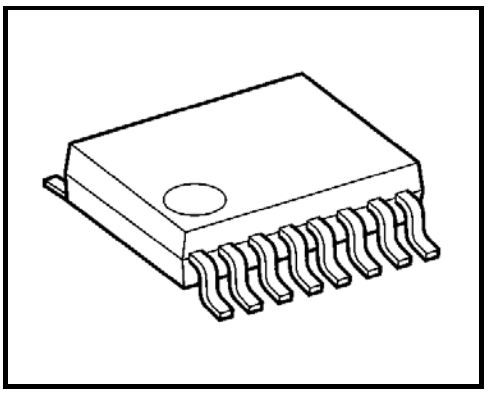
TOSHIBA CDMOS Integrated Circuit Silicon Monolithic

TC78H651FNG

1.8-V Dual bridge driver IC

The TC78H651FNG is a dual bridge driver IC for DC motors/Stepping motors which incorporate DMOS with low ON resistance in output transistors. Forward, reverse, or stop mode can be selected. Over current detection, thermal shutdown, and under voltage lockout functions are implemented.



P-TSSOP16-0505-0.65-001
Weight: 0.06 g (typ.)

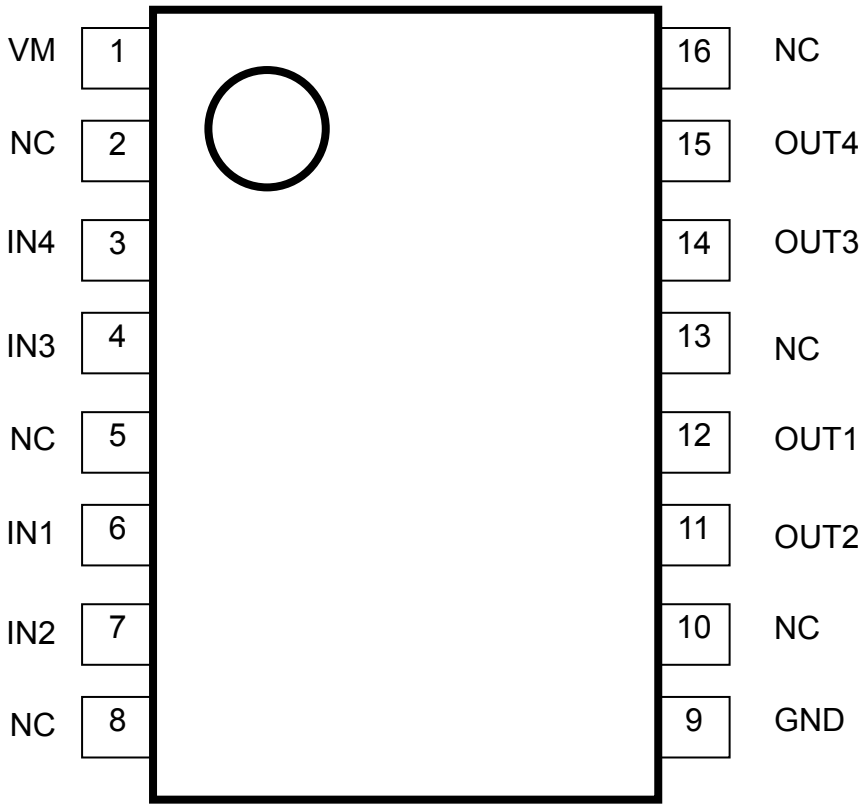
Features

- Power supply voltage (Absolute maximum ratings): 7.0 V (max)
- Power supply voltage (Operating Range): 1.8 V to 6.0 V
- Output current (Absolute maximum ratings): 1.6 A (max)
- Output ON resistance: 0.22 Ω (typ.)
  (Ta = 25 °C, Sum of upper and lower side, V_M = 5.0 V)
- Built-in standby function: Consumption current 0 μA (typ.)
- Built-in cross conduction protection circuit
- Built-in over current detection (ISD), thermal shutdown (TSD), and under voltage lockout (UVLO)
- Forward / Reverse / Stop modes are selectable
- Package: P-TSSOP16-0505-0.65-001

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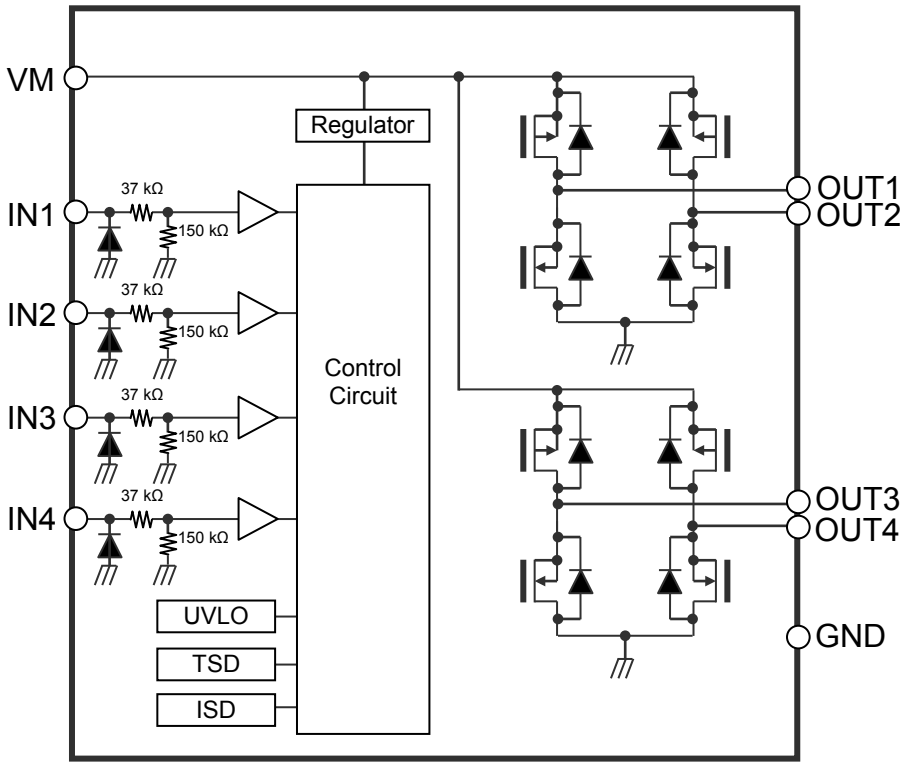
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Pin assignment (Top view)



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Block Diagram



Note: Please note that in the block diagram, functional blocks or constants may be omitted or simplified for explanatory purposes.

Pin Functions

Pin name	Pin No.	Functional description	Remarks
VM	1	Power supply pin for motor	Operation range is from 1.8 V to 6.0 V.
NC	2	No connection	Use this pin as open.
IN4	3	Control input pin 4	Refer to the section of “Input/Output Functions”.
IN3	4	Control input pin 3	Refer to the section of “Input/Output Functions”.
NC	5	No connection	Use this pin as open.
IN1	6	Control input pin 1	Refer to the section of “Input/Output Functions”.
IN2	7	Control input pin 2	Refer to the section of “Input/Output Functions”.
NC	8	No connection	Use this pin as open.
GND	9	GND pin	—
NC	10	No connection	Use this pin as open.
OUT2	11	Output pin 2	Motor coil connection pin
OUT1	12	Output pin 1	Motor coil connection pin
NC	13	No connection	Use this pin as open.
OUT3	14	Output pin 3	Motor coil connection pin
OUT4	15	Output pin 4	Motor coil connection pin
NC	16	No connection	Use this pin as open.

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Input/Output Functions

IN1	IN2	IN3	IN4	OUT1	OUT2	OUT3	OUT4	Mode
L	L	—	—	OFF	OFF	—	—	Stop
H	L	—	—	H	L	—	—	Forward
L	H	—	—	L	H	—	—	Reverse
H	H	—	—	(Note1)	(Note1)	—	—	—
—	—	L	L	—	—	OFF	OFF	Stop
—	—	H	L	—	—	H	L	Forward
—	—	L	H	—	—	L	H	Reverse
—	—	H	H	—	—	(Note1)	(Note1)	—
L	L	L	L	OFF	OFF	OFF	OFF	Standby

Note1: ”H” that is input previously becomes effective.

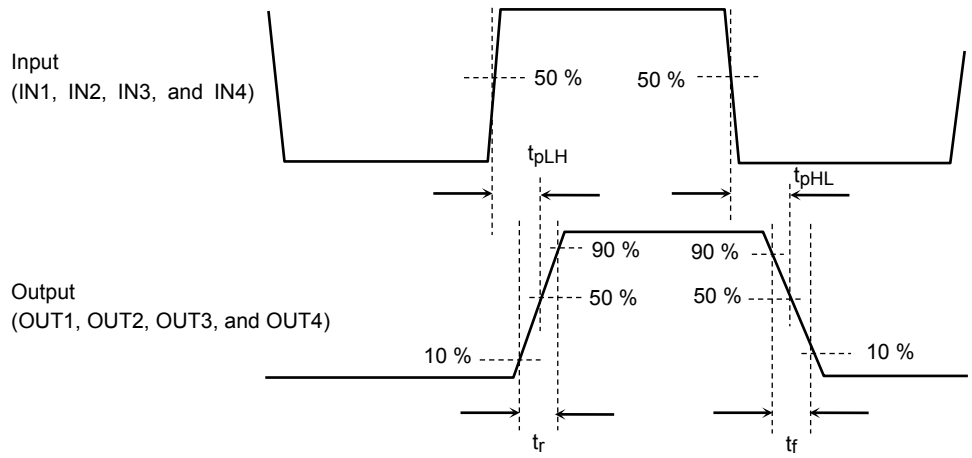
Note: —: Don’t Care

Switching from “IN1 = L / IN2= L” to “IN1 = H / IN2 = H”: Don’t Care

Switching from “IN3 = L / IN4= L” to “IN3 = H / IN4 = H”: Don’t Care

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Timing Chart of Output Waveforms



Note: Timing charts may be simplified for explanatory purposes.

AC characteristics (V_M = 3.0 V, T_a = 25°C)

Symbol	Typ.	Unit
t_{pLH}	90	ns
t_{pHL}	90	
t_r	20	
t_f	10	

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Absolute Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit
Power supply voltage	V_M	7.0	V
Input voltage	V_{IN}	-0.3 to 6	V
Output current	I_{OUT}	1.6	A
Output DMOS body diode forward current	I_f	1.6	A
Power dissipation	P_D	0.78 (Note 1)	W
Operation temperature	T_{opr}	-40 to 105	°C
Storage temperature	T_{stg}	-55 to 150	°C

Note 1: When mounted on a single-side glass epoxy board (50 mm × 50 mm × 1.6 mm, Cu area: 40 %, Cu thick: 35 μm)

Back-EMF

While a motor is rotating, there is a timing at which power is fed back to the power supply. At that timing, the motor current recirculates back to the power supply due to the effect of the motor back-EMF. If the power supply does not have enough sink capability, the power supply and output pins of the device might rise above the rated voltage (7 V). The magnitude of the motor back-EMF varies with usage conditions and motor characteristics. It must be fully verified that there is no risk that the device or other components will be damaged or fail due to the motor back-EMF.

When the power is fed back to the power supply, the body diode of the output DMOS may turn on and a regenerative current may flow. At this time, the voltage applied to the output pin may become a negative value by the voltage of the body diode (V_f). However, if the current of the body diode (I_f) is a rated value (shown in above table) or less, it is no problem.

Over Current Detection (ISD) and Thermal Shutdown (TSD)

The ISD and TSD circuits are only intended to provide temporary protection against irregular conditions such as an output short-circuits; they do not necessarily guarantee the complete IC safety. If the device is used beyond the specified operating ranges, these circuits may not operate properly: then the device may be damaged due to an output short-circuit. The ISD circuit is only intended to provide a temporary protection against an output short-circuit. If such condition persists for a long time, the device may be damaged due to overstress. Overcurrent conditions must be removed immediately by external hardware.

IC Mounting

Do not insert devices incorrectly or in the wrong orientation. Otherwise, it may cause breakdown, damage and/or deterioration of the device.

Operating Range (Ta = -40 to 105°C)

Characteristics	Symbol	Min	Typ.	Max	Unit	Remarks
Power supply voltage	V_M	1.8	3.0	6.0	V	—
Output current	I_{OUT}	—	—	1.5	A	V_M = 5.0 V
PWM frequency	f_{PWM}	—	—	500	kHz	Duty = 50 %

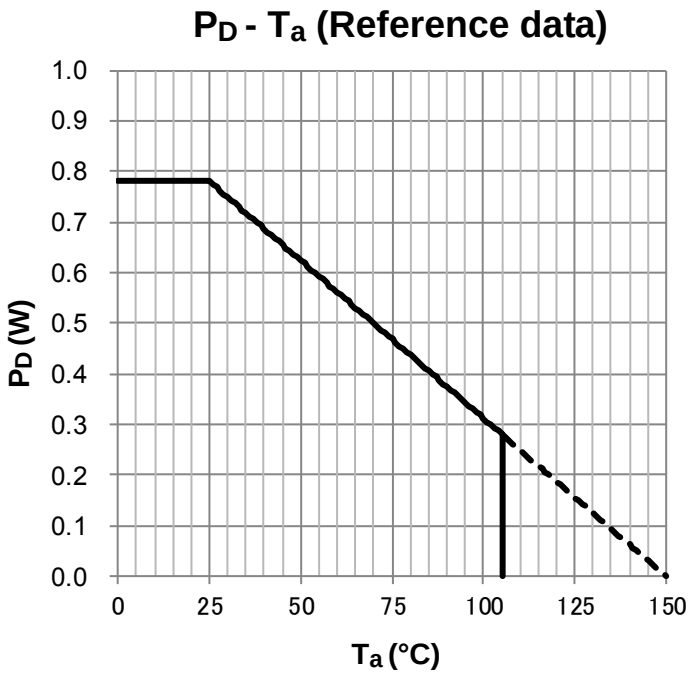
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Electrical Characteristics (V_M = 1.8 to 6.0 V, T_a = 25°C, unless otherwise specified.)

Characteristics		Symbol	Test condition	Min	Typ.	Max	Unit
Consumption current		I_{CC1}	Forward / Reverse mode, V_M = 3.0 V, Output Open	—	0.6	1.0	mA
		I_{CC2}	Standby mode, V_M = 3.0 V	—	0	0.22	μA
Control circuit	Input voltage	V_{IH}	—	2.0	—	5.5	V
		V_{IL}	—	-0.3	—	0.5	
	Input current	I_{IH}	V_{IN} = 3.0 V	10	16	22	μA
		I_{IL}	—	—	—	1.0	
ON-resistance between drain and source of output transistor (Sum of upper and lower side)		$R_{ON(D-S)}$	I_{OUT} = 1.0 A, V_M = 5.0 V	—	0.22	0.35	Ω
Output leakage current		I_{OH}	V_M = 3.0 V	—	—	1.0	μA
		I_{OL}		—	—	1.0	
Output DMOS body diode forward voltage		V_f	I_f = 0.4 A, V_M = 5.0 V	—	0.7	1.0	V

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Power dissipation graph



When mounted on a single-side glass epoxy board (50 mm × 50 mm × 1.6 mm, Cu area: 40%, Cu thick: 35 μm)

Note: Characteristics shown above are reference values and not guaranteed.

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Error Detection Functions

TSD (Thermal shut down)

When the junction temperature (T_j) of the IC exceeds 170°C (typ.), all outputs are turned off. When the junction temperature (T_j) falls by 40°C (typ.) or more, it returns to the normal mode.

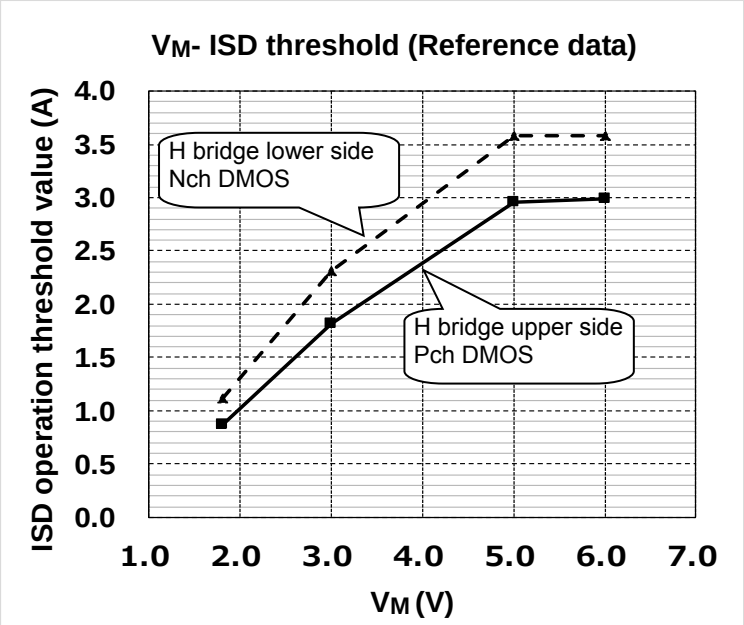
Note: Above TSD operation and release thresholds are reference values, and are not guaranteed.

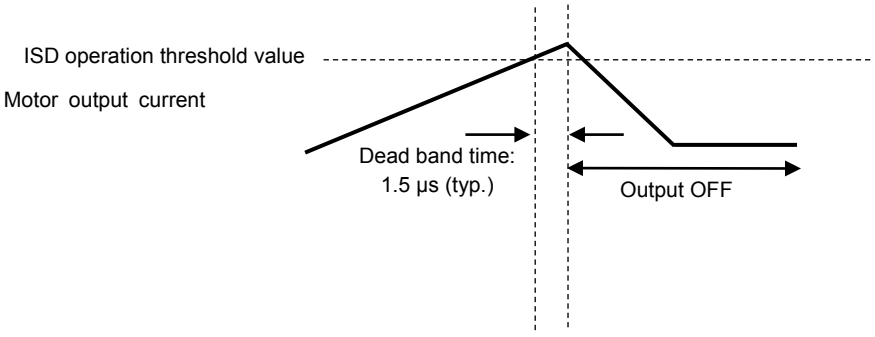
ISD (Over current detection)

When the IC detects an over current in the output transistors (exceeding ISD operation threshold value), all outputs are turned off. It has a dead band time of 1.5 µs (typ.) to avoid ISD misdetection, which may be triggered by switching noise, etc.

ISD releases when one of the followings is provided.

1. Power supply turns on again.
2. Operation mode is re-configured after setting to the standby mode (pin voltages of IN1, IN2, IN3, and IN4 = low level).





Note: Above ISD operation threshold value and dead band time are reference values, and are not guaranteed.

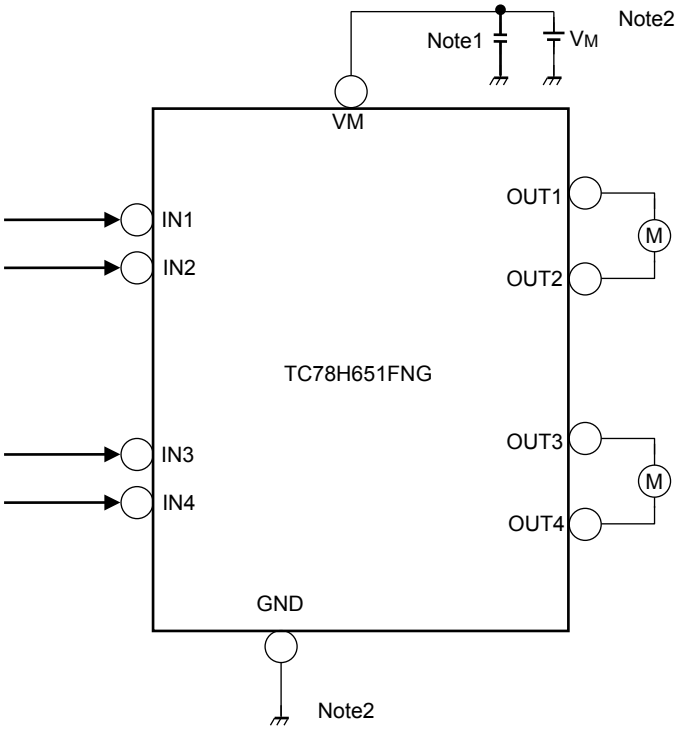
Under voltage lockout (UVLO)

When VM pin voltage falls to 1.7 V (typ.) or less, all outputs are turned off. UVLO is released when VM pin voltage rises more than 1.7 V (typ.).

Note: Above UVLO operation and release thresholds are reference values, and are not guaranteed.

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Application Circuit Example



Note1: A power supply ceramics capacitor for noise absorption should be connected as close to the IC as possible.

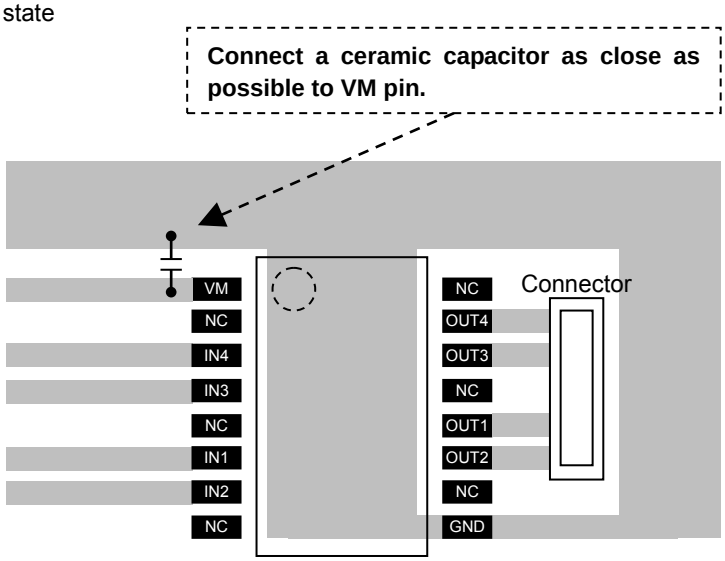
Note2: Utmost care is necessary in the design of V_M and GND line since the IC may be destroyed by short-circuiting between outputs, by short-circuiting to the power supply or ground, or by short-circuiting between contiguous pins.

Capacitor Connection to VM Pin

Connect a capacitor to VM pin to reduce the effects of power supply noise and back electromotive force during inductive load drive for power supply stabilization. To avoid voltage drops due to the wire impedance, connect the capacitor as close as possible to the IC. Also, in the electrolytic capacitor, the ESR may cause a voltage drop. Therefore, use a ceramic capacitor with a low ESR. Select a capacity value that can stabilize the power supply voltage in the operation range after enough evaluation.

Board Layout Example

When NC pin is in open state

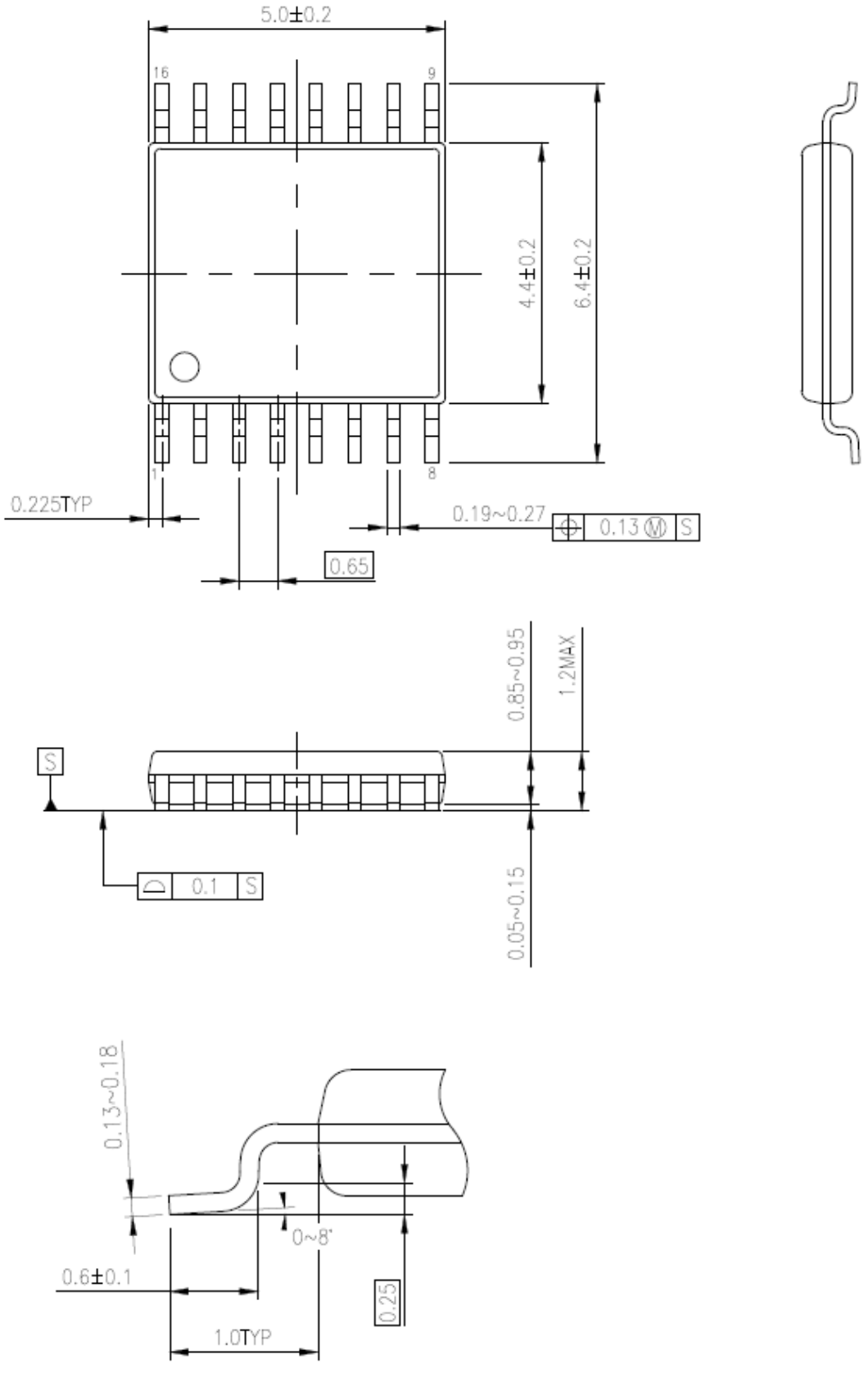


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Package Dimensions

P-TSSOP16-0505-0.65-001

Unit: mm



Weight: 0.06 g (typ.)

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Notes on Contents

1. Block Diagrams

Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purposes.

2. Equivalent Circuits

The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

3. Timing Charts

Timing charts may be simplified for explanatory purposes.

4. Application Circuits

The application circuits shown in this document are provided for reference purposes only. Thorough evaluation is required, especially at the mass production design stage.
Providing these application circuit examples does not grant a license for industrial property rights.

IC Usage Considerations

Notes on handling of ICs

[1] The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings.
Exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.

[2] Use an appropriate power supply fuse to ensure that a large current does not continuously flow in case of over current and/or IC failure. The IC will fully break down when used under conditions that exceed its absolute maximum ratings, when the wiring is routed improperly or when an abnormal pulse noise occurs from the wiring or load, causing a large current to continuously flow and the breakdown can lead smoke or ignition. To minimize the effects of the flow of a large current in case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.

[3] If your design includes an inductive load such as a motor coil, incorporate a protection circuit into the design to prevent device malfunction or breakdown caused by the current resulting from the inrush current at power ON or the negative current resulting from the back electromotive force at power OFF. IC breakdown may cause injury, smoke or ignition.
Use a stable power supply with ICs with built-in protection functions. If the power supply is unstable, the protection function may not operate, causing IC breakdown. IC breakdown may cause injury, smoke or ignition.

[4] Do not insert devices in the wrong orientation or incorrectly.
Make sure that the positive and negative terminals of power supplies are connected properly.
Otherwise, the current or power consumption may exceed the absolute maximum rating, and exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.
In addition, do not use any device that is applied the current with inserting in the wrong orientation or incorrectly even just one time.

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Points to remember on handling of ICs

(1) Thermal Shutdown Circuit

Thermal shutdown circuits do not necessarily protect ICs under all circumstances. If the thermal shutdown circuits operate against the over temperature, clear the heat generation status immediately.
Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the thermal shutdown circuit to not operate properly or IC breakdown before operation.

(2) Heat Radiation Design

In using an IC with large current flow such as power amp, regulator or driver, please design the device so that heat is appropriately radiated, not to exceed the specified junction temperature (T_j) at any time and condition. These ICs generate heat even during normal use. An inadequate IC heat radiation design can lead to decrease in IC life, deterioration of IC characteristics or IC breakdown. In addition, please design the device taking into considerate the effect of IC heat radiation with peripheral components.

(3) Back-EMF

When a motor rotates in the reverse direction, stops or slows down abruptly, a current flow back to the motor's power supply due to the effect of back-EMF. If the current sink capability of the power supply is small, the device's motor power supply and output pins might be exposed to conditions beyond absolute maximum ratings. To avoid this problem, take the effect of back-EMF into consideration in system design.

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