36-V, 1.5-MHz, Low-Noise Operational Amplifier

Features

- Supply Voltage: 3 V to 36 V
- Offset Voltage: ±2 mV (Max)
- Differential Input Voltage Range to Supply Rail, can Work as Comparator
- Bandwidth: 1.5 MHz, Slew Rate: 0.5 V/μs
- Input Rail to $-V_S$, No Internal ESD Diode to $+V_S$
- Low 1/f Noise: 50 nV/Hz at 10 Hz
- High PSRR+: 60 dB at 100 KHz
- No Significant Output Glitch during Power-on and Power-off
- Operating Temperature Range: –40℃ to 125℃

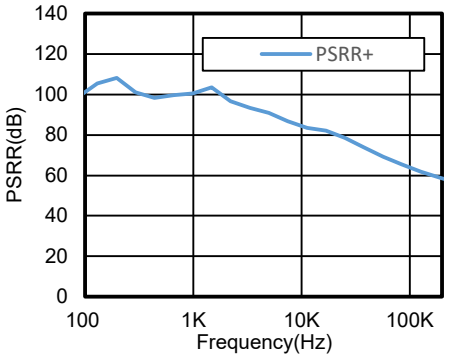
Applications

- Instrumentation
- Sensor Interface
- Motor Control
- Industrial Control

Description

The TPA264x is a series of the newest high supply voltage amplifiers with 2-mV offset, low noise, and immunity to high-frequency noise from the power supply. It incorporates 3PEAK's proprietary and patented design techniques to achieve excellent AC performance with a 1.5-MHz bandwidth, a 0.5-V/μs slew rate, and low distortion while drawing a quiescent current of only 550 μA per amplifier.

The input common-mode voltage range extends to $-V_S$, and there is no internal ESD diode between the input and $+V_S$. This feature can block the current path from the input to $+V_S$ during power-off but the signal is still in the input pin. It is widely used in battery-related applications.



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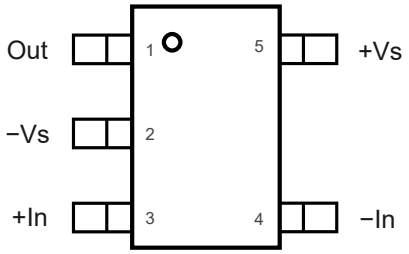
Revision History

Date	Revision	Notes
2020-04-26	Rev.A.0	Initial version.
2023-04-09	Rev.A.1	The following updates are all about the new datasheet formats or typos, and the actual product remains unchanged. Updated the Package Outline Dimensions.
2023-11-05	Rev.A.2	The following updates are all about the new datasheet formats or typos, and the actual product remains unchanged. Updated the input voltage noise in Electrical Characteristics: from 1 μV_{RMS} to 1.6 μV_{PP}.
2024-12-18	Rev.A.3	The following updates are all about the new datasheet formats or typos, and the actual product remains unchanged. Updated to a new datasheet format. Updated to a new format of Package Outline Dimensions. Updated the Tape and Reel Information.

Pin Configuration and Functions

TPA2641
SOT23-5
Top View



TPA2641U
SOT23-5
Top View

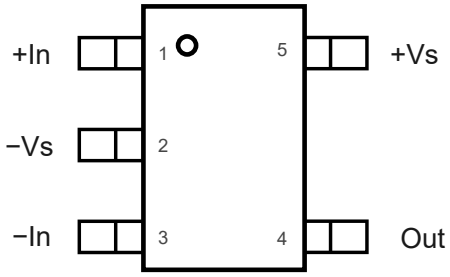


Table 1. Pin Functions: TPA2641, TPA2641U

Pin No.		Name	I/O	Description
TPA2641	TPA2641U			
1	4	Out	O	Output
2	2	$-V_S$	-	Negative power supply
3	1	+In	I	Non-inverting input
4	3	−In	I	Inverting input
5	5	$+V_S$	-	Positive power supply

TPA2642
SOP8/TSSOP8/MSOP8
Top View

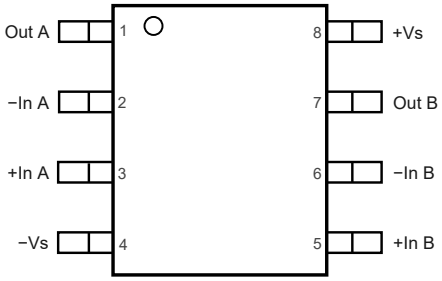
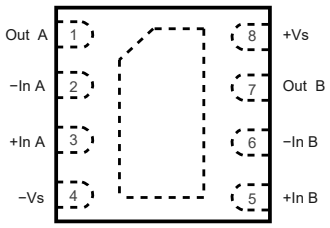


Table 2. Pin Functions: TPA2642

Pin No.	Name	I/O	Description
1	Out A	O	Output
2	−In A	I	Inverting input
3	+In A	I	Non-inverting input
4	$-V_S$	-	Negative power supply
5	+In B	I	Non-inverting input
6	−In B	I	Inverting input
7	Out B	O	Output
8	$+V_S$	-	Positive power supply

TPA2642
DFN2X2-8
Top View



The thermal pad of the DFN2X2-8 package is recommended to be left float or connected to $-V_S$.

Table 3. Pin Functions: TPA2642

Pin No.	Name	I/O	Description
1	Out A	O	Output
2	−In A	I	Inverting input
3	+In A	I	Non-inverting input
4	$-V_S$	-	Negative power supply
5	+In B	I	Non-inverting input
6	−In B	I	Inverting input
7	Out B	O	Output
8	$+V_S$	-	Positive power supply

TPA2644
SOP14/TSSOP14
Top View

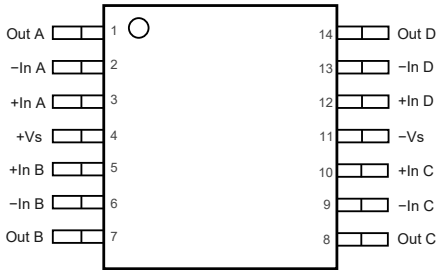


Table 4. Pin Functions: TPA2644

Pin No.	Name	I/O	Description
1	Out A	O	Output
2	−In A	I	Inverting input
3	+In A	I	Non-inverting input
4	$+V_S$	-	Positive power supply
5	+In B	I	Non-inverting input
6	−In B	I	Inverting input
7	Out B	O	Output power supply
8	Out C	O	Output power supply
9	−In C	I	Inverting input
10	+In C	I	Non-inverting input
11	$-V_S$	-	Negative power supply
12	+In D	I	Non-inverting input
13	−In D	I	Inverting input
14	Out D	O	Output

Specifications

Absolute Maximum Ratings (1)

Parameter		Min	Max	Unit
	Supply Voltage, $(+V_S) – (–V_S)$		40	V
	Input Voltage	$(-V_S) – 0.3$	40	V
	Input Current: +IN, –IN (2)	−10	10	mA
	Output Voltage	$(-V_S) - 0.3$	$(+V_S) + 0.3$	V
	Output Short-Circuit Duration (3)		Infinite	
T_J	Maximum Junction Temperature		150	°C
T_A	Operating Temperature Range	−40	125	°C
T_{STG}	Storage Temperature Range	−65	150	°C
T_L	Lead Temperature (Soldering, 10 sec)		260	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.
(2) The inputs are protected by ESD-protection diodes to the negative power supply. If the input extends more than 300 mV beyond the negative power supply, the input current should be limited to less than 10 mA.
(3) A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. The thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

ESD, Electrostatic Discharge Protection

Symbol	Parameter	Condition	Minimum Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 (1)	2	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 (2)	1	kV

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
SOT23-5	250	81	°C/W
SOP8	158	43	°C/W
MSOP8	210	45	°C/W
TSSOP8	191	44	°C/W
DFN2X2-8	100	60	°C/W
SOP14	120	36	°C/W
TSSOP14	180	35	°C/W

Electrical Characteristics

All test conditions: T_A = 25°C, R_L = 10 kΩ, C_L = 100 pF, unless otherwise noted.

Symbol	Parameter	Conditions	T_A	Min	Typ	Max	Unit
Power Supply							
V_S	Supply Voltage Range			3		36	V
I_Q	Quiescent Current per Amplifier	V_S = 5 V to 36 V			350	550	μA
			−40°C to 125°C			650	μA
PSRR	Power Supply Rejection Ratio	V_S = 5 V to 36 V		100	120		dB
			−40°C to 125°C	95			dB
Input Characteristics							
V_{OS}	Input Offset Voltage	V_S = 36 V, V_{CM} = 0 V to 28 V		−2	0.1	2	mV
			−40°C to 85°C	−3		3	mV
			−40°C to 125°C	−3.5		3.5	mV
		V_S = 5 V, V_{CM} = 2.5 V		−2	0.1	2	mV
			−40°C to 85°C	−3		3	mV
			−40°C to 125°C	−3.5		3.5	mV
V_{OS} TC	Input Offset Voltage Drift		−40°C to 125°C		5		μV/°C
I_B	Input Bias Current	V_S = 36 V, V_{CM} = 18 V			15	30	nA
			−40°C to 125°C			50	nA
I_{OS}	Input Offset Current	V_S = 36 V, V_{CM} = 18 V			1	10	nA
			−40°C to 125°C			30	nA
I_B	Input Bias Current	V_S = 36 V, V_{CM} = 0 V			20	50	nA
			−40°C to 125°C			100	nA
I_{OS}	Input Offset Current	V_S = 36 V, V_{CM} = 0 V			1	30	nA
						50	nA
I_{IN}	Different Input Current	V_S = 36 V, V_{ID} = 36 V		−300	50	300	nA
			−40°C to 125°C	−500		500	nA
C_{IN}	Input Capacitance	Differential mode			5		pF
		Common mode			5		pF
A_V	Open-Loop Voltage Gain			110	130		dB
			−40°C to 125°C	100			dB
V_{CMR}	Common-Mode Input Voltage Range		−40°C to 125°C	($-V_S$)		($+V_S$) – 2	V
CMRR	Common-Mode Rejection Ratio	V_{CM} = 0 V to 28 V		85	110		dB
			−40°C to 125°C	80			dB
Output Characteristics							
	Output Voltage Swing from Positive Rail	I_{LOAD} = 50 μA to V_S / 2			1.1	1.2	V

Symbol	Parameter	Conditions	T_A	Min	Typ	Max	Unit
			−40°C to 125°C			1.4	V
		I_{LOAD} = 1 mA to V_S / 2			1.3	1.5	V
			−40°C to 125°C			1.7	V
		I_{LOAD} = 5 mA to V_S / 2			1.9	2.4	V
			−40°C to 125°C			2.5	V
	Output Voltage Swing from Negative Rail	I_{LOAD} = 50 µA to V_S / 2			70	100	mV
			−40°C to 125°C			150	mV
		I_{LOAD} = 1 mA to V_S / 2			0.9	1	V
			−40°C to 125°C			1.1	V
		I_{LOAD} = 5 mA to V_S / 2			1.2	1.5	V
			−40°C to 125°C			1.6	V
		V_S = 5 V, R_{LOAD} = 10 kΩ to 0 V			5	10	mV
			−40°C to 125°C			15	mV
I_{SC}	Output Short-Circuit Current				50		mA
			−40°C to 125°C		30		mA
AC Specifications							
GBW	Gain-Bandwidth Product				1.5		MHz
SR	Slew Rate	G = 1, 2-V step			0.5		V/µs
t_{OR}	Overload Recovery	From positive rail			1.5		µs
		From negative rail			8		µs
t_S	Settling Time, 0.1%	G = 1, 2-V step			3		µs
	Settling Time, 0.01%				4		µs
PM	Phase Margin	R_L = 10 kΩ, C_L = 100 pF			60		°
GM	Gain Margin	R_L = 10 kΩ, C_L = 100 pF			15		dB
	Channel Separation	f = 100 kHz			120		dB
Noise Performance							
E_N	Input Voltage Noise	f = 0.1 Hz to 10 Hz			1.6		μV_{PP}
e_N	Input Voltage Noise Density	f = 1 kHz			50		nV/√Hz
i_N	Input Current Noise	f = 1 kHz			200		fA/√Hz
THD+N	Total Harmonic Distortion and Noise	f = 1 kHz, G = 1, R_L = 10 kΩ, V_{OUT} = 6 V_{RMS}			0.01		%

Typical Performance Characteristics

All test conditions: V_S = ±15 V, V_{CM} = 0 V, R_L = 10 kΩ, unless otherwise noted.

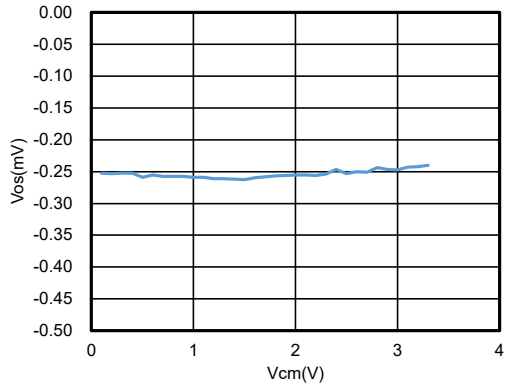


Figure 1. Offset Voltage vs. Common-Mode Voltage, V_S = 5 V

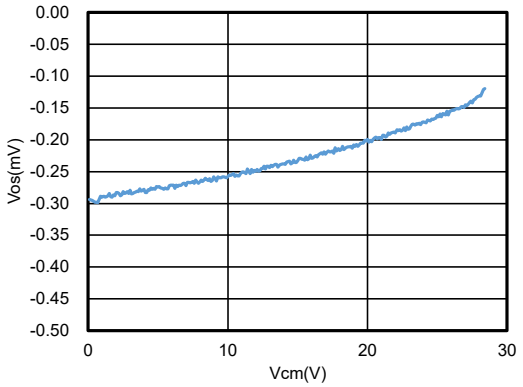


Figure 2. Offset Voltage vs. Common-Mode Voltage, V_S = 30 V

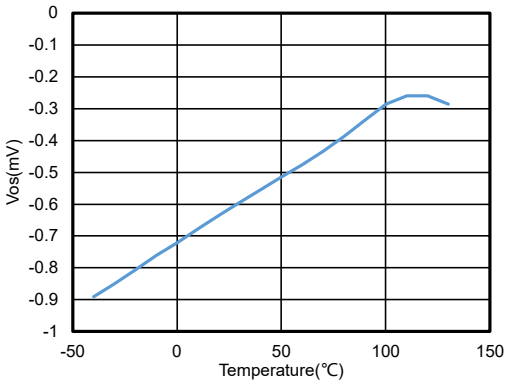


Figure 3. Offset Voltage vs. Temperature, V_S = 30 V, V_{CM} = 15 V

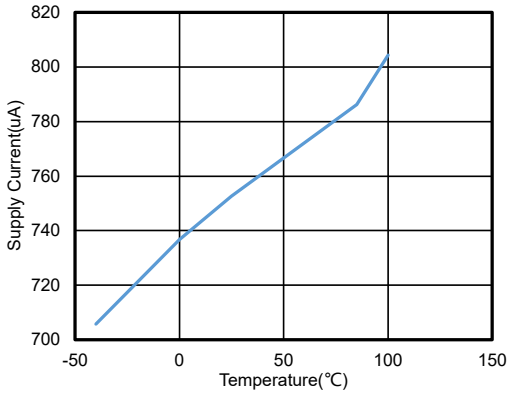


Figure 4. I_Q vs. Temperature, ±15-V Supply, TPA2642

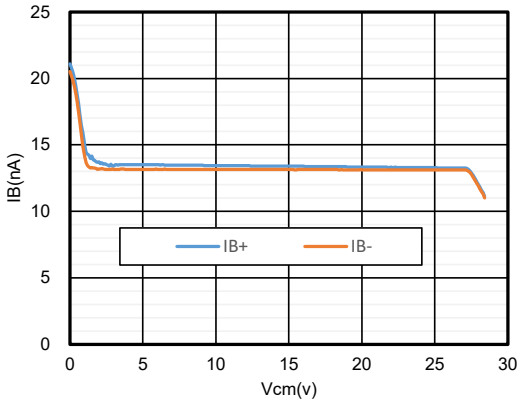


Figure 5. I_B vs. Common-Mode Voltage, V_S = 30 V

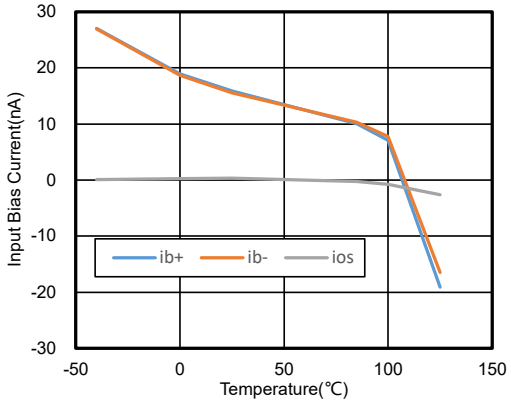


Figure 6. I_B and I_{OS} vs. Temperature, V_S = 30 V, V_{CM} = 15 V

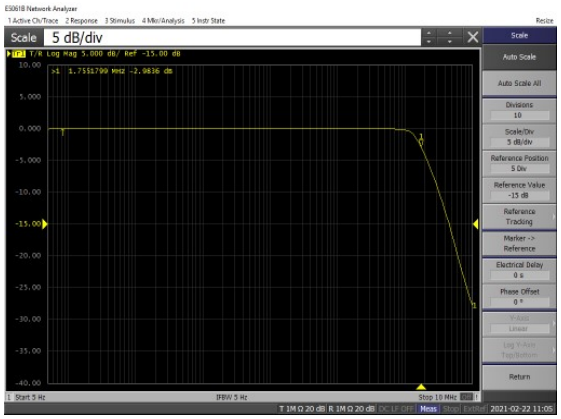


Figure 7. −3-dB Bandwidth, G = 1, V_S = 30 V

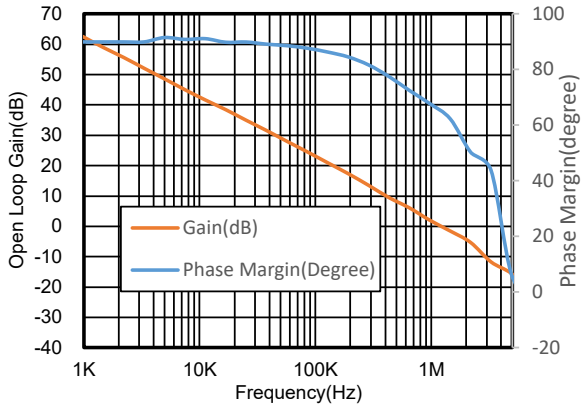


Figure 8. Open-Loop Gain and Phase vs. Frequency

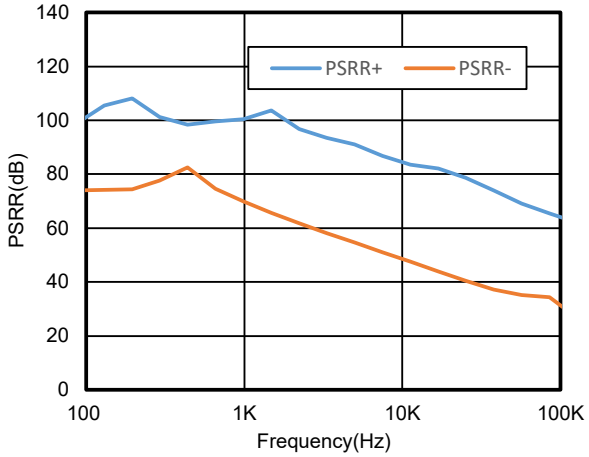


Figure 9. PSRR vs. Frequency

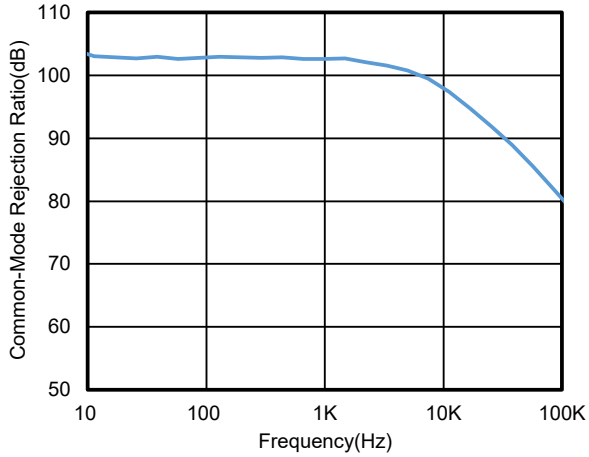


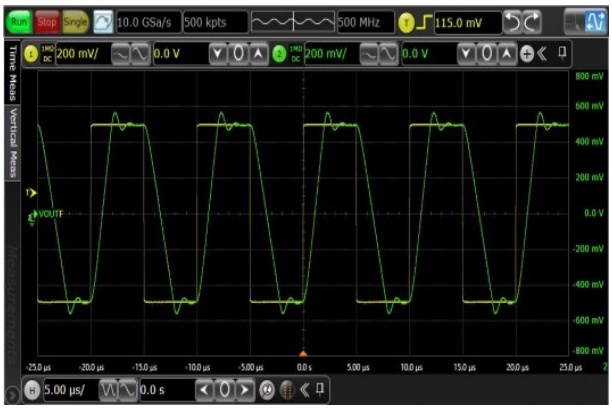
Figure 10. CMRR vs. Frequency

Time: 10 µs/div, Measure Time: 1.4 µs, G = 11

Figure 11. Positive Overload Recovery

Time: 10 µs/div, Measure Time: 7.8 µs, G = 11

Figure 12. Negative Overload Recovery



Voltage: 200 mV/div, Time: 5 µs/div

R_L = 100 kΩ, C_L = 1 nF, G = 1

Figure 13. 1-V Signal Step Response

Voltage: 2 mV/div, Time: 5 µs/div

C_L = 50 pF, G = 1

Figure 14. 10-mV Signal Step Response

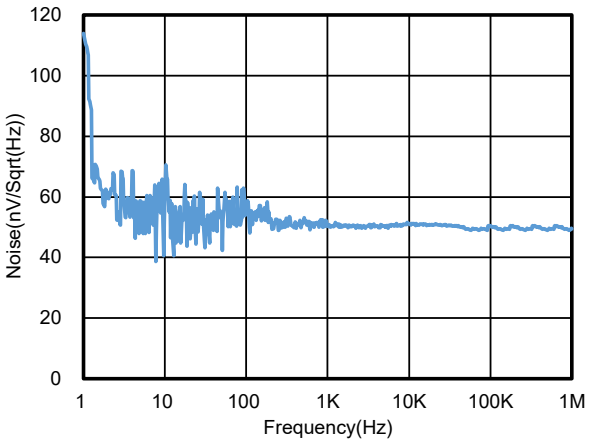


Figure 15. Voltage Noise Density vs. Frequency

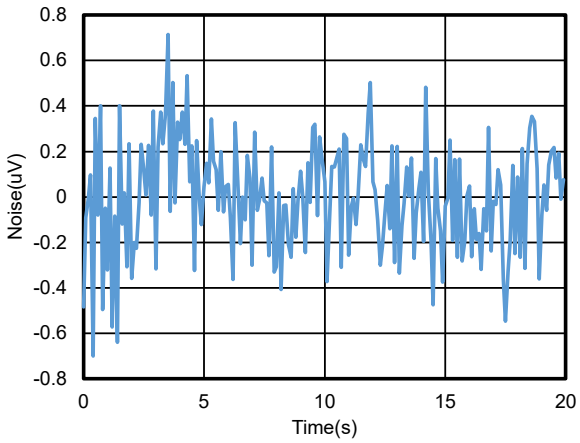


Figure 16. 0.1-Hz to 10-Hz Voltage Noise

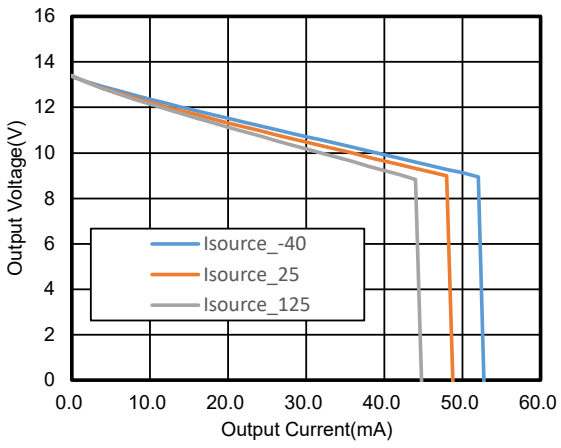


Figure 17. V_{OUT} vs. I_{OUT}, Source

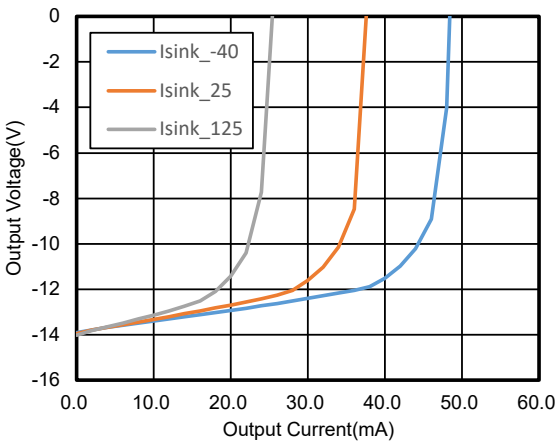


Figure 18. V_{OUT} vs. I_{OUT}, Sink

Typical Performance Characteristics (Continued)

All test conditions: power-on and power-off behaviors, 36-V single supply, G = 1, input = V_S / 2, yellow: V_S, green: output, unless otherwise noted.

Figure 19. 2-ms Power-on and Power-off Time

Figure 20. 10-ms Power-on and Power-off Time

Figure 21. 100-ms Power-on and Power-off Time

Figure 22. 1-s Power-on and Power-off Time

Typical Performance Characteristics (Continued)

All test conditions: power-on and power-off behaviors, +18-V and −18-V dual supply, G = 1, input = ground, green: $+V_S$, red: $-V_S$, yellow: output, unless otherwise noted.

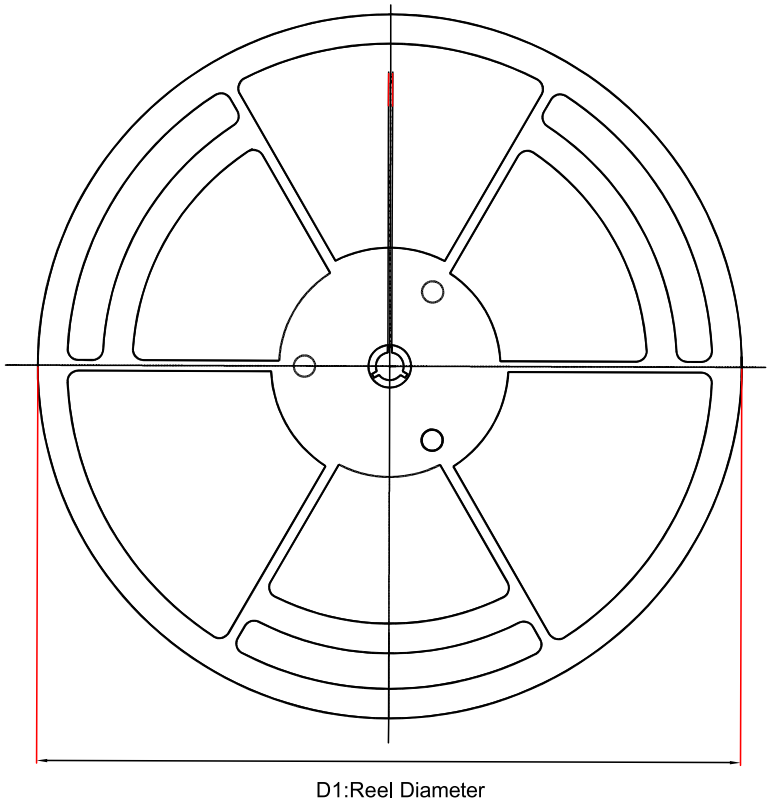
Figure 23. 1-ms Power-on and Power-off Time

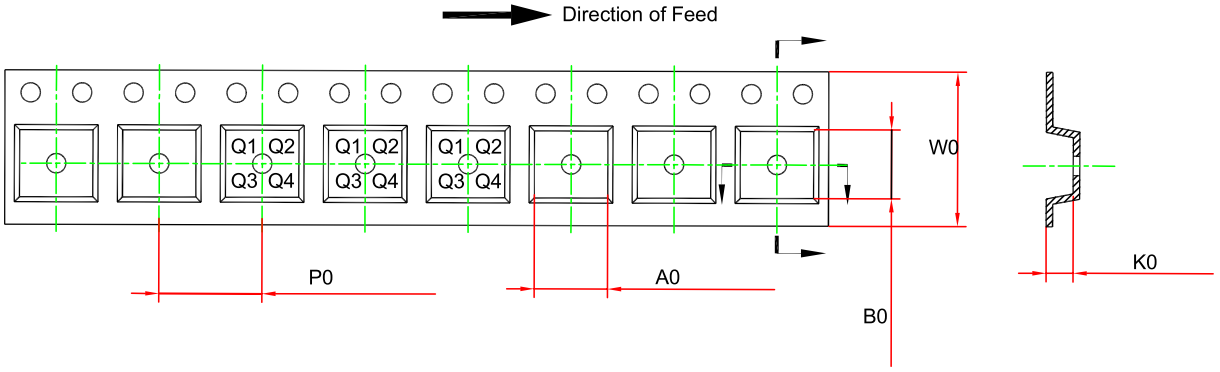
Figure 24. 10-ms Power-on and Power-off Time

Figure 25. 100-ms Power-on and Power-off Time

Figure 26. 1-s Power-on and Power-off Time

Tape and Reel Information





Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) (1)	B0 (mm) (1)	K0 (mm) (1)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA2641-S5TR	SOT23-5	180.0	13.1	3.2	3.2	1.4	4.0	8.0	Q3
TPA2641U-S5TR	SOT23-5	180.0	13.1	3.2	3.2	1.4	4.0	8.0	Q3
TPA2642-SO1R	SOP8	330.0	17.6	6.4	5.4	2.1	8.0	12.0	Q1
TPA2642-DF4R	DFN2X2-8	180.0	13.1	2.3	2.3	1.1	4.0	8.0	Q1
TPA2642-TS1R	TSSOP8	330.0	17.6	6.8	3.3	1.2	8.0	12.0	Q1
TPA2642-VS1R	MSOP8	330.0	17.6	5.2	3.3	1.5	8.0	12.0	Q1

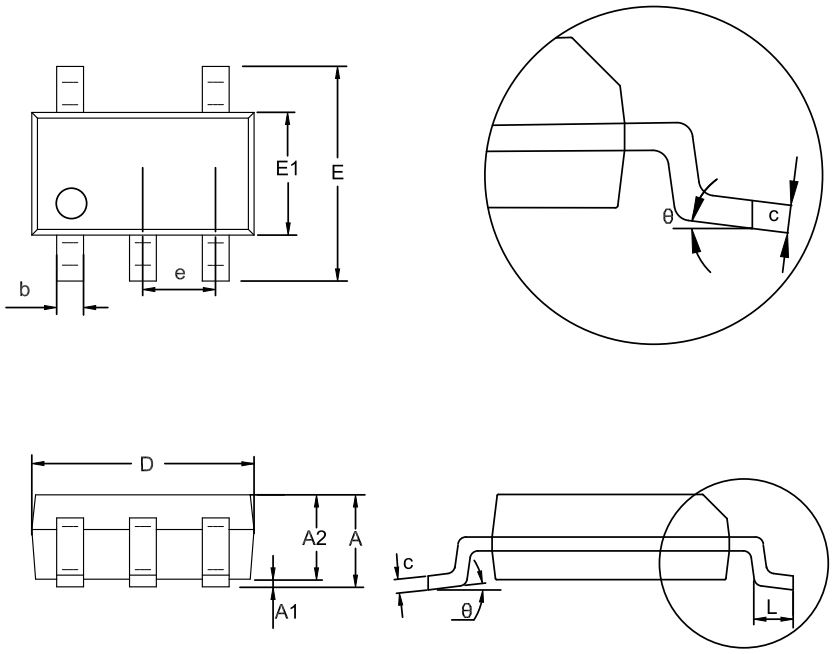
Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm) (1)	B0 (mm) (1)	K0 (mm) (1)	P0 (mm)	W0 (mm)	Pin1 Quadrant
TPA2644-SO2R	SOP14	330.0	21.6	6.5	9.0	2.1	8.0	16.0	Q1
TPA2644-TS2R	TSSOP14	330.0	17.6	6.8	5.4	1.2	8.0	12.0	Q1

(1) The value is for reference only. Contact the 3PEAK factory for more information.

Package Outline Dimensions

SOT23-5

Package Outline Dimensions S5T(SOT23-5-A)



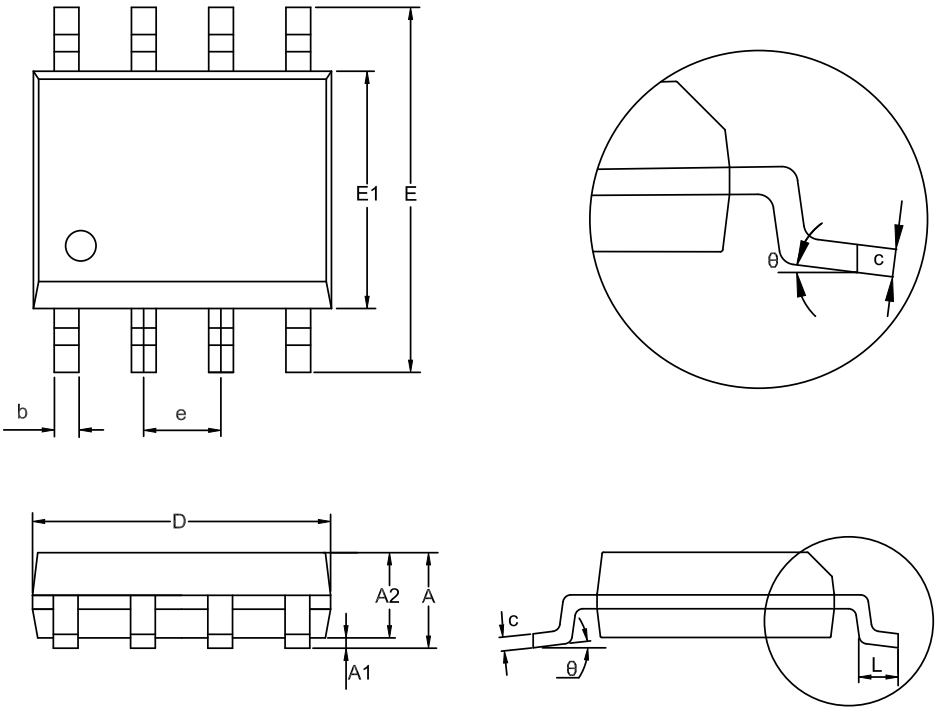
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.280	0.500	0.011	0.020
c	0.100	0.230	0.004	0.009
D	2.820	3.020	0.111	0.119
E	2.600	3.000	0.102	0.118
E1	1.500	1.720	0.059	0.068
e	0.950 BSC		0.037 BSC	
L	0.300	0.600	0.012	0.024
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

SOP8

Package Outline Dimensions SO1(SOP-8-A)



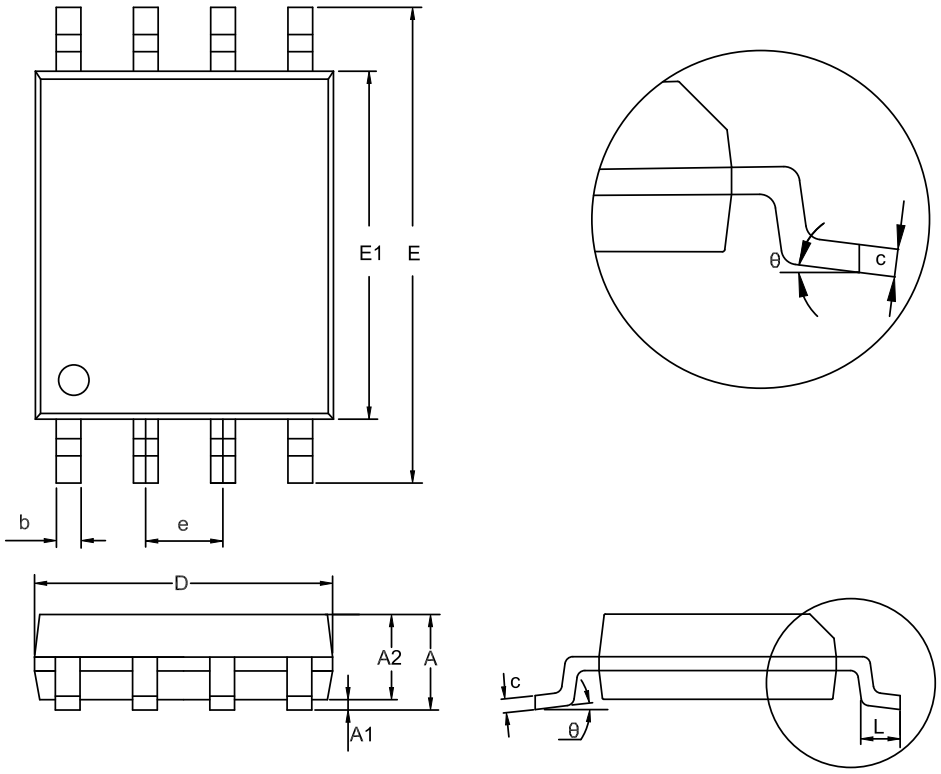
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 BSC	
L	0.400	1.000	0.016	0.039
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

TSSOP8

Package Outline Dimensions TS1(TSSOP-8-A)



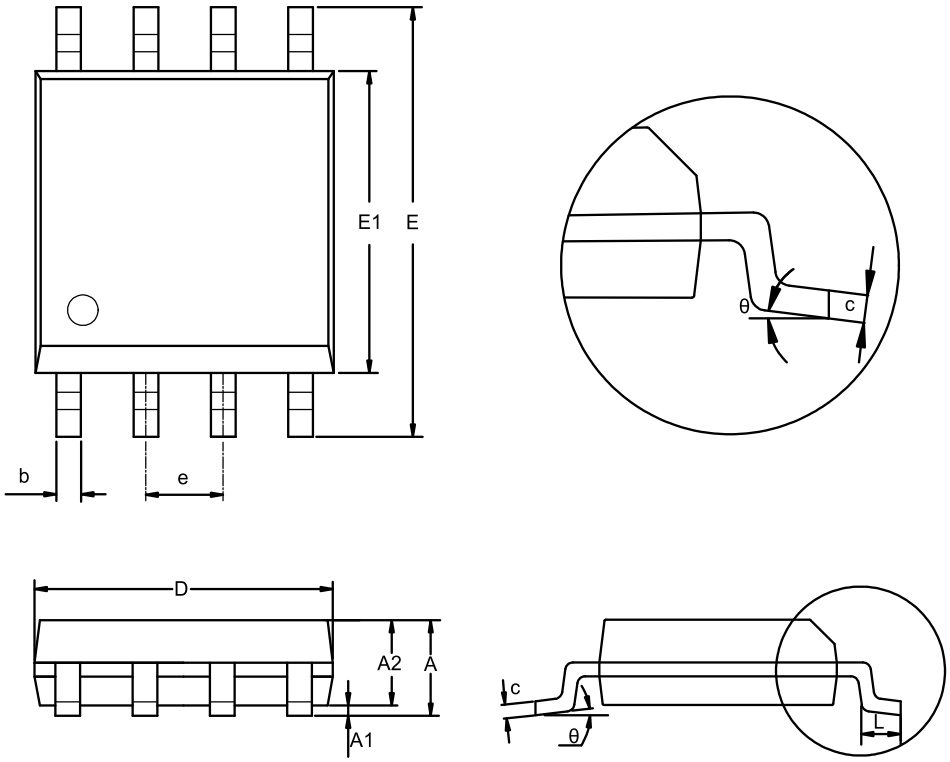
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.200	0.035	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	2.900	3.100	0.114	0.122
E	6.200	6.600	0.244	0.260
E1	4.300	4.500	0.169	0.177
e	0.650 BSC		0.026 BSC	
L	0.450	0.750	0.018	0.030
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

MSOP8

Package Outline Dimensions VS1(MSOP-8-A)



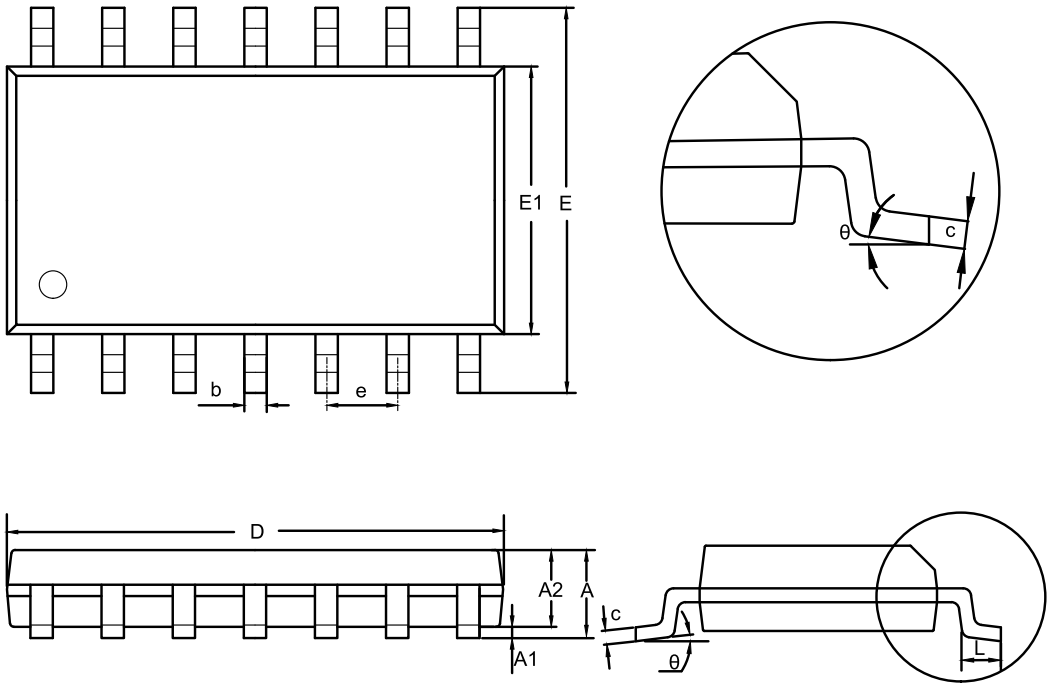
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

SOP14

Package Outline Dimensions SO2(SOP-14-A)



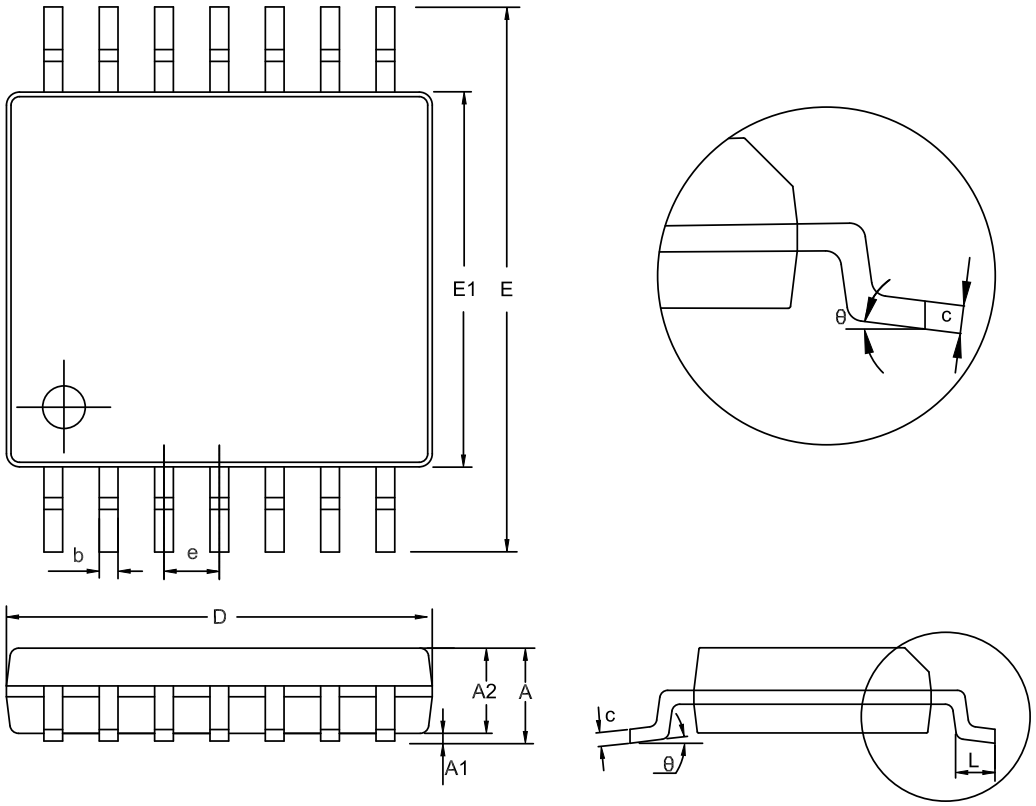
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.650	0.049	0.065
b	0.310	0.510	0.012	0.020
c	0.100	0.250	0.004	0.010
D	8.450	8.850	0.333	0.348
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

TSSOP14

Package Outline Dimensions TS2(TSSOP-14-A)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.900	1.200	0.035	0.047
A1	0.050	0.150	0.002	0.006
A2	0.800	1.050	0.031	0.041
b	0.190	0.300	0.007	0.012
c	0.090	0.200	0.004	0.008
D	4.900	5.100	0.193	0.201
E	6.200	6.600	0.244	0.260
E1	4.300	4.500	0.169	0.177
e	0.650 BSC		0.026 BSC	
L	0.450	0.750	0.018	0.030
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
TPA2641-S5TR	−40 to 125°C	SOT23-5	641	3	Tape and Reel, 3000	Green
TPA2641U-S5TR	−40 to 125°C	SOT23-5	64U	3	Tape and Reel, 3000	Green
TPA2642-SO1R	−40 to 125°C	SOP8	A2642	3	Tape and Reel, 4000	Green
TPA2642-DF4R (1)	−40 to 125°C	DFN2X2-8	642	3	Tape and Reel, 3000	Green
TPA2642-TS1R (1)	−40 to 125°C	TSSOP8	A2642	3	Tape and Reel, 3000	Green
TPA2642-VS1R	−40 to 125°C	MSOP8	A2642	3	Tape and Reel, 3000	Green
TPA2644-SO2R	−40 to 125°C	SOP14	A2644	3	Tape and Reel, 2500	Green
TPA2644-TS2R	−40 to 125°C	TSSOP14	A2644	3	Tape and Reel, 3000	Green

(1) For future products, contact the 3PEAK factory for more information and samples.

Green: 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.

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