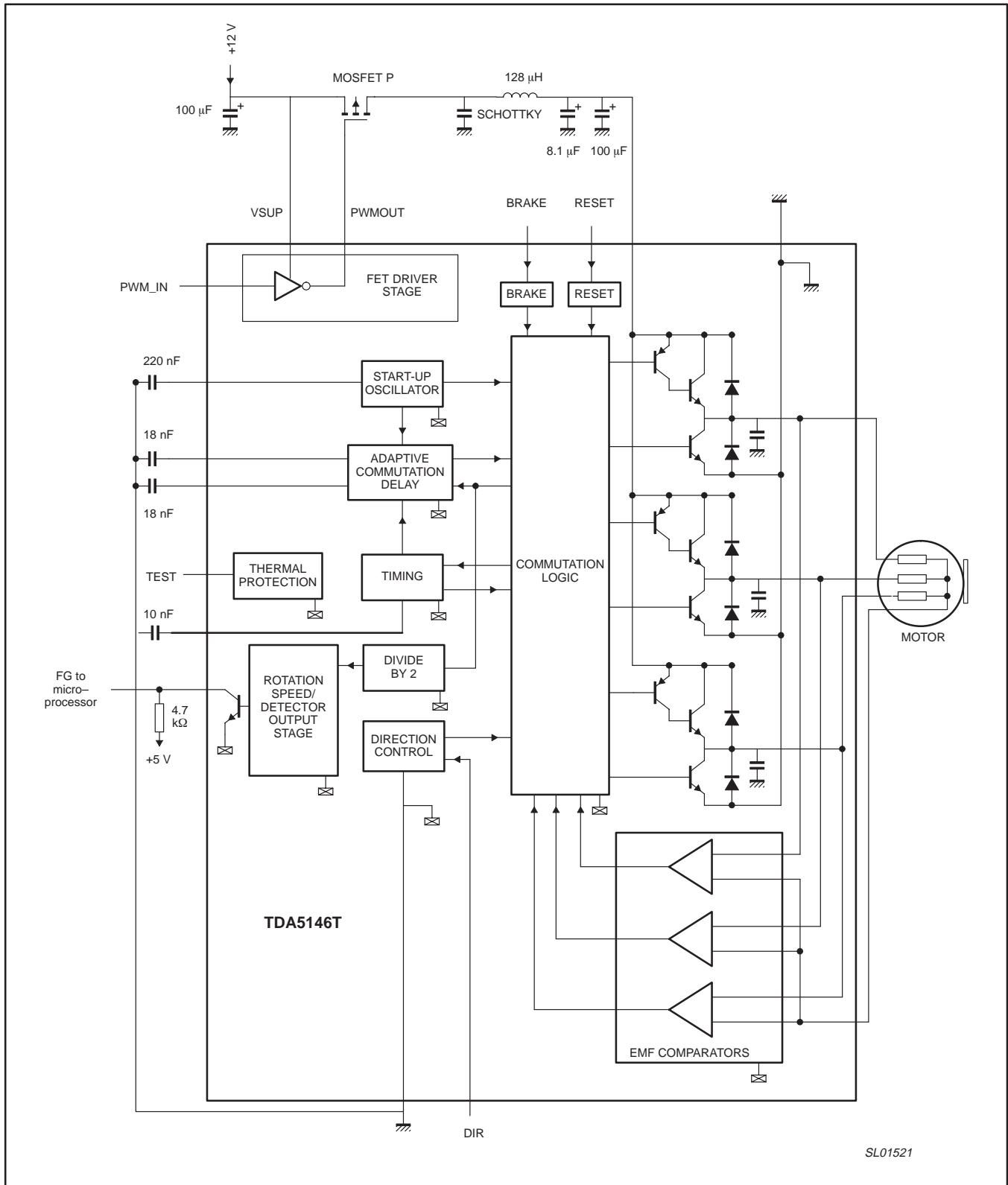


Figure 7. Typical Application diagram of the TDA5146T with use of the FET driver stage

# Brushless DC motor drive circuit

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The system will only function when the EMF voltage from the motor is present. Therefore, a start oscillator is provided that will generate commutation pulses when no zero-crossings in the motor voltage are available.

A timing function is incorporated into the device for internal timing and for timing of the reverse rotation detection.

The TDA5146T is designed for systems with low current consumption: use of  $I^2L$  logic, adaptive base drive for the output transistors (patent pending).

## Adjustments

The system has been designed in such a way that the tolerances of the application components are not critical. However, the approximate values of the following components must still be determined:

- The start capacitor; this determines the frequency of the start oscillator
- The two capacitors in the adaptive commutation delay circuit. These are important in determining the optimum moment for commutation, depending on the type and loading of the motor
- The timing capacitor; this provides the system with its timing signals
- Three external, damping RC-combinations that can be used to reduce BF interference and acoustic noise from the motor

### The Start Capacitors (CAP-ST)

This capacitor determines the frequency of the start oscillator. It is charged and discharged, with a current of 2  $\mu\text{A}$ , from 0.05 V to 2.2 V and back to 0.05 V. The time taken to complete one cycle is given by:

$$t_{\text{start}} = (2.15 \times C)\text{s} \quad (\text{with } C \text{ in } \mu\text{F})$$

The start oscillator is reset by a commutation pulse and so is only active when the system is in the start-up mode. A pulse from the start oscillator will cause the outputs to change to the next state (torque in the motor). If the movement of the motor generates enough EMF the TDA5146T will run the motor. If the amount of EMF generated is insufficient, then the motor will move one step only and will oscillate in its new position. The amplitude of the oscillation must decrease sufficiently before the arrival of the next start pulse, to prevent the pulse arriving during the wrong phase of the oscillation. The oscillation of the motor is given by:

$$f_{\text{OSC}} = (0.5/\pi) \times (K_t \times I \times p/J)^{1/2}$$

where:  $K_t$  = torque constant (N.m/A)  
 $I$  = current (A)  
 $p$  = number of magnetic pole-pairs  
 $J$  = inertia J (kg/m<sup>2</sup>)

Example:  $J = 72 \times 10^{-6} \text{ kg/m}^2$ ,  $K = 25 \times 10^{-3} \text{ N.m/A}$ ,  $p = 6$  and  $I = 0.5 \text{ A}$ ; this gives  $f_{\text{osc}} = 5 \text{ Hz}$ . If the damping is high then a start frequency of 2 Hz can be chosen or  $t = 500 \text{ ms}$ , thus  $C = 0.5/2 = 0.25 \mu\text{F}$ , (choose 220 nF).

### The Adaptive Commutation Delay (CAP-CDM and CAP-CDS)

In this circuit capacitor CAP-CDM is charged during one commutation period, with an interruption of the charging current during the diode pulse. During the next commutation period this capacitor (CAP-CDM) is discharged at twice the charging current. The charging current is 8.1  $\mu\text{A}$  and the discharging current 16.2  $\mu\text{A}$ ; the voltage range is from 0.9 to 2.2V. The voltage must stay within this range at the lowest commutation frequency of interest,  $f_{c1}$ :

$$C = 8.1 \cdot 10^{-6} / f \times 1.3 = 6231/f_{c1} \quad (\text{C in nF})$$

If the frequency is lower, then a constant commutation delay after the zero-crossing is generated by the discharge from 2.2 to 0.9V at 16.2  $\mu\text{A}$ .

$$\text{maximum delay} = (0.076 \times C) \text{ ms} \quad (\text{with } C \text{ in nF})$$

Example: nominal commutation frequency = 900 Hz and the lowest usable frequency = 400 Hz, so:

$$\text{CAP-CDM} = 6231 / 400 = 15.6 \quad (\text{choose } 18 \text{ nF})$$

The other capacitor, CAP-CDS, is used to repeat the same delay by charging and discharging with 20  $\mu\text{A}$ . The same value can be chosen as for CAP-CDM. Figure 8 illustrates typical voltage waveforms.

# Brushless DC motor drive circuit

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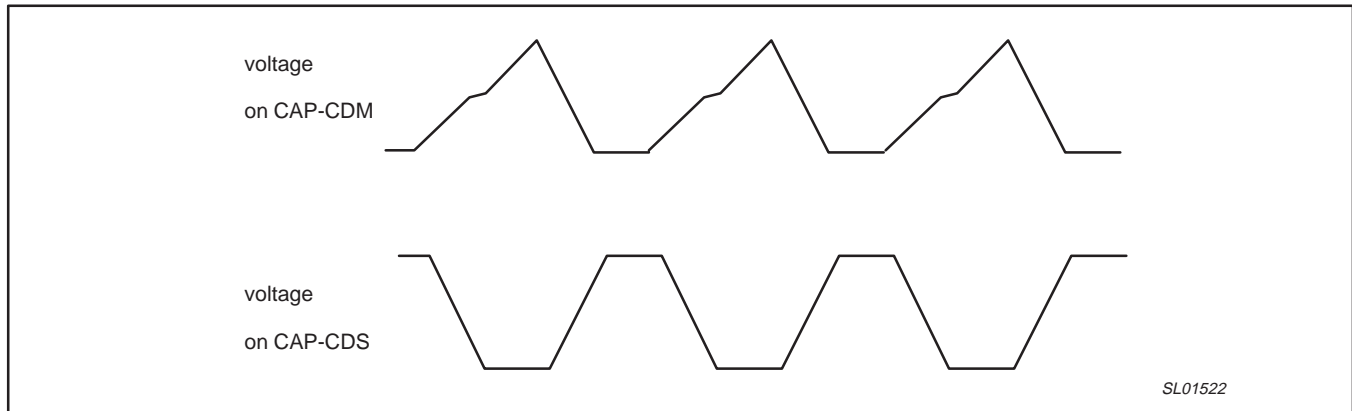


Figure 8. CAP-CDM and CAP-CDS voltage waveform in normal running mode

### The Timing Capacitor (CAP-TI)

Capacitor CAP-TI is used for timing the successive steps within one commutation period; these steps include some internal delays.

The most important function is the watchdog time in which the motor EMF has to recover from a negative diode-pulse back to a positive EMF voltage (or vice versa). A watchdog timer is a guarding function that only becomes active when the expected event does not occur within a predetermined time.

The EMF usually recovers within a short time if the motor is running normally (<< ms). However, if the motor is motionless or rotating in the reverse direction, then the time can be longer (>> ms).

A watchdog time must be chosen so that it is long enough for a motor without EMF (still) and eddy currents that may stretch the voltage in a motor winding; however, it must be short enough to detect reverse rotation. If the watchdog time is made too long, then the motor may run in the wrong direction (with little torque).

The capacitor is charged, with a current of 57 μA, from 0.2 to 0.3V. Above this level it is charged, with a current of 5 μA, up to 2.2 V only if the selected motor EMF remains in the wrong polarity (watchdog function). At the end, or, if the motor voltage becomes positive, the capacitor is discharged with a current of 28 μA. The watchdog time is the time taken to charge the capacitor, with a current of 5 μA, from 0.3 to 2.2V. The value of CAP-T1 is given by:

$$C = 5 \times 10^{-6} \times t_m / 1.9 - 2.63 t_m \quad (C \text{ in nF; } t \text{ in ms})$$

Example: If after switching off, the voltage from a motor winding is reduced, in 3.5 ms, to within 20 mv (the offset of the EMF comparator), then the value of the required timing capacitor is given by:

$$C = 2.63 \times 3.5 = 9.2 \quad (\text{choose } 10 \text{ nF})$$

Typical voltage waveforms are illustrated by Figure 9.

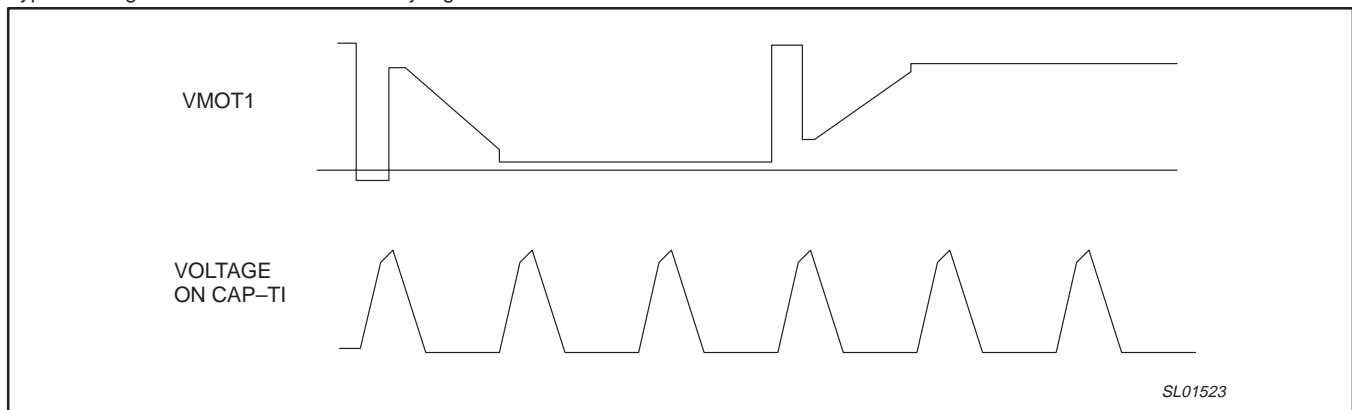


Figure 9. Typical Cap-TI and VMOT1 voltage waveforms in normal running mode

# Brushless DC motor drive circuit

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## NOTE:

1. If the chosen value of CAP-T1 is too small, then oscillations can occur in certain positions of a blocked rotor. If the chosen value is too large, then it is possible that the motor may run in the reverse direction (synchronously with little torque).

## The External Damping Components

Flyback pulses from the motor windings may cause H F interference and acoustic noise. The flyback pulses can be damped by RC-combinations in parallel with the motor windings. This reduces the HF interference; it also reduces the acoustic noise by several dB, depending on the motor construction.

These damping components also have negative effects. They not only dissipate energy from the flyback pulses, but also contribute to the overall energy consumption. Other negative effects are discussed below.

One negative effect is the distortion of the motor EMF sensed by the comparators in the TDA5146T. This distortion may influence the correct functioning of the TDA5146T, for example, an (damped) oscillation occurring after the winding has been switched off. This oscillation must be critically (or over critically) damped, so that:

$$R^2 \times C = 4 \times L \quad (L = \text{inductance of one coil, } R \text{ and } C \text{ for damping})$$

A second requirement is that the effect of the damping components must be negligible by the time that the zero-crossing of the EMF is expected. This is because the remainder of the step (due to RC components) causes shifting of the zero-crossing. For a critically damped combination the voltage can be calculated as a negative exponential with  $\omega\sigma \times t$ .

Example: Commutation frequency = 900 Hz, so  $t = 1100 \mu\text{s}$ , the time taken from the end of the diode pulse to the zero-crossing of the EMF will be approximately  $t = 440 \mu\text{s}$ . If a damping voltage from 9 V to 3 mV is required, then the reduction is 3000-fold, or  $e^{-8} = e^{-\omega\sigma \times t}$ . This gives  $\omega\sigma = 18180 \text{ rad/s}$ . With  $L = 3 \text{ mH}$ , C is found to be  $1.01 \mu\text{F}$  (use  $1 \mu\text{F}$ ) and R is found to be  $109.1 \Omega$  (use  $100 \Omega$ ).

A motor voltage of 7 V (peak-to-peak) at 150 Hz gives 3300 V/s, thus a 3 mV remainder shifts the zero-crossing  $1 \mu\text{s}$ . Eddy currents will also contribute to this phase shift. A shift of  $20 \mu\text{s}$  corresponds with 0.18 degrees (mechanically) for a 1500 rpm motor, or 0.1 mm on a VHS scanner drum.

## Other Design Aspects

There are other design aspects concerning the application of the TDA5146T besides the commutation function. They are:

- Generation of the tachometer signal FG
- Possibilities of motor control
- Preposition input
- Direction input
- Brake input
- Reliability

## FG Signal

The FG signal is generated in the TDA5146T by using the zero-crossing of the motor EMF from the three motor windings. Every zero-crossing in a (star connected) motor winding is used to toggle the FG output signal. The FG frequency is therefore half the commutation frequency. All transitions indicate the detection of a zero-crossing (except for PG). The negative-going edges are called FG pulses because they generate an interrupt in a controlling microprocessor.

The accuracy of the FG output signal (jitter) is very good. This accuracy depends on the symmetry of the motor's electromagnetic construction, which also affects the satisfactory functioning of the motor itself.

Example: A three phase motor with 6 magnetic pole-pairs at 1500 rpm and with a full-wave drive has a commutation frequency of  $25 \times 6 \times 6 = 900 \text{ Hz}$ , and generates a tachometer signal of 450 Hz.

## DIRECTION Input

If the voltage on pin 24 is less than 0.8 V, the motor is running in one direction (depending on the motor connections). If the voltage on pin 24 is higher than 2.0V, the motor is running in the other direction.

## BRAKE function

If the voltage on pin 23 is higher than 2.0V, the motor brakes. In that condition, the 3 outputs MOT1, MOT2, and MOT3 are forced at a low level and the current limitation is done internally by the sink drivers.

## TEST function

It is possible to turn off the three outputs by forcing in pin 16 a current of  $600 \mu\text{A}$ .

# Brushless DC motor drive circuit

# TDA5146T

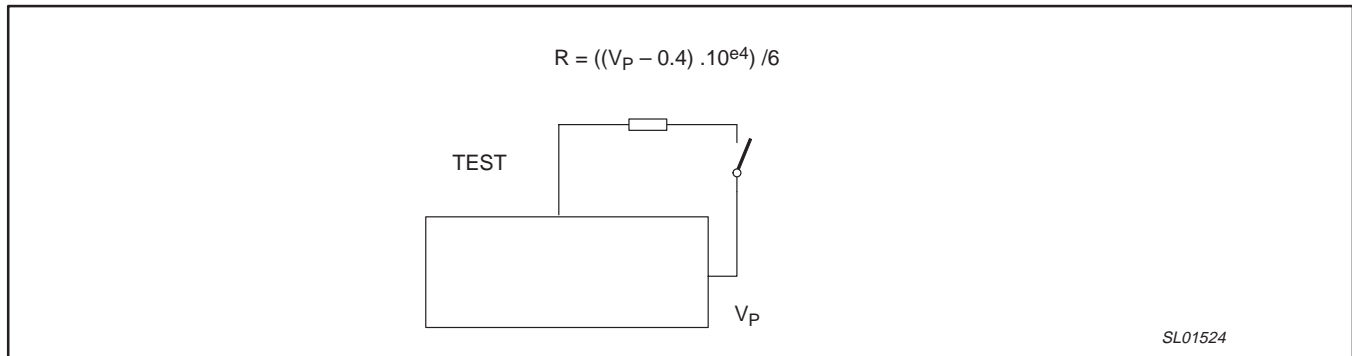


Figure 10.

### RESET function

If the voltage on pin 8 is higher than 2.0V, the output states are:

- MOT 1 – Float
- MOT 2 – Low
- MOT 3 – High

### SWITCHING SEQUENCE AFTER A RESET PULSE

DIR	RESET	MOT1	MOT2	MOT3	FUNCTION
H	H	F	L	H	Reset
H	L	F	L	H	Normal direction mode sequence
H	L	H	L	F	
H	L	H	F	L	
H	L	F	H	L	
H	L	L	H	F	
H	L	L	F	H	
L	H	H	L	F	
L	L	H	L	F	Reverse direction mode sequence
L	L	F	L	H	
L	L	L	F	H	
L	L	L	H	F	
L	L	F	H	L	
L	L	H	F	L	
L	L	H	F	L	

### PRIORITY OF FUNCTION

BRAKE	TEST	RESET	FUNCTION
L	L	L	Normal
L	L	H	Reset
L	H	L	Test
L	H	H	Test
H	L	L	Brake
H	L	H	Brake
H	H	L	Brake
H	H	H	Brake

### RELIABILITY

It is necessary to protect high current circuits and the output stages are protected in two ways:

- Current limiting of the 'lower' output transistors. The 'upper' output transistors use the same base current as the conducting 'lower' transistor (+15%). This means that the current to and from the output stages is limited.
- Thermal protection of the six output transistors is achieved by each transistor having a thermal sensor that is active when the transistor is switched on. The transistors are switched off when the local temperature becomes too high.

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# Brushless DC motor drive circuit

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## SOLDERING

### Plastic mini-packs

#### BY WAVE

During placement and before soldering, the component must be fixed with a droplet of adhesive. After cutting the adhesive, the component can be soldered. The adhesive can be applied by screen printing, pin transfer or syringe dispensing.

Maximum permissible solder temperature is 260 °C; and maximum duration of package immersion in solder bath is 10 s, if allowed to cool to less than 150 °C within 6 s. Typical dwell time is 4 s at 250 °C.

A modified wave soldering technique is recommended using two solder waves (dual-wave), in which a turbulent wave with high upward pressure is followed by a smooth laminar wave. Using a mildly activated flux eliminates the need for removal of corrosive residues in most applications.

#### BY SOLDER PASTE REFLOW

Reflow soldering requires the solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the substrate by screen printing, stencilling or pressure-syringe dispensing before device placement.

Several techniques exist for reflowing; for example, thermal conduction by heated belt, infrared and vapor-phase reflow. Dwell times vary between 50 and 300 s according to method. Typical reflow temperatures range from 215 to 250 °C.

Preheating is necessary to dry the paste and evaporate the binding agent. Preheating duration: 45 min at 45 °C.

#### REPAIRING SOLDERED JOINTS (BY HAND-HELD SOLDERING IRON OR PULSE-HEATED SOLDER TOOL)

Fix the component by first soldering two, diagonally opposite, end pins. Apply the heating tool to the flat part of the pin only. Contact time must be limited to 10 s at up 300 °C. When using proper tools, all other pins can be soldered in one operation within 2 to 5 s at between 270 and 320 °C. Pulse-heated soldering is not recommended for SO packages.

For pulse-heated solder tool (resistance) soldering of VSO packages, solder is applied to the substrate by dipping or by an extra thick tin/lead plating before package placement.

### Plastic dual in-line packages

#### BY DIP OR WAVE

The maximum permissible temperature of the solder is 260 °C; this temperature must not be in contact with the joint for more than 5 s. The total contact time of successive solder waves must not exceed 5 s.

The device may be mounted up to the seating plane, but the temperature of the plastic body must not exceed the specified storage maximum. If the printed-circuit board has been pre-heated, forced cooling may be necessary immediately after soldering to keep the temperature within the permissible limit.

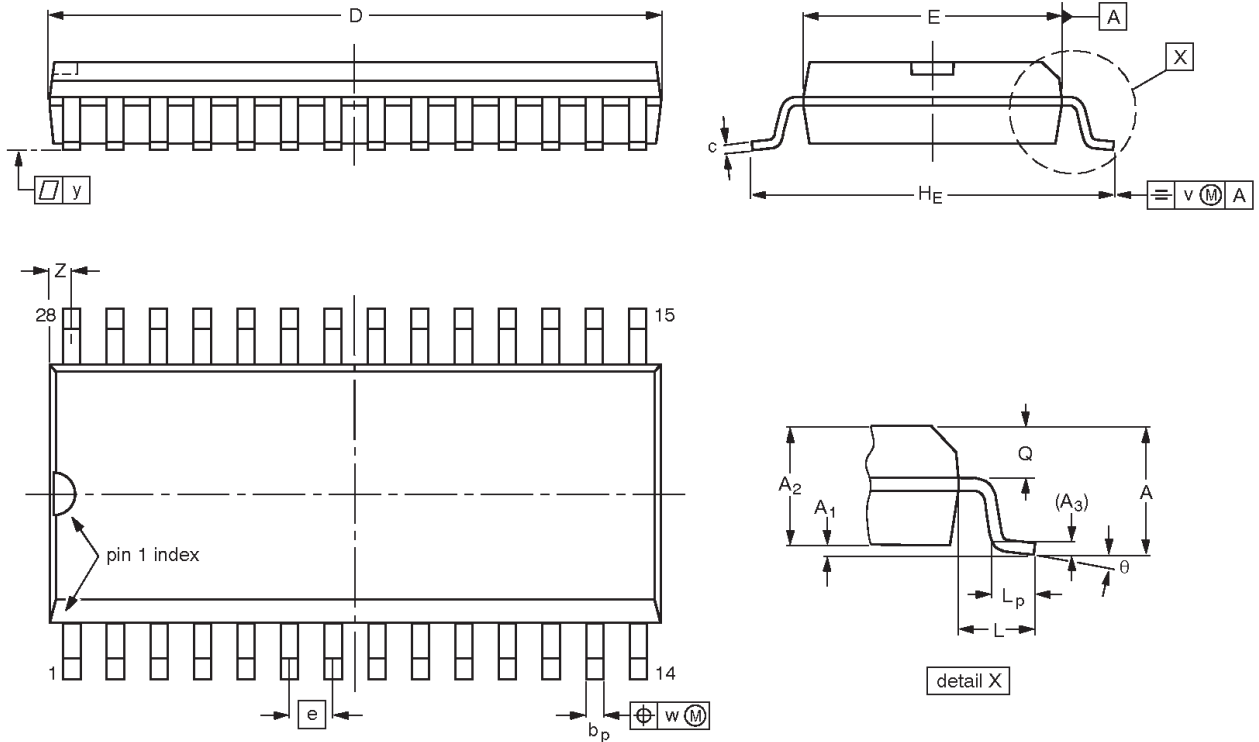


Brushless DC motor drive circuit

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SO28: plastic small outline package; 28 leads; body width 7.5 mm

SOT136-1



**DIMENSIONS (inch dimensions are derived from the original mm dimensions)**

UNIT	A max.	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(1)</sup>	e	H <sub>E</sub>	L	L <sub>p</sub>	Q	v	w	y	z <sup>(1)</sup>	θ
mm	2.65	0.30 0.10	2.45 2.25	0.25	0.49 0.36	0.32 0.23	18.1 17.7	7.6 7.4	1.27	10.65 10.00	1.4	1.1 0.4	1.1 1.0	0.25	0.25	0.1	0.9 0.4	8° 0°
inches	0.10	0.012 0.004	0.096 0.089	0.01	0.019 0.014	0.013 0.009	0.71 0.69	0.30 0.29	0.050	0.419 0.394	0.055	0.043 0.016	0.043 0.039	0.01	0.01	0.004	0.035 0.016	

**Note**

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT136-1	075E06	MS-013				-97-05-22 99-12-27

## Brushless DC motor drive circuit

TDA5146T

## Data sheet status

Data sheet status <sup>[1]</sup>	Product status <sup>[2]</sup>	Definitions
Objective specification	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
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