

## 1 Overview

### 1.1 Features

- Delivers up to 5 A continuous 6 A peak current
- Optimized for DC motor management applications
- Operates at supply voltages up to 40 V
- Very low  $R_{DS\ ON}$ ; typ. 200 m $\Omega$  @ 25 °C per switch
- Output full short circuit protected
- Overtemperature protection with hysteresis and diagnosis
- Short circuit diagnosis with open drain error flag
- Undervoltage lockout
- CMOS/TTL compatible inputs with hysteresis
- No crossover current
- Internal freewheeling diodes
- Wide temperature range;  $-40\text{ }^{\circ}\text{C} < T_j < 150\text{ }^{\circ}\text{C}$

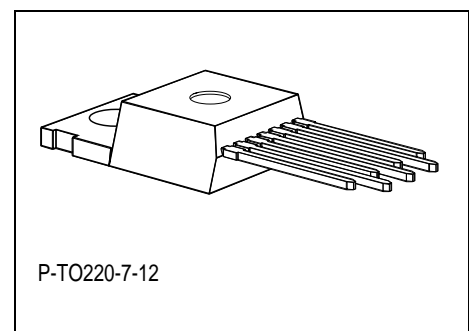
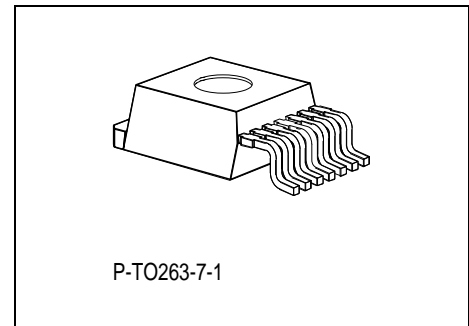
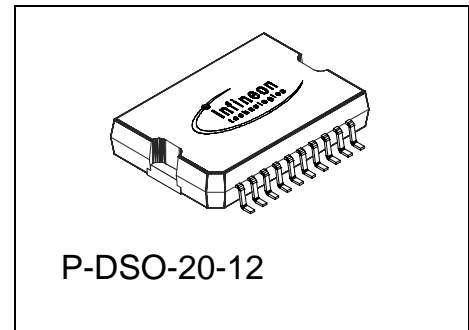
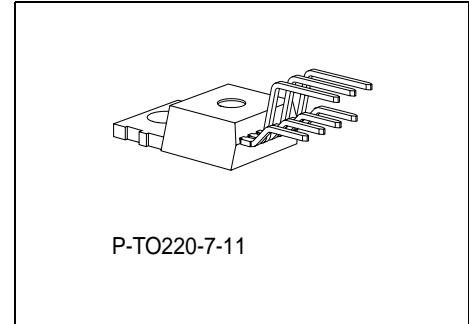
Type	Ordering Code	Package
TLE 5206-2	Q67000-A9290	P-TO220-7-11
TLE 5206-2GP	Q67006-A9239	P-DSO-20-12
TLE 5206-2G	Q67006-A9323	P-TO263-7-1
TLE 5206-2S	Q67000-A9326	P-TO220-7-12

### Description

The TLE 5206-2 is an integrated power H-bridge with DMOS output stages for driving DC-Motors. The part is built using the SIEMENS multi-technology process SPT<sup>®</sup> which allows bipolar and CMOS control circuitry plus DMOS power devices to exist on the same monolithic structure.

Operation modes forward (cw), reverse (ccw), brake

high and brake low are invoked from just two control pins with TTL/CMOS compatible levels. The combination of an extremely low  $R_{DS\ ON}$  and the use of a power IC package with low thermal resistance and high thermal capacity helps to minimize system power dissipation. A blocking capacitor at the supply voltage is the only external circuitry due to the integrated freewheeling diodes.



1.2 Pin Configuration (top view)

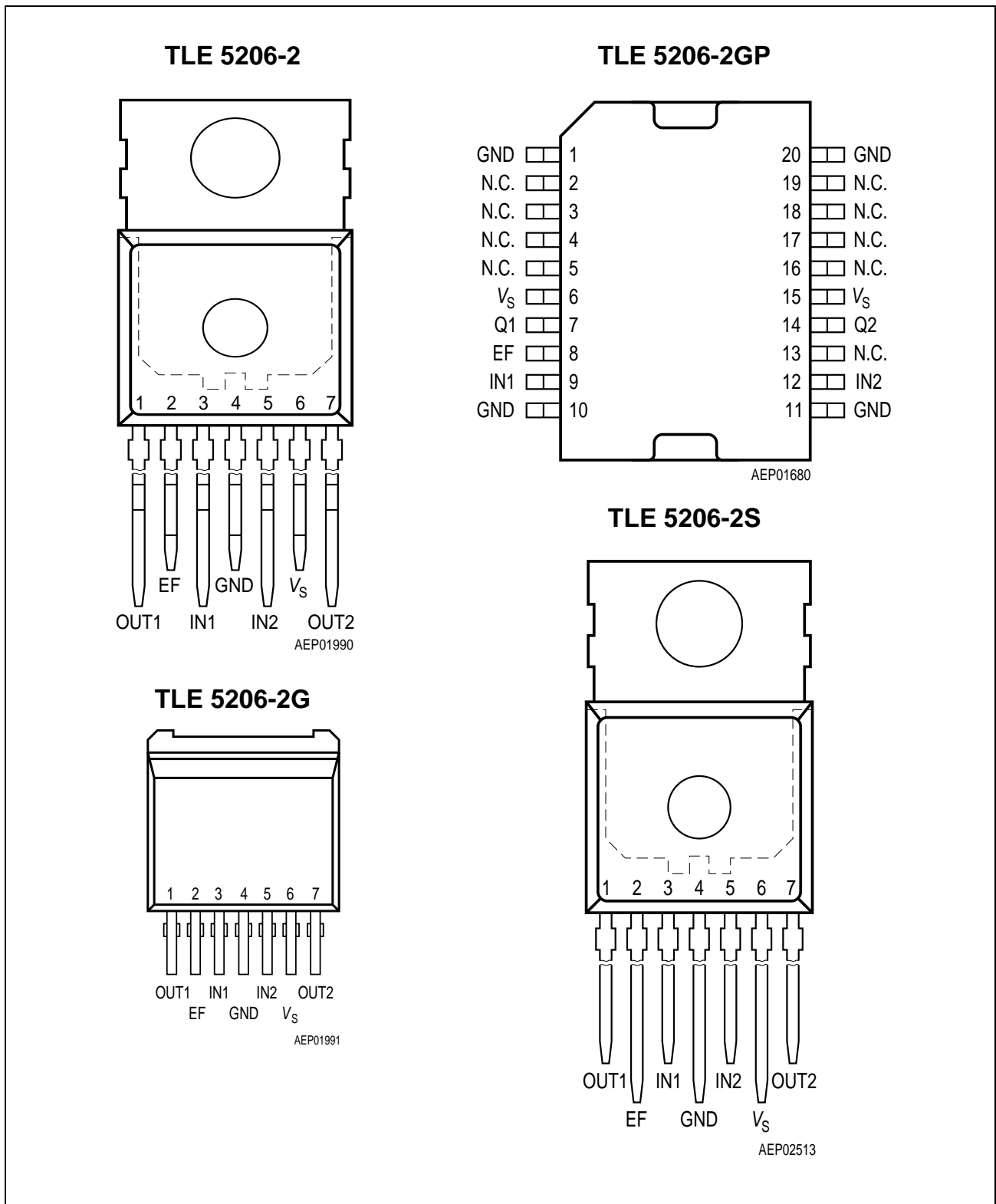


Figure 1

### 1.3 Pin Definitions and Functions

Pin No. P-TO220	Pin No. P-DSO	Symbol	Function
1	7	OUT1	<b>Output of Channel 1;</b> Short-circuit protected; integrated freewheeling diodes for inductive loads.
2	8	EF	<b>Error Flag;</b> TTL/CMOS compatible output for error detection; (open drain)
3	9	IN1	<b>Control Input 1;</b> TTL/CMOS compatible
4	1, 10, 11, 20	GND	<b>Ground;</b> internally connected to tab
5	12	IN2	<b>Control Input 2;</b> TTL/CMOS compatible
6	6, 15	$V_S$	<b>Supply Voltage;</b> block to GND
7	14	OUT2	<b>Output of Channel 2;</b> Short-circuit protected; integrated freewheeling diodes for inductive loads.
–	2, 3, 4, 5, 16, 17, 18, 19	N.C.	<b>Not Connected</b>

### 1.4 Functional Block Diagram

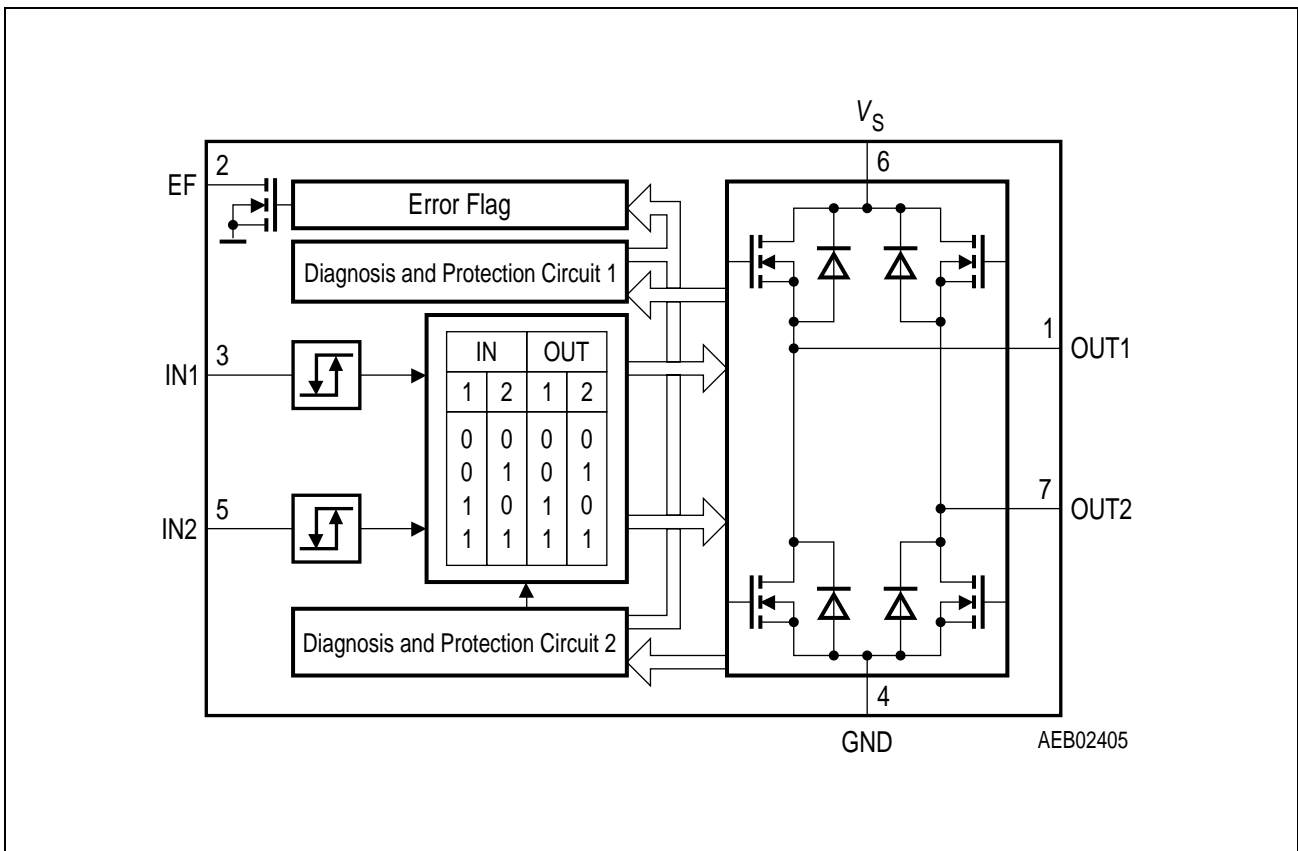


Figure 2 Block Diagram

## 1.5 Circuit Description

### Input Circuit

The control inputs consist of TTL/CMOS-compatible schmitt-triggers with hysteresis. Buffer amplifiers are driven by this stages.

### Output Stages

The output stages consist of a DMOS H-bridge. Integrated circuits protect the outputs against short-circuit to ground and to the supply voltage. Positive and negative voltage spikes, which occur when switching inductive loads, are limited by integrated freewheeling diodes.

A monitoring circuit for each output transistor detects whether the particular transistor is active and in this case prevents the corresponding source transistor (sink transistor) from conducting in sink operation (source operation). Therefore no crossover currents can occur.

## 1.6 Input Logic Truth Table

### Functional Truth Table

IN1	IN2	OUT1	OUT2	Comments
L	L	L	L	Brake; both low side transistors turned-ON
L	H	L	H	Motor turns counterclockwise
H	L	H	L	Motor turns clockwise
H	H	H	H	Brake; both high side transistors turned-ON

### Notes for Output Stage

Symbol	Value
L	Low side transistor is turned-ON High side transistor is turned-OFF
H	High side transistor is turned-ON Low side transistor is turned-OFF

## 1.7 Monitoring Functions

Undervoltage lockout (UVLO):

When  $V_S$  reaches the switch on voltage  $V_{S\text{ ON}}$  the IC becomes active with a hysteresis. All output transistors are switched off if the supply voltage  $V_S$  drops below the switch off value  $V_{S\text{ OFF}}$ .

## 1.8 Protective Function

Various errors like short-circuit to +  $V_S$ , ground or across the load are detected. All faults result in turn-OFF of the output stages after a delay of 50  $\mu\text{s}$  and setting of the error flag EF to ground. Changing the inputs resets the error flag.

### a. Output Shorted to Ground Detection

If a high side transistor is switched on and its output is shorted to ground, the output current is internally limited. After a delay of 50  $\mu\text{s}$  all outputs will be switched-OFF and the error flag is set.

### b. Output Shorted to + $V_S$ Detection

If a low side transistor is switched on and its output is shorted to the supply voltage, the output current is internally limited. After a delay of 50  $\mu\text{s}$  all outputs will be switched-OFF and the error flag is set.

### c. Overload Detection

An internal circuit detects if the current through the low side transistor exceeds the trippoint  $I_{\text{SDL}}$ . In this case all outputs are turned off after 50  $\mu\text{s}$  and the error flag is set.

### d. Overtemperature Protection

At a junction temperature higher than 150 °C the thermal shutdown turns-OFF, all four output stages commonly and the error flag is set with a delay.

## 2 Diagnosis

Various errors as listed in the table “Diagnosis” are detected. Short circuits and overload result in turning off the output stages after a delay  $t_{\text{qSD}}$  and setting the error flag simultaneously [EF = L]. Changing the inputs to a state where the fault is not detectable resets the error flag (input toggling) with the exception of short circuit from OUT1 to OUT2 (load short circuit).

Flag	IN1	IN2	OUT1	OUT2	EF	Remarks
Short circuit from OUT1 to OUT2	0	0	L	L	1	Not detectable
	0	1	X	X	0	
	1	0	X	X	0	Not detectable
	1	1	H	H	1	
Short circuit from OUT1 to GND	0	0	GND	L	1	Not detectable
	0	1	GND	X	1	Not detectable
	1	0	GND	L	0	
	1	1	GND	X	0	
Short circuit from OUT2 to GND	0	0	L	GND	1	Not detectable
	0	1	L	GND	0	
	1	0	X	GND	1	Not detectable
	1	1	X	GND	0	
Short circuit from OUT1 to $V_s$	0	0	$V_s$	X	0	
	0	1	$V_s$	H	0	
	1	0	$V_s$	X	1	Not detectable
	1	1	$V_s$	H	1	Not detectable
Short circuit from OUT2 to $V_s$	0	0	X	$V_s$	0	
	0	1	X	$V_s$	1	Not detectable
	1	0	H	$V_s$	0	
	1	1	H	$V_s$	1	Not detectable
Overtemperature or undervoltage	0	0	Z	Z	0	
	0	1	Z	Z	0	
	1	0	Z	Z	0	
	1	1	Z	Z	0	

IN: 0 = Logic LOW  
1 = Logic HIGH

OUT: Z = Output in tristate condition  
L = Output in sink condition  
H = Output in source condition  
X = Voltage level undefined

EF: 1 = No error  
0 = Error

For Open circuit detection, use the TLE 5205-2.

**Electrical Characteristics**
**3 Electrical Characteristics**
**3.1 Absolute Maximum Ratings**

$$-40\text{ }^{\circ}\text{C} < T_j < 150\text{ }^{\circ}\text{C}$$

Parameter	Symbol	Limit Values		Unit	Remarks
		min.	max.		

**Voltages**

Supply voltage	$V_S$	- 0.3	40	V	-
		- 1	40	V	$t < 0.5\text{ s}; I_S > -5\text{ A}$
Logic input voltage	$V_{IN1,2}$	- 0.3	7	V	$0\text{ V} < V_S < 40\text{ V}$
Diagnostics output voltage	$V_{EF}$	- 0.3	7	V	-

**Currents of DMOS-Transistors and Freewheeling Diodes**

Output current (cont.)	$I_{OUT1,2}$	- 5	5	A	-
Output current (peak)	$I_{OUT1,2}$	- 6	6	A	$t_p < 100\text{ ms}; T = 1\text{ s}$
Output current (peak)	$I_{OUT1,2}$	-	-	A	$t_p < 50\text{ }\mu\text{s}; T = 1\text{ s};$ internally limited; see overcurrent

**Temperatures**

Junction temperature	$T_j$	- 40	150	$^{\circ}\text{C}$	-
Storage temperature	$T_{stg}$	- 50	150	$^{\circ}\text{C}$	-

**Thermal Resistances**

Junction case	$R_{thjC}$	-	3	K/W	P-TO220-7-11/12, P-TO263-7-1
Junction ambient	$R_{thjA}$	-	65	K/W	P-TO220-7-11/12
		-	75	K/W	P-TO263-7-1
Junction case	$R_{thjC}$	-	5	K/W	P-DSO-20-12
Junction ambient	$R_{thjA}$	-	50	K/W	P-DSO-20-12

*Note: Maximum ratings are absolute ratings; exceeding any one of these values may cause irreversible damage to the integrated circuit.*



**Electrical Characteristics**
**3.2 Operating Range**

Parameter	Symbol	Limit Values		Unit	Remarks
		min.	max.		
Supply voltage	$V_S$	$V_{UV\ ON}$	40	V	After $V_S$ rising above $V_{UV\ ON}$
Supply voltage increasing		- 0.3	$V_{UV\ ON}$	V	Outputs in tristate condition
Supply voltage decreasing		- 0.3	$V_{UV\ OFF}$	V	
Logic input voltage	$V_{IN1,2}$	- 0.3	7	V	-
Junction temperature	$T_j$	- 40	150	°C	-

**3.3 Electrical Characteristics**
 $6\text{ V} < V_S < 18\text{ V}$ ;  $IN1 = IN2 = \text{HIGH}$ 
 $I_{OUT1,2} = 0\text{ A}$  (No load);  $-40\text{ °C} < T_j < 150\text{ °C}$ ; unless otherwise specified

Parameter	Symbol	Limit Values			Unit	Test Condition
		min.	typ.	max.		

**Current Consumption**

Quiescent current	$I_S$	-	-	10	mA	$IN1 = IN2 = \text{LOW}$ ; $V_S = 13.2\text{ V}$
-------------------	-------	---	---	----	----	---

**Under Voltage Lockout**

UV-Switch-ON voltage	$V_{UV\ ON}$	-	5.3	6	V	$V_S$ increasing
UV-Switch-OFF voltage	$V_{UV\ OFF}$	3.5	4.7	5.6	V	$V_S$ decreasing
UV-ON/OFF-Hysteresis	$V_{UV\ HY}$	0.2	0.6	-	V	$V_{UV\ ON} - V_{UV\ OFF}$

**Electrical Characteristics**
**3.3 Electrical Characteristics (cont'd)**
 $6\text{ V} < V_S < 18\text{ V}; \text{IN1} = \text{IN2} = \text{HIGH}$ 
 $I_{\text{OUT1,2}} = 0\text{ A (No load)}; -40\text{ }^\circ\text{C} < T_j < 150\text{ }^\circ\text{C};$  unless otherwise specified

Parameter	Symbol	Limit Values			Unit	Test Condition
		min.	typ.	max.		

**Outputs OUT1, 2**
**Static Drain-Source-On Resistance**

Source $I_{\text{OUT}} = -3\text{ A}$	$R_{\text{DS ON H}}$	–	220	350	mΩ	$6\text{ V} < V_S < 18\text{ V}$ $T_j = 25\text{ }^\circ\text{C}$
			–	500	mΩ	$6\text{ V} < V_S < 18\text{ V}$
			350	500	mΩ	$V_{\text{S ON}} < V_S \leq 6\text{ V}$ $T_j = 25\text{ }^\circ\text{C}$
			–	800	mΩ	$V_{\text{S ON}} < V_S \leq 6\text{ V}$
Sink $I_{\text{OUT}} = 3\text{ A}$	$R_{\text{DS ON L}}$	–	230	350	mΩ	$6\text{ V} < V_S < 18\text{ V}$ $T_j = 25\text{ }^\circ\text{C}$
			–	500	mΩ	$6\text{ V} < V_S < 18\text{ V}$
			400	600	mΩ	$V_{\text{S ON}} < V_S \leq 6\text{ V}$ $T_j = 25\text{ }^\circ\text{C}$
			–	1000	mΩ	$V_{\text{S ON}} < V_S \leq 6\text{ V}$

Note: Values of  $R_{\text{DS ON}}$  for  $V_{\text{S ON}} < V_S \leq 6\text{ V}$  are guaranteed by design.

**Overcurrent**

Source shutdown trippoint	$-I_{\text{SDH}}$	–	–	10	A	$T_j = -40\text{ }^\circ\text{C}$
		–	8	–	A	$T_j = 25\text{ }^\circ\text{C}$
		6	–	–	A	$T_j = 150\text{ }^\circ\text{C}$
Sink shutdown trippoint	$I_{\text{SDL}}$	–	–	10	A	$T_j = -40\text{ }^\circ\text{C}$
		–	8	–	A	$T_j = 25\text{ }^\circ\text{C}$
		6	–	–	A	$T_j = 150\text{ }^\circ\text{C}$
Shutdown delay time	$t_{\text{dSD}}$	25	50	80	μs	–

**Electrical Characteristics**
**3.3 Electrical Characteristics (cont'd)**
 $6\text{ V} < V_S < 18\text{ V}; \text{IN1} = \text{IN2} = \text{HIGH}$ 
 $I_{\text{OUT}1,2} = 0\text{ A (No load)}; -40\text{ }^\circ\text{C} < T_j < 150\text{ }^\circ\text{C};$  unless otherwise specified

Parameter	Symbol	Limit Values			Unit	Test Condition
		min.	typ.	max.		

**Short Circuit Current Limitation**

Source current	$-I_{\text{SCH}}$	–	–	20	A	$t < t_{\text{dSD}}$
Sink current	$I_{\text{SCL}}$	–	–	15	A	$t < t_{\text{dSD}}$

**Output Delay Times (Device Active for  $t > 1\text{ ms}$ )**

Source ON	$t_{\text{d ON H}}$	–	10	20	$\mu\text{s}$	$I_{\text{OUT}} = -3\text{ A}$ resistive load
Sink ON	$t_{\text{d ON L}}$	–	10	20	$\mu\text{s}$	$I_{\text{OUT}} = 3\text{ A}$ resistive load
Source OFF	$t_{\text{d OFF H}}$	–	2	5	$\mu\text{s}$	$I_{\text{OUT}} = -3\text{ A}$ resistive load
Sink OFF	$t_{\text{d OFF L}}$	–	2	5	$\mu\text{s}$	$I_{\text{OUT}} = 3\text{ A}$ resistive load

**Output Switching Times (Device Active for  $t > 1\text{ ms}$ )**

Source ON	$t_{\text{ON H}}$	–	15	30	$\mu\text{s}$	$I_{\text{OUT}} = -3\text{ A}$ resistive load
Sink ON	$t_{\text{ON L}}$	–	5	10	$\mu\text{s}$	$I_{\text{OUT}} = 3\text{ A}$ resistive load
Source OFF	$t_{\text{OFF H}}$	–	2	5	$\mu\text{s}$	$I_{\text{OUT}} = -3\text{ A}$ resistive load
Sink OFF	$t_{\text{OFF L}}$	–	2	5	$\mu\text{s}$	$I_{\text{OUT}} = 3\text{ A}$ resistive load

**Clamp Diodes**
**Forward Voltage**

High-side	$V_{\text{FH}}$	–	1	1.5	V	$I_{\text{F}} = 3\text{ A}$
Low-side	$V_{\text{FL}}$	–	1.1	1.5	V	$I_{\text{F}} = 3\text{ A}$

**Electrical Characteristics**
**3.3 Electrical Characteristics (cont'd)**
 $6\text{ V} < V_S < 18\text{ V}; \text{IN1} = \text{IN2} = \text{HIGH}$ 
 $I_{\text{OUT1,2}} = 0\text{ A (No load)}; -40\text{ }^\circ\text{C} < T_j < 150\text{ }^\circ\text{C}; \text{ unless otherwise specified}$ 

Parameter	Symbol	Limit Values			Unit	Test Condition
		min.	typ.	max.		

**Leakage Current**

Source	$I_{\text{LKH}}$	- 100	- 35	-	$\mu\text{A}$	OUT1 = $V_S$
Sink	$I_{\text{LKL}}$	-	35	100	$\mu\text{A}$	OUT2 = GND

**Logic**
**Control Inputs IN 1, 2**

H-input voltage threshold	$V_{\text{INH}}$	2.8	2.5	-	V	-
L-input voltage	$V_{\text{INL}}$	-	1.7	1.2	V	-
Hysteresis of input voltage	$V_{\text{INHY}}$	0.4	0.8	1.2	V	-
H-input current	$I_{\text{INH}}$	- 2	-	2	$\mu\text{A}$	$V_{\text{IN}} = 5\text{ V}$
L-input current	$I_{\text{INL}}$	- 10	- 4	0	$\mu\text{A}$	$V_{\text{IN}} = 0\text{ V}$

**Error Flag Output EF**

Low output voltage	$V_{\text{EFL}}$	-	0.25	0.5	V	$I_{\text{EF}} = 3\text{ mA}$
Leakage current	$I_{\text{EFL}}$	-	-	10	$\mu\text{A}$	$V_{\text{EF}} = 7\text{ V}$

**Thermal Shutdown**

Thermal shutdown junction temperature	$T_{\text{jSD}}$	150	175	200	$^\circ\text{C}$	-
Thermal switch-on junction temperature	$T_{\text{jSO}}$	120	-	170	$^\circ\text{C}$	-
Temperature hysteresis	$\Delta T$	-	30	-	K	-

*Note: Values of thermal shutdown are guaranteed by design.*

Electrical Characteristics

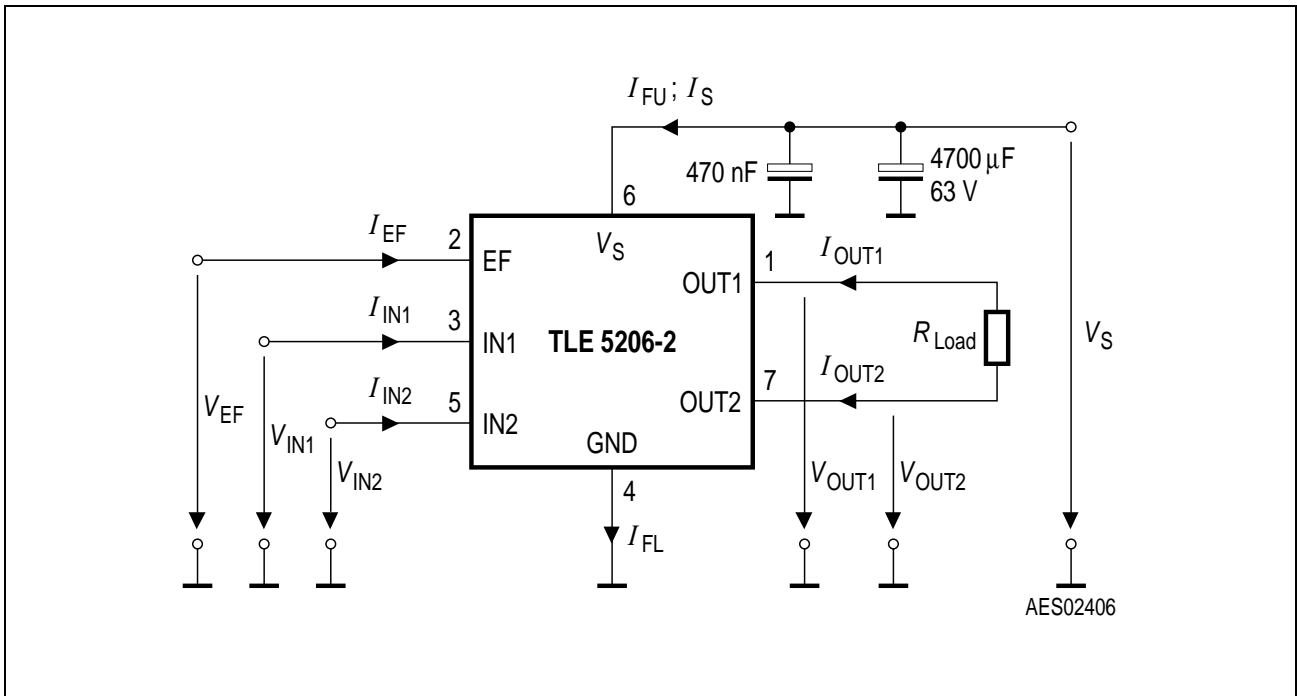


Figure 3 Test Circuit

	Overcurrent	Short Circuit	Open Circuit
$I_{OUT}$	$I_{SD}$	$I_{SC}$	$I_{OC}$

Electrical Characteristics

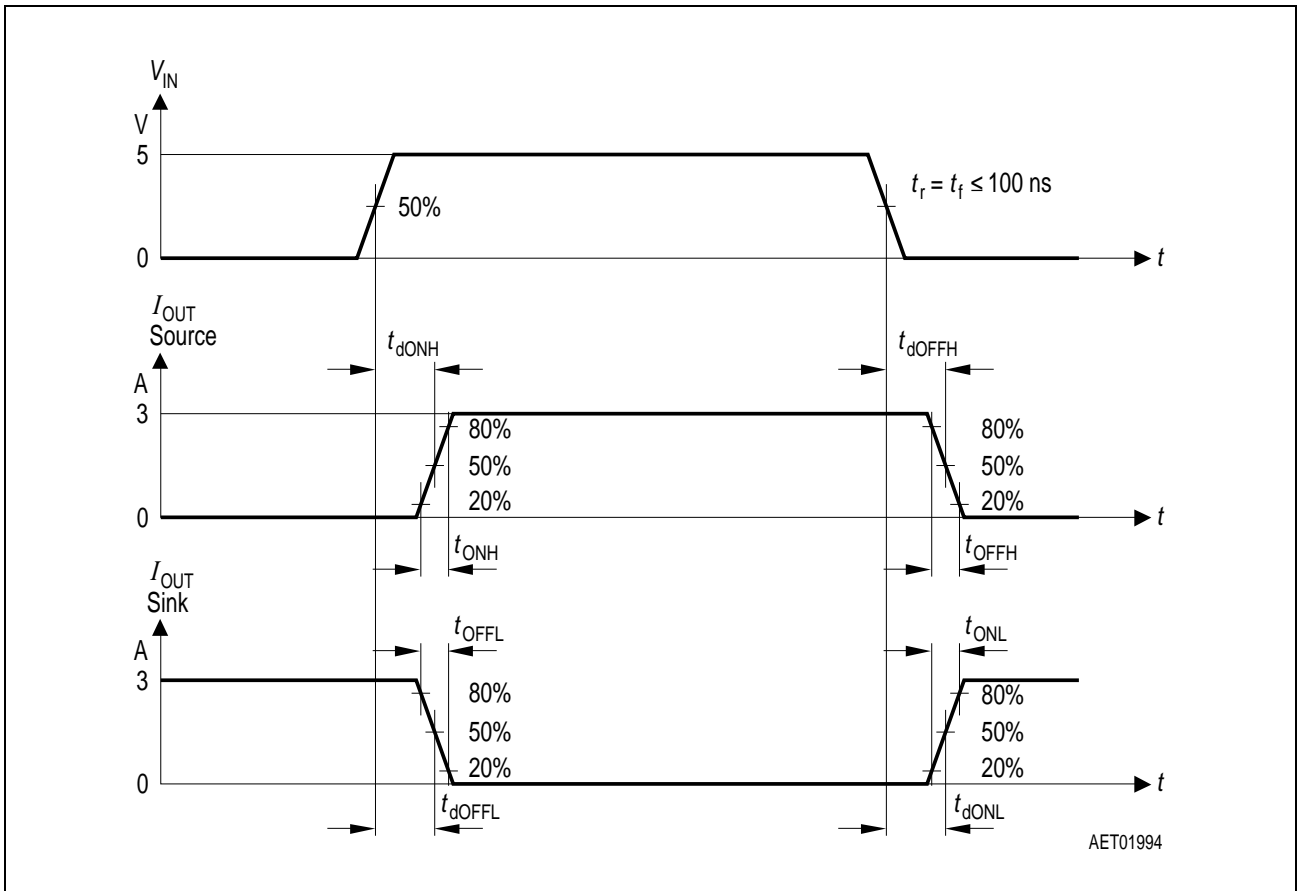


Figure 4 Switching Time Definitions

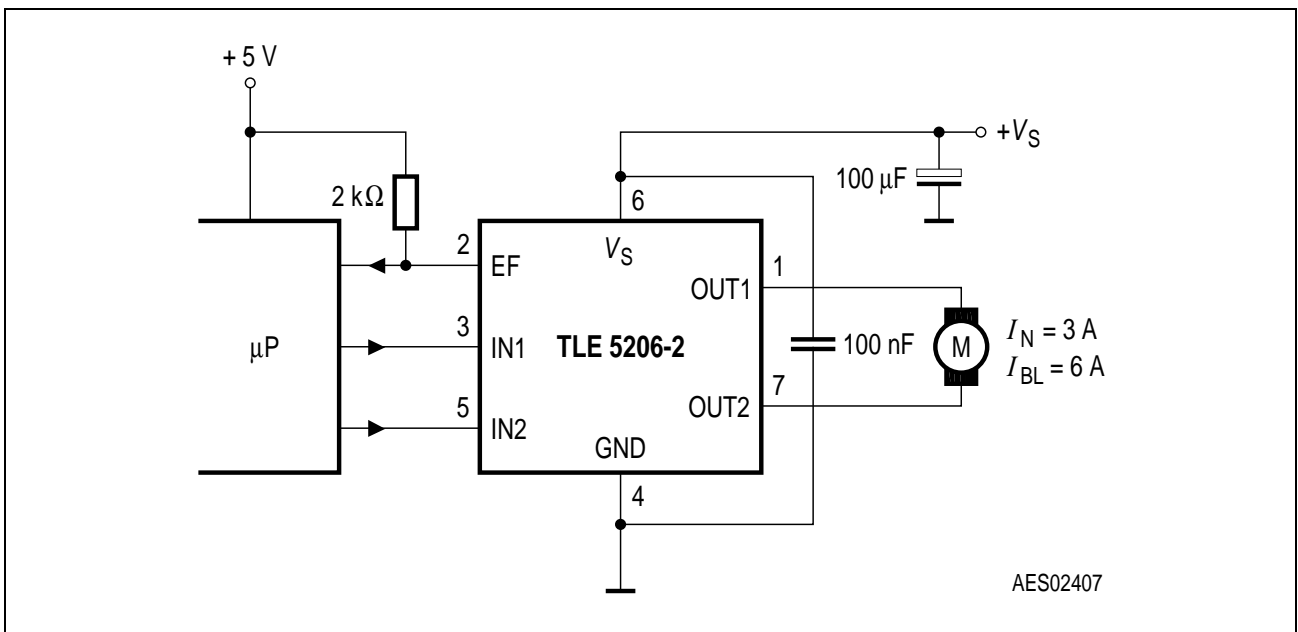


Figure 5 Application Circuit

## Application Modes

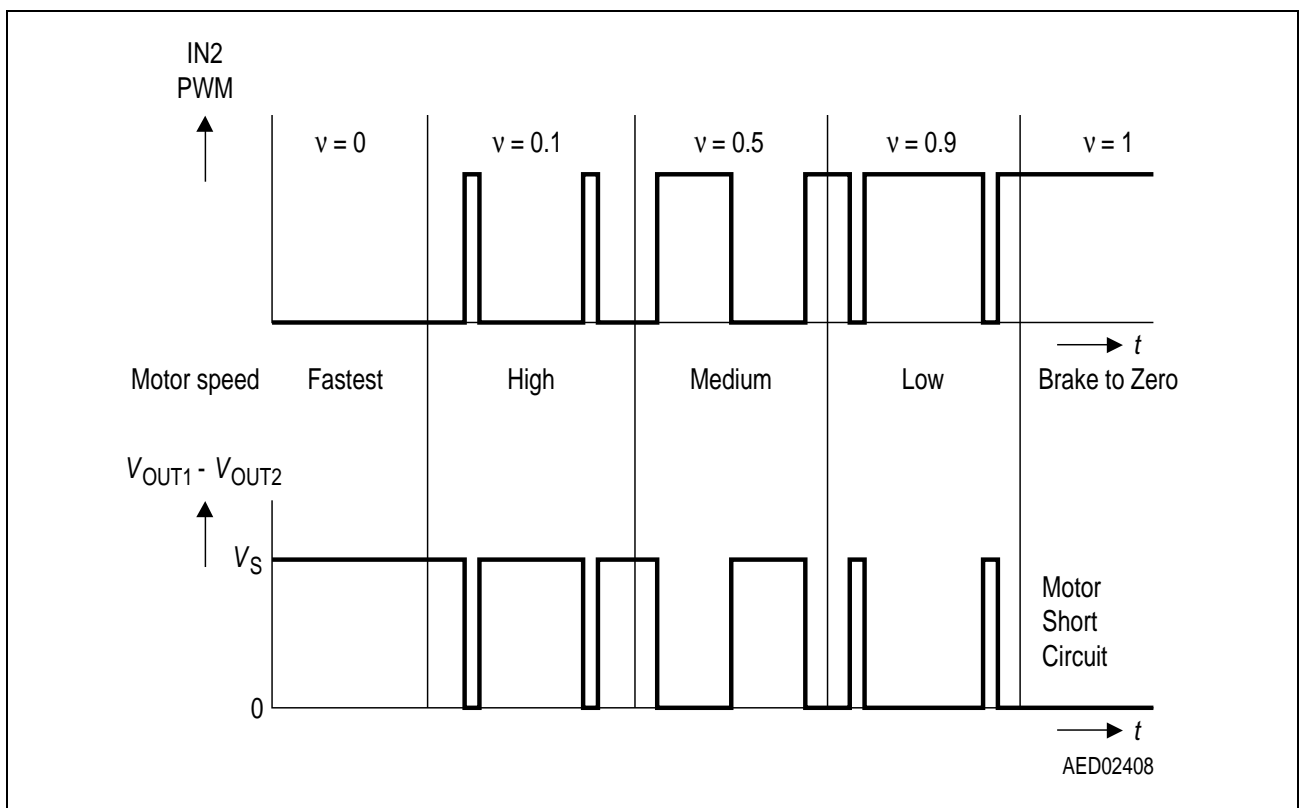
### 1. Simple CW/CCW-Control

For low-cost application simple CW/CCW-Control without any speed regulation is recommended. A low-speed two-line interface is sufficient for the brake low, clockwise, counter clockwise and brake high command.

### 2. Sign/Magnitude Control

For this mode two ports with PWM capability are necessary. Motor turns clockwise (current flows from OUT1 to OUT2; means: OUT1 is switched HIGH continuously and OUT2 is PWM controlled).

To achieve motor counter clockwise turning change input signals to:  
 IN1 = PWM; IN2 = H.



**Figure 6 Input/Output Diagram for CW Operation (IN1 = H)**

### 3. Locked Anti-Phase Control

The most important advantage to drive a motor in locked anti-phase mode is: Only one variable duty cycle signal is necessary in which is encoded both direction- and amplitude information. So the interface is very simple: A PWM input driven by a dedicated PWM port from  $\mu$ P.

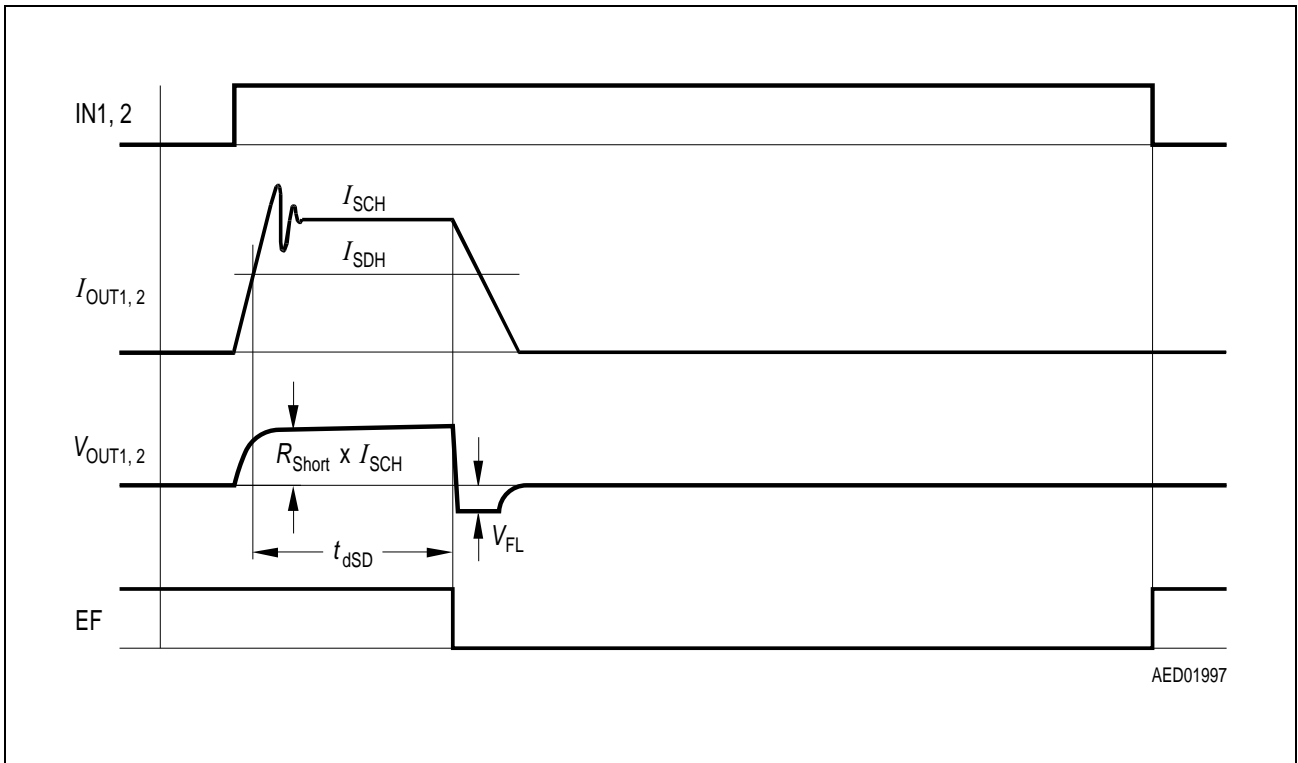


Figure 7 Timing Diagram for Output Shorted to Ground

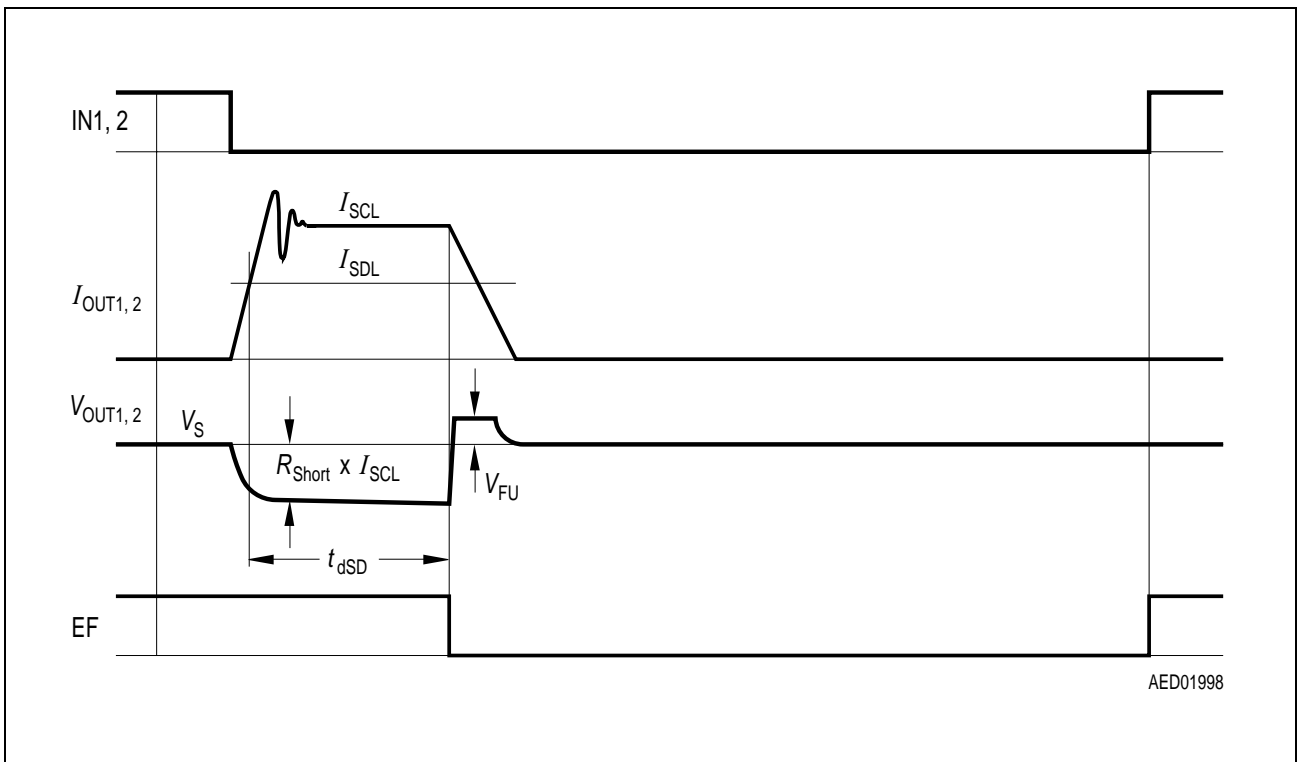


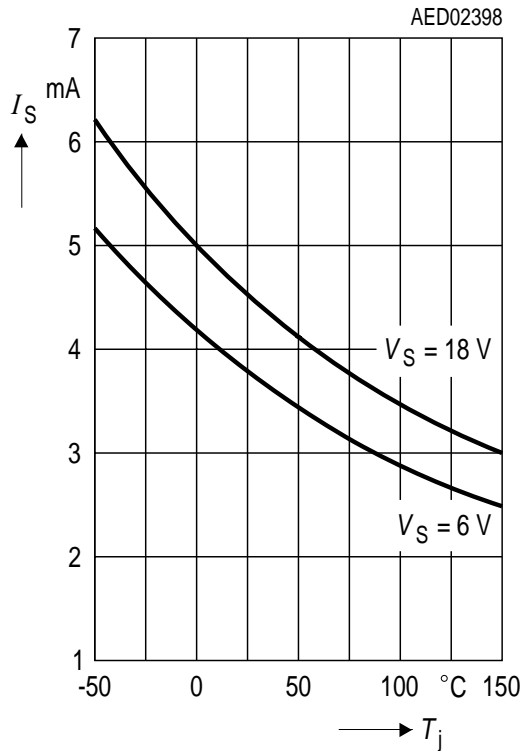
Figure 8 Timing Diagram for Output Shorted to  $V_S$



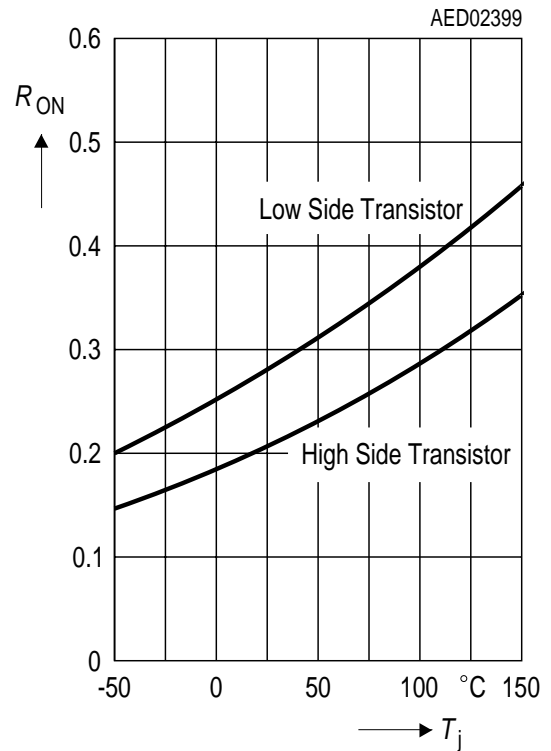
Electrical Characteristics

Diagrams

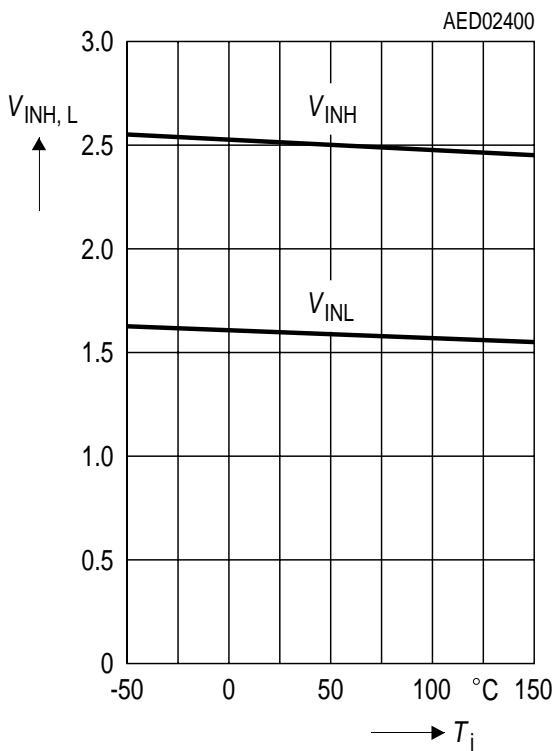
Quiescent Current  $I_S$  (active) versus Junction Temperature  $T_j$



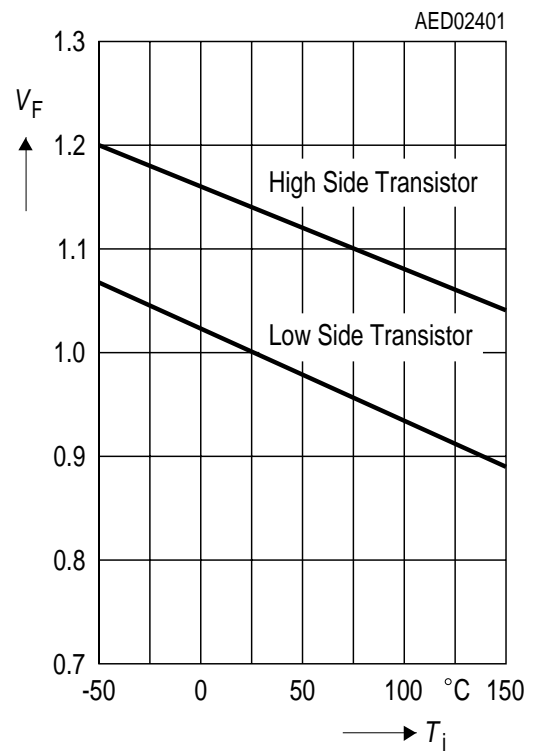
Static Drain-Source ON-Resistance versus Junction Temperature  $T_j$



Input Switching Thresholds  $V_{INH, L}$  versus Junction Temperature  $T_j$

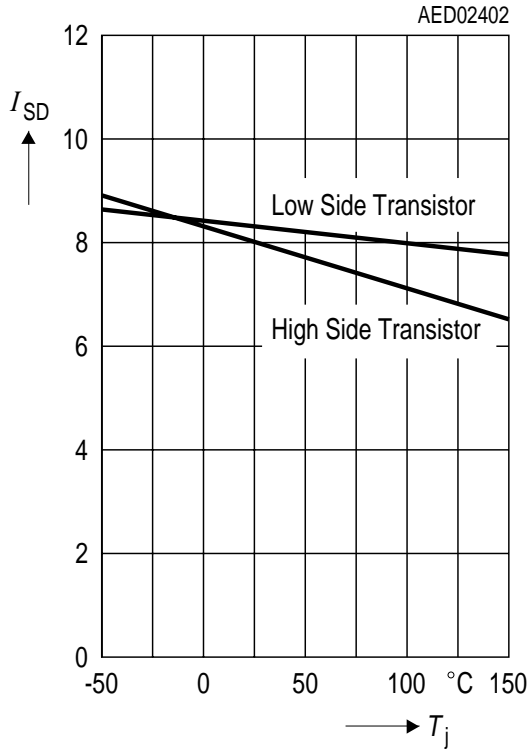


Clamp Diode Forward Voltage  $V_F$  versus Junction Temperature  $T_j$

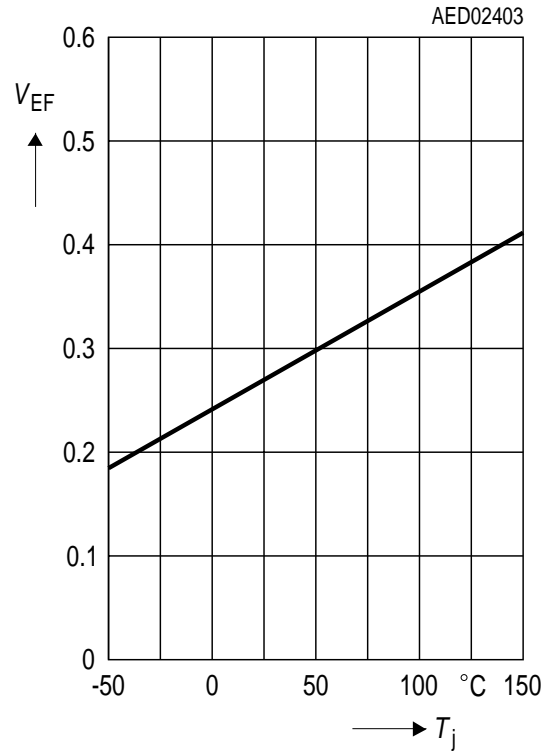


Electrical Characteristics

Overcurrent Shutdown Threshold  $I_{SD}$  versus Junction Temperature  $T_j$

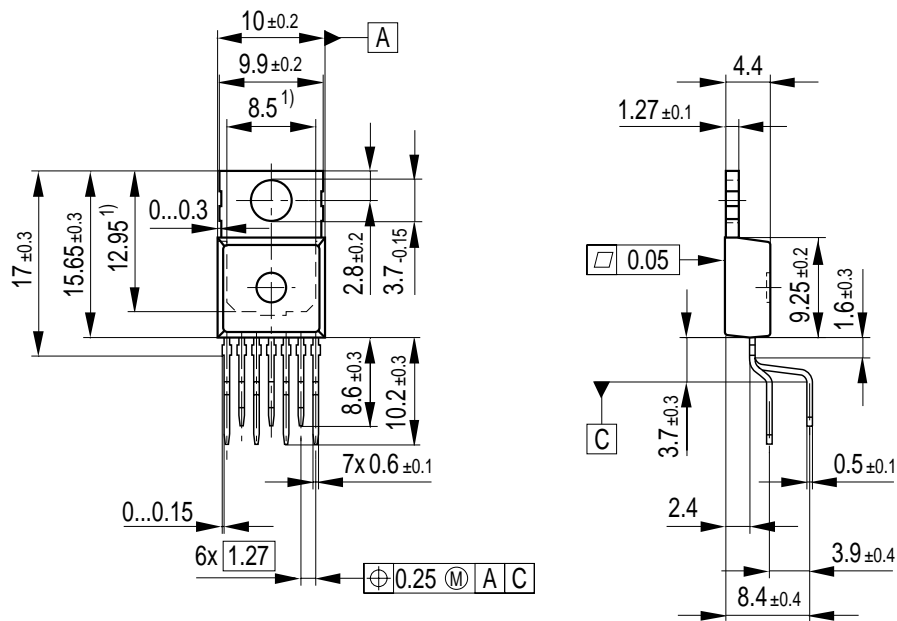


Error-Flag Saturation Output Voltage  $V_{EF}$  versus Junction Temperature  $T_j$



4 Package Outlines

**P-TO220-7-11**  
(Plastic Transistor Single Outline Package)



1) Typical  
Metal surface min. X=7.25, Y=12.3  
All metal surfaces tin plated, except area of cut.

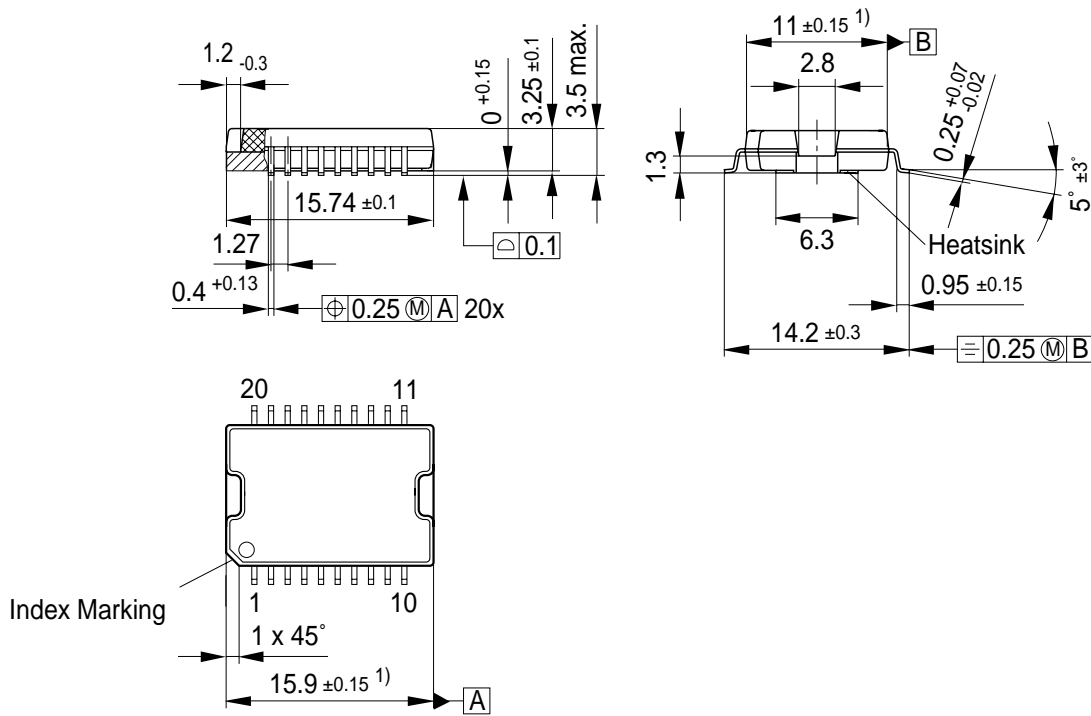
GPT09083

**Sorts of Packing**

Package outlines for tubes, trays etc. are contained in our Data Book "Package Information".

Dimensions in mm

**P-DSO-20-12**  
(Plastic Dual Small Outline Package)



1) Does not include plastic or metal protrusion of 0.15 max. per side

GPS05791

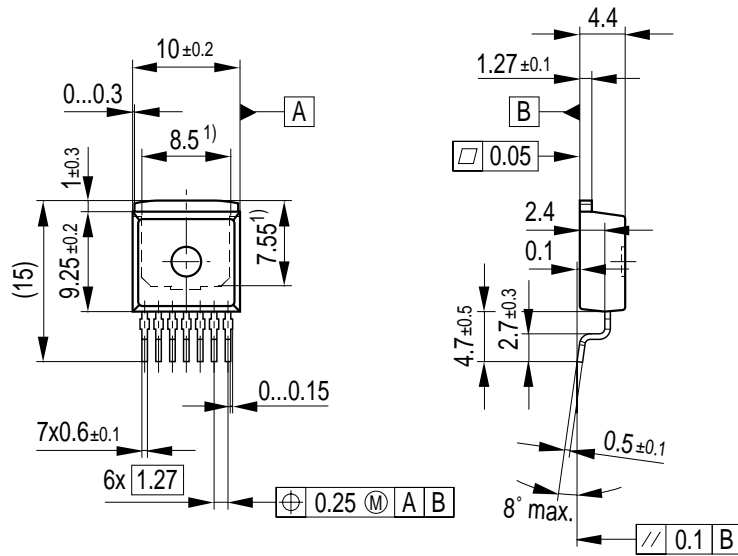
**Sorts of Packing**

Package outlines for tubes, trays etc. are contained in our Data Book "Package Information".

**SMD = Surface Mounted Device**

Dimensions in mm

**P-TO263-7-1 Option E3180**  
**(Plastic Transistor Single Outline Package)**



<sup>1)</sup> Typical  
 Metal surface min. X=7.25, Y=6.9  
 All metal surfaces tin plated, except area of cut.

GPT09114

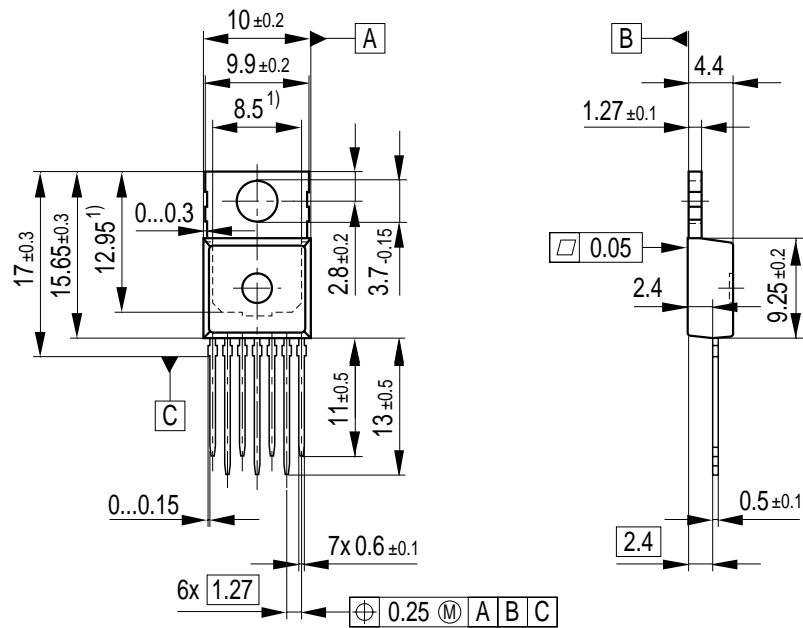
**Sorts of Packing**

Package outlines for tubes, trays etc. are contained in our Data Book "Package Information".

**SMD = Surface Mounted Device**

Dimensions in mm

**P-TO220-7-12**  
 (Plastic Transistor Single Outline Package)



<sup>1)</sup> Typical  
 Metal surface min. X=7.25, Y=12.3  
 All metal surfaces tin plated, except area of cut.

**Sorts of Packing**

Package outlines for tubes, trays etc. are contained in our Data Book "Package Information".

Dimensions in mm