6W/Ch STEREO CLASS-D AUDIO POWER AMPLIFIER

GENERAL DESCRIPTION

The TMPA402DS is a Single-ended (SE) output Class-D audio power amplifier for driving speakers with high power efficiency. It is able to drive 4Ω, 6Ω, 8Ω or 16Ω speakers. The output power can be up to 6W per channel. No external heat-sink is necessary.

The gain of the amplifier can be changed by adding external input resistance.

Thermal protection and short-circuit protection are integrated for safety purpose.

The internal depop circuitry eliminates pop noise at power-up & shutdown operations.

FEATURES

- 6W/Ch Stereo Class-D Output
- Power efficiency is up to 82%
- Time delay for de-pop control
- Thermal Protection
- Output Pin Short-Circuit Protection (Short to Other Outputs, Short to VCC, Short to Ground)
- Low Quiescent Current (5mA Typical at 12V)
- Low Current in Shutdown Mode (<1μA Typical)
- Separate VCC & PVCC

APPLICATIONS

LCD Monitors, TVs, DVD Players and Powered Speakers

PACKAGE

TSSOP20 available

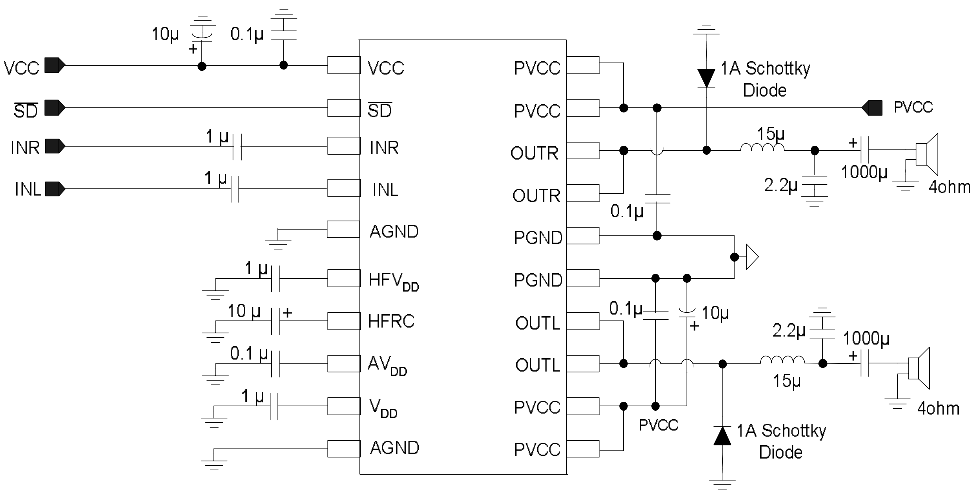
For best performance, please refer to

http://www.taimec.com.tw/English/EVM.htm

http://www.class-d.com.tw/English/EVM.htm

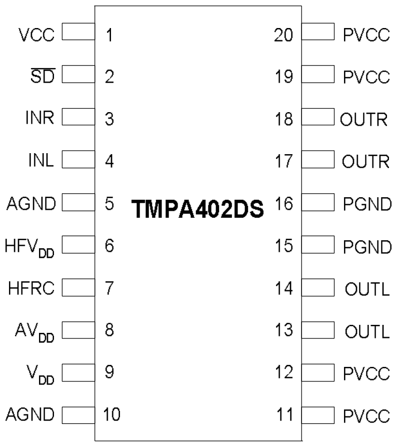
for PCB layout.

REFERENCE CIRCUIT



TMPA402DS

TOP VIEW



（Please email david@taimec.com.tw for complete datasheet.）

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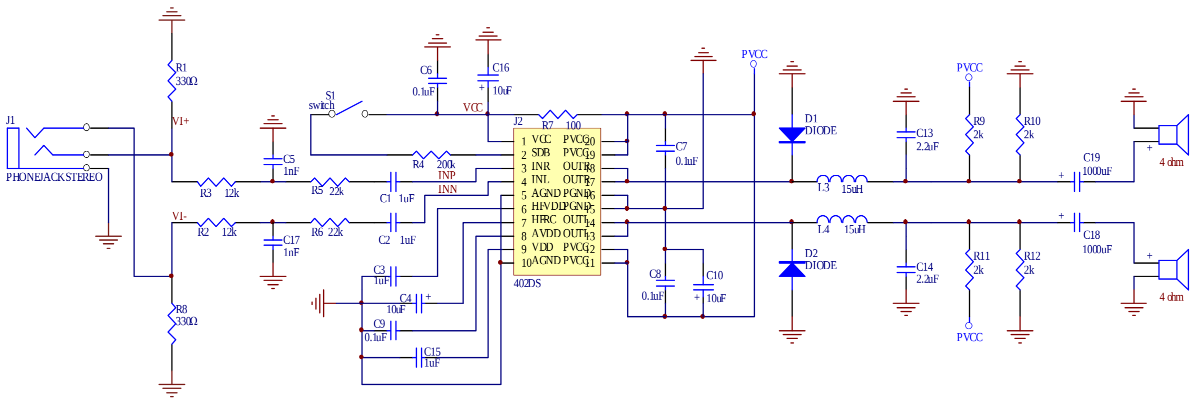
Note that the external components or PCB layout should be designed not to generate abnormal voltages to the chip to prevent from latch up which may cause damage to the device.

Typical Application



TERMINAL FUNCTIONS

TERMINAL		I/O	DESCRIPTION
NAME	PIN NO		
AGND	5,10	–	Analog ground
AV_{DD}	8	O	5-V analog power supply
HFRC	7	I	De-pop control
HFV_{DD}	6	O	2.5-V Reference for convenience of single-ended input
INL	4	I	Negative differential input
INR	3	I	Positive differential input
OUTN	13,14	O	Negative output
OUTP	17,18	O	Positive output
PGND	15,16	–	Power ground
PVCC	11,12,19,20	–	Power supply for output MOS (8V to 15V)
V_{CC}	1	–	High-voltage power supply (8V to 15V)
V_{DD}	9	O	5-V Reference output(25-mA)
$\overline{SD}$	2	I	Shutdown (Low valid)

ABSOLUTE MAXIMUM RATINGS

Over operating free-air temperature range unless otherwise noted(1)

Supply voltage, PVcc, Vcc	In normal mode	-0.3V to 18V	V
	In shutdown mode	-0.3V to 18V	V
Input voltage, $\overline{SD}$		-0.3V to Vcc+0.3V	V
Input voltage, INR, INL		-0.3V to 5V	V
Continuous total power dissipation		See package dissipation ratings	
Operating free-air temperature, T_A		-20 to 85	°C
Operating junction temperature, T_J		-20 to 150	°C
Storage temperature, T_{stg}		-40 to 150	°C

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions "is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

		MIN	MAX	UNIT
Supply voltage, V_{CC}	PV_{CC}, V_{CC}	8	15	V
High-level input voltage, V_{IH}	$\overline{SD}$	2.0		V
Low-level input voltage, V_{IL}	$\overline{SD}$		0.8	V
Operating free-air temperature, T_A		-20	85	°C

PACKAGE DISSIPATION RATINGS

PACKGE	DERATING FACTOR	$T_A \leq 25$ °C POWER RATING	$T_A = 70$ °C POWER RATING	$T_A = 85$ °C POWER RATING
TSSOP20(FD)	30 mW/ °C	3.75W	2.4W	1.95W

DC CHARACTERISTICS

T_A=25 °C, V_{CC}=15V, R_L=8Ω speaker (unless otherwise noted)

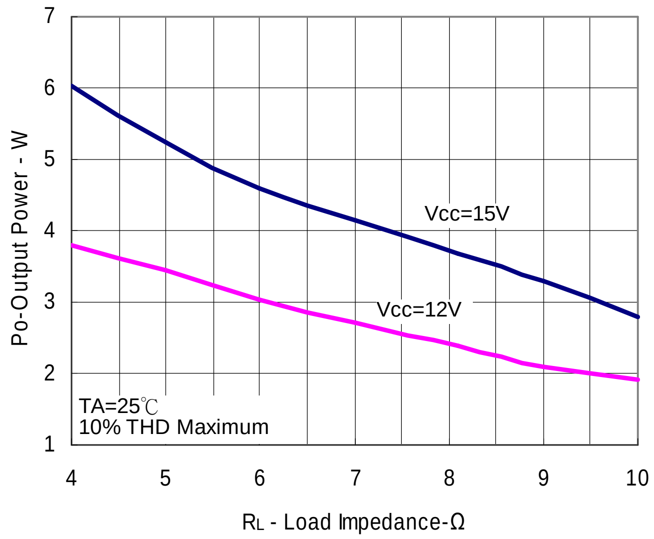
PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
|Vos|	Output offset voltage	INL and INR AC grounded Gain=20dB			80		mV
HFVDD	Half VDD reference output	No load			0.5x AVDD		V
AVDD/VDD	5-V Regulated voltage	Io=0 to 25mA, $\overline{SD}$ =High, Vcc=8V to 15V		4.5	5.0	5.5	V
Icc	Quiescent current (no load)	$\overline{SD}$ =High, Vcc= 12V			5	10	mA
		$\overline{SD}$ =High, Vcc= 15V			8	16	
Icc(SD)	Supply current in shutdown mode	$\overline{SD}$ =0V, Vcc= 12V			0.2	1	uA
		$\overline{SD}$ =0V, Vcc= 15V			0.2	1	
$r_{ds(on)}$	Drain-source on-state resistance	Vcc=15V	High side		600		mΩ
		Io=1A,	Low side		500		
*Gain	Voltage Gain	Ri=40k			22		dB
		Ri=20k			25.5		
		Ri=10k			28		
		Ri= 0k			31.5		
IIH	High-level input current	VI =2V($\overline{SD}$), Vcc=8~15V				20	uA
IIL	Low-level input current	VI =0V($\overline{SD}$), Vcc=8~15V				1	uA
fosc	Oscillator frequency	Vcc=8~15V		200		300	kHz
Zi	Input resistance of INR/INL				20		kΩ

*Gain= $\frac{750k}{Ri+20K}$ (Vcc=15V) , Gain= $\frac{600k}{Ri+20K}$ (Vcc=12V), Ri：external input resistance of INR/INL inputs

AC CHARACTERISTICS

T_A=25 °C, V_{CC}=15V, R_L=8Ω speaker (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Po(max)	Maximum continuous output power (r.m.s) per channel at 1kHz	RL=4Ω		6		W
		RL=6Ω		4.6		W
		RL=8Ω		3.75		W
THD+N	Total harmonic distortion plus noise	Vcc=12V, PO=4W, RL=4Ω, f=1kHz		0.4		%
		Vcc=15V, PO=5W, RL=4Ω, f=1kHz		0.47		
Vn	Output noise	Vcc=12V, Po at THD+N<0.5%, f=1kHz Gain=20dB		-70		dB
SNR	Signal-to-noise ratio	Maximum output at THD+N＜0.5%, f=1kHz		85		dB
Crosstalk	Crosstalk between outputs	Vcc=12V, Po=1W RL=8Ω		-60		dB
	Thermal trip point			145		°C
	Thermal hysteresis			25		°C


Po-Output Power - W
RL - Load Impedance-Ω
Vcc=15V
Vcc=12V
TA=25℃
10% THD Maximum
7
6
5
4
3
2
1
4
5
6
7
8
9
10

DETAILED DESCRIPTION

Efficiency

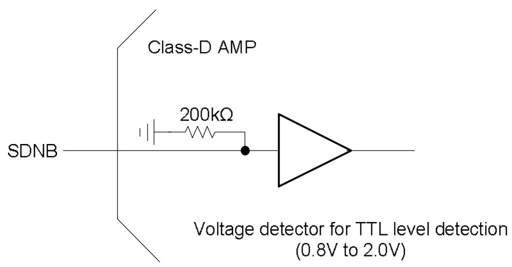
The output transistors of a class D amplifier act as switches. The power loss is mainly due to the turn on resistance of the output transistors when driving current to the load. As the turn on resistance is so small that the power loss is small and the power efficiency is high. With 8 ohm load the power efficiency can be better than 80%.

PCB layout for power dissipation

No heat sink is necessary for power dissipation. However the PCB layout should be well designed to dissipate heat for high output power. With 80% power efficiency the generated heat when driving 12 watts to the 8 ohm load is about 3 watts. The heat can be carried out through the thermal pad of the device to the PCB. To ensure proper dissipation of heat the PCB has to have heat path from the bottom of the device which is soldered to the PCB. The area of the metal on the PCB for heat dissipation should be big enough. It is suggested that both sides of the PCB are used for power dissipation.

Shutdown

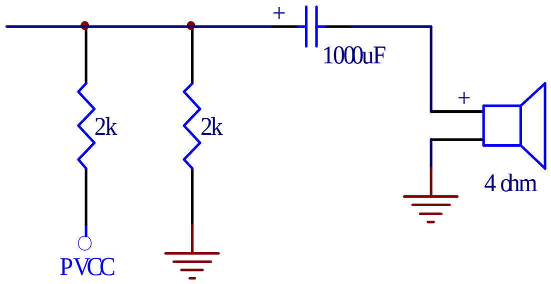
The shutdown mode reduces power consumption. A LOW at shutdown pin forces the device in shutdown mode and a HIGH forces the device in normal operating mode. Shutdown mode is useful for power saving when not in use. This function is useful when other devices like earphone amplifier on the same PCB are used but class D amplifier is not necessary.
Internal circuit for shutdown is shown below.



Pop-less

A soft start capacitor can be added to the HFRC pin. This capacitor introduced delay for the circuit to be stable before driving the load. The set up time for internal circuit to be stable is quite fast, typically it is less than 100ms. Thus the pop noise caused by shutdown operation can be fixed easily. But for external circuitry the setup time depends on the component values used in the application.

For single-ended outputs a voltage divider is to provide half Vcc to the output pin as shown in the following diagram. During power up this divider is to pre-charge output capacitor to half Vcc before output signal is enabled to drive the speaker. Since the equivalent resistance of the voltage divider is 1k ohms (2kohms//2kohms) and the capacitance of the output coupling capacitor is 1000uF the RC constant is 1 second. This indicates that the power up delay has to be much longer than 1 second. Normally a capacitor of 10uF would provide enough delay time to save power up noise.



HFRC

HFRC provides a way of soft start up delay. A half_Vcc voltage detector is integrated to detect a RC charge up. The resistor of 320k ohms of the RC circuit is also integrated in the chip but the capacitor is externally hooked up. For C=10uF the half_Vcc delay is

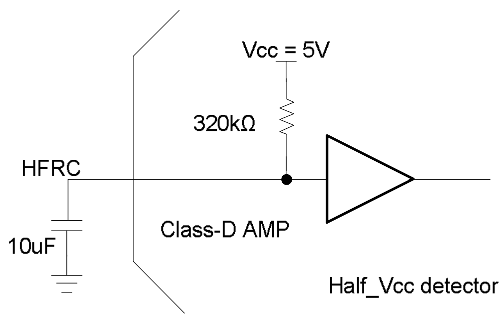
$$1-e^{-t/RC}=0.5$$

or

$$e^{-t/RC}=0.5$$

that is

$t = -RC\ln(0.5) = (320k \times 10u)(0.693) = 2.2$ seconds



To further reduce pop noise one can apply 22uF instead of 10uF at HFRC. But the delay time becomes 4.8 seconds

Voltage gain

The voltage gain can be set through external resistance connecting to input pins. Higher external resistance can be used for lower gain. The formula for voltage gain is defined in the datasheet.

The voltage gain of the amplifier by itself is 40 at Vcc=15v. If for some reason the voltage gain has to be reduced an external resistor can be added in series with the input signal. The formula for voltage gain at Vcc=15v becomes

gain = 800k ohms/(Zi + Rext)

where Zi(=20k ohms) is the internal resistance of the amplifier and Rext is the external added resistance.

Without Rext(Rext=0 ohm) the voltage gain is 800k/20k=40. If Rext is 30K ohms then the voltage gain is 800k/(20k+30k)=16.

The voltage gain is pretty much proportional to supply voltage. For example the formula for Vcc=12v is

gain = 640k ohms/(Zi + Rext)

Input filter

The AC coupling capacitors are used to block the DC voltage from the device. They also define the –3db frequency at the low frequency side. Since the input pins of the device have high impedance an input filter, if required, can be incorporated as shown in the application. A bypass capacitor placed in between the input signal path and ground is to attenuate the high frequencies. It defines the –3db frequency at the high frequency side.

The –3db frequency of the low frequency side is

f-3db = 1/ 2 π R C

where C is the AC coupling capacitance and R is the total resistance in series with C.

The –3db frequency of the high frequency side is

f-3db = 1/ 2 π R C

where C is the bypass capacitance and R is the total resistance in parallel with C.

Note that there is 20K internal resistor integrated in the chip for each input INR/INL.

Output coupling capacitor

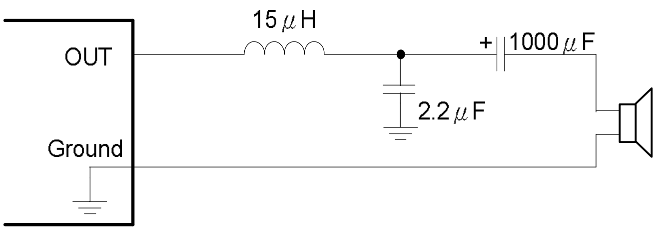
Since the output is singled-ended, coupling capacitor is required to isolate DC voltage between output pin and its corresponding speaker. If the -3db frequency of the output coupling stage is set 20Hz then the coupling capacitance is C= 1/(2 π x 8 ohm x 20Hz) =1000uF for 8 ohm load.

Output filter

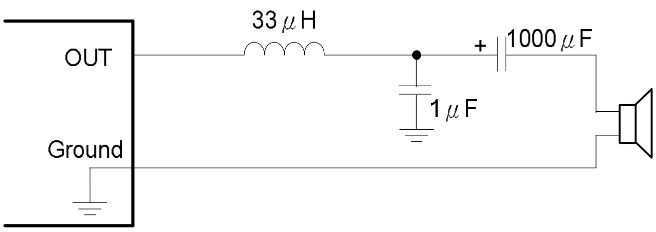
Ferrite bead filter can be used for EMI purpose. The ferrite filter reduces EMI around 1 MHz and higher（FCC and CE only test radiated emissions greater than 30 MHz）. When selecting a ferrite bead, choose one with high impedance at high frequencies, but low impedance at low frequencies.

Use an LC output filter if there are low frequency（＜1 MHz）EMI sensitive circuits and/or there are long wires from the amplifier to the speaker. EMI is also affected by PCB layout and the placement of the surrounding components.

The suggested LC values for different speaker impendence are showed in following figures for reference.



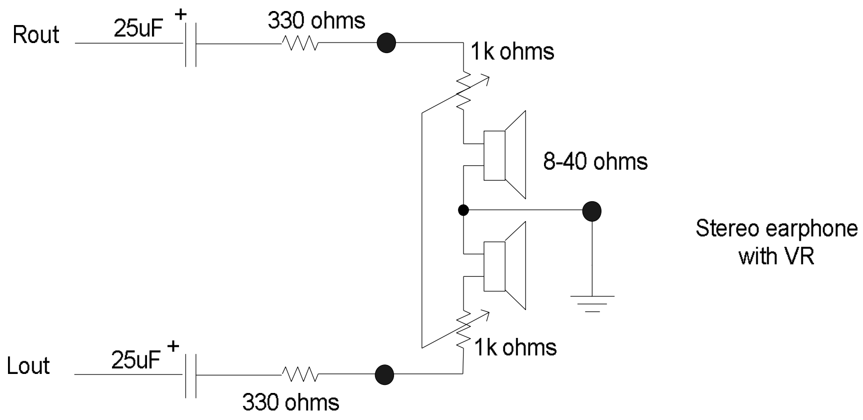
LC Output Filter(1), Speaker Impedance= 4Ω

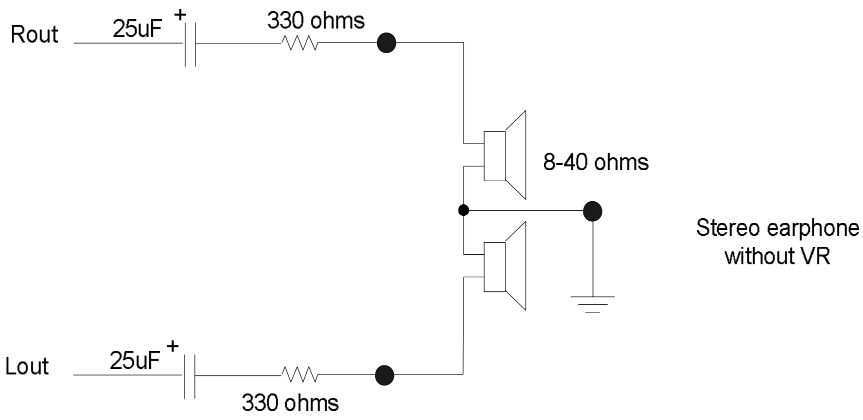


LC Output Filter(2), Speaker Impedance= 6Ω & 8Ω

EARPHONE USE

Class-D output can be used to drive earphone. However to avoid high power to overdrive earphone and to prevent human ear to accidentally be hurt, a resistor has to be put in series with the earphone speaker. Typically a resistor of 330 ohms is adequate for this purpose.





Over temperature protection

A temperature sensor is built in the device to detect the temperature inside the device. When a high temperature around 145oC and above is detected the switching output signals are disabled to protect the device from over temperature. Automatic recovery circuit enables the device to come back to normal operation when the internal temperature of the device is below around 120oC.

Over temperature protection

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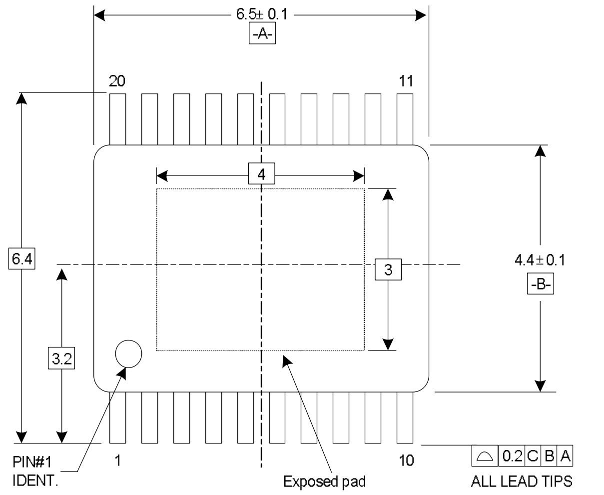
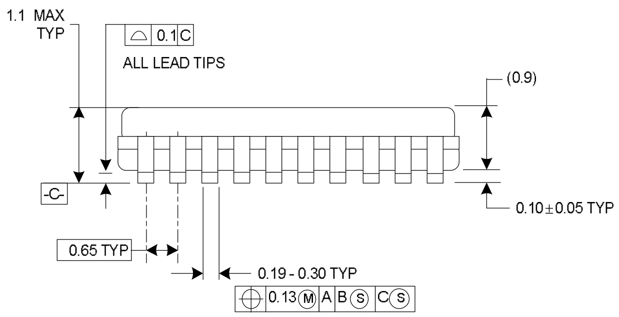
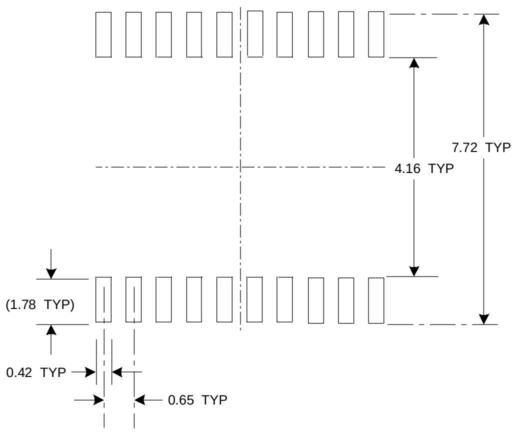
Over current protection

A current detection circuit is built in the device to detect the switching current of the output stages of the device. It disables the device when the current is beyond about 3.5amps. It protects the device when there is an accident short between outputs or between output and power/gnd pins It also protects the device when an abnormal low impedance is tied to the output. High current beyond the specification may potentially causes electron migration and permanently damage the device. Shutdown or power down is necessary to resolve the protection situation. There is no automatic recovery from over current protection.

Physical Dimensions (IN MILLIMETERS)







TSSOP20

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