# Supertex inc.



# P-Channel Enhancement Mode **Vertical DMOS FETs**

#### **Features**

- High input impedance and high gain
- Low power drive requirement
- Ease of paralleling ►
- Low C<sub>iss</sub> and fast switching speeds
- Excellent thermal stability
- Integral source-drain diode
- Free from secondary breakdown

# **Applications**

- Logic level interfaces ideal for TTL and CMOS
- Solid state relays
- Analog switches
- Power management
- **Telecom switches**

# **General Description**

This low threshold enhancement-mode (normally-off) transistor utilizes a vertical DMOS structure and Supertex's well-proven silicon-gate manufacturing process. This combination produces a device with the power handling capabilities of bipolar transistors and with the high input impedance and positive temperature coefficient inherent in MOS devices. Characteristic of all MOS structures. this device is free from thermal runaway and thermallyinduced secondary breakdown.

Supertex's vertical DMOS FETs are ideally suited to a wide range of switching and amplifying applications where very low threshold voltage, high breakdown voltage, high input impedance, low input capacitance, and fast switching speeds are desired.

## **Ordering Information**

Devie	Package O	ptions	$BV_{DSS}/BV_{DGS}$	$R_{DS(ON)}$	V <sub>GS(th)</sub> (max) (V)				
Device	TO-236AB (SOT-23)	TO-92	(V)	(max) (Ω)					
TP2104	TP2104K1-G	TP2104N3-G	-40	6.0	-2.0				
indicates package is	RoHS compliant ('Green')								
	en Initiax.	Pin	on						

# **Absolute Maximum Ratings**

Parameter	Value
Drain-to-source voltage	BV <sub>DSS</sub>
Drain-to-gate voltage	$BV_{DGS}$
Gate-to-source voltage	±20V
Operating and storage temperature	-55°C to +150°C
Soldering temperature*	+300°C

Absolute Maximum Ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied. Continuous operation of the device at the absolute rating level may affect device reliability. All voltages are referenced to device ground.

Distance of 1.6mm from case for 10 seconds.



DRAIN

TO-236AB (SOT-23) (K1)

DRAIN

# **Thermal Characteristics**

Package	I <sub>D</sub> (continuous) <sup>†</sup> (mA)	l <sub>D</sub> (pulsed) (A)	Power Dissipation @ T <sub>A</sub> = 25°C (W)	<i>θ<sub>jc</sub></i> ∘C/W	θ <sub>ja</sub> °C/W	l <sub>DR</sub> † (mA)	I <sub>DRM</sub> (A)
TO-236AB (SOT-23)	-160	-0.8	0.36	200	350	-160	-0.8
TO-92	-250	-1.0	0.74	125	170	-250	-1.0

*†*  $I_{D}$  (continuous) is limited by max rated  $T_{i}$ .

#### **Electrical Characteristics** (*T<sub>A</sub>* = 25°C unless otherwise specified)

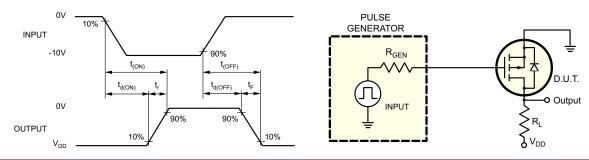
$ \begin{array}{c c c c c c } I_{DSS} & Zero gate voltage drain current & - & - & -1.0 & mA & V_{DS}^{DS} = 0.8  Max  Rating, \\ V_{QS}^{DS} = 0V,  T_A = 125^{\circ}C \\ \hline I_{D(ON)} & On-state drain current & -0.6 & - & - & A & V_{GS} = -10V,  V_{DS} = -25V \\ \hline R_{DS(ON)} & Static drain-to-source on-state resistance & - & 10 & - & 0.5 \\ \hline R_{DS(ON)} & Change in R_{DS(ON)} with temperature & - & 0.55 & 1.0 & 96^{\circ}C & V_{GS} = -10V,  I_D = -500mA \\ \hline \Delta R_{DS(ON)} & Change in R_{DS(ON)} with temperature & - & 0.55 & 1.0 & 96^{\circ}C & V_{GS} = -10V,  I_D = -500mA \\ \hline G_{FS} & Forward transconductance & 150 & 200 & - & mmho & V_{DS} = -25V,  I_D = -500mA \\ \hline G_{ISS} & Input capacitance & - & 35 & 600 \\ \hline C_{ISS} & Input capacitance & - & 35 & 600 \\ \hline C_{RSS} & Reverse transfer capacitance & - & 22 & 300 \\ \hline C_{RSS} & Reverse transfer capacitance & - & 8.0 & 100 \\ \hline t_{d(ON)} & Turn-on delay time & - & 4.0 & 6.0 \\ \hline t_{I} & Rise time & - & 4.0 & 6.0 \\ \hline t_{I} & Rise time & - & 5.0 & 9.0 \\ \hline t_{I} & Rise time & - & 5.0 & 8.0 \\ \hline V_{SD} & Diode forward voltage drop & - & -1.2 & -2.0 & V & V_{GS} = 0V,  I_{SD} = -500mA \\ \hline \end{array}$	Sym	Parameter	Min	Тур	Мах	Units	Conditions
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	$BV_{DSS}$	Drain-to-source breakdown voltage	-40	-	-	V	V <sub>GS</sub> = 0V, I <sub>D</sub> = -1.0mA
$ \begin{array}{c c c c c c } \hline I_{\text{DSS}} & \text{Gate body leakage} & - & -1.0 & -100 & nA & V_{\text{GS}} = \pm 20V, V_{\text{DS}} = 0V \\ \hline I_{\text{DSS}} & Zero gate voltage drain current & - & - & -10 & \muA & V_{\text{GS}} = 0V, V_{\text{DS}} = \text{Max Rating}, \\ \hline V_{\text{GS}} = 0.8 & \text{Max Rating}, \\ \hline V_{\text{GS}} = 0.8 & \text{Max Rating}, \\ \hline V_{\text{GS}} = 0.7 & \text{A} & V_{\text{GS}} = 0.8 & \text{Max Rating}, \\ \hline V_{\text{GS}} = 0.7 & \text{A} & V_{\text{GS}} = -10V, V_{\text{DS}} = -25V \\ \hline I_{\text{D}(\text{ON})} & \text{Static drain-to-source on-state} & - & - & 0.6 & - & - & A & V_{\text{GS}} = -10V, V_{\text{DS}} = -25V \\ \hline R_{\text{DS}(\text{ON})} & \text{Static drain-to-source on-state} & - & 0.55 & 1.0 & 90 \\ \hline C_{\text{GS}} & \text{Forward transconductance} & 150 & 200 & - & mmho & V_{\text{GS}} = -10V, I_{\text{D}} = -500mA \\ \hline G_{\text{FS}} & \text{Forward transconductance} & 150 & 200 & - & mmho & V_{\text{DS}} = -25V, I_{\text{D}} = -500mA \\ \hline C_{\text{GS}} & \text{Common source output capacitance} & - & 35 & 60 \\ \hline C_{\text{GS}} & \text{Common source output capacitance} & - & 8.0 & 10 \\ \hline I_{d(\text{ON})} & \text{Turn-on delay time} & - & 4.0 & 8.0 \\ \hline I_{\text{UN}-\text{F}} & \text{Turn-off delay time} & - & 4.0 & 8.0 \\ \hline I_{\text{G}(\text{OFF})} & \text{Turn-off delay time} & - & 5.0 & 9.0 \\ \hline I_{\text{M}} & \text{Fall time} & - & 5.0 & 8.0 \\ \hline V_{\text{SD}} & \text{Diode forward voltage drop} & - & -1.2 & -2.0 & V & V_{\text{GS}} = 0V, I_{\text{SD}} = -500mA \\ \hline \end{array}$	$V_{GS(th)}$	Gate threshold voltage	-1.0	-	-2.0	V	$V_{GS} = V_{DS}, I_{D} = -1.0 \text{mA}$
$ \begin{array}{c c c c c c } \hline I_{GSS} & Gate body leakage & - & -1.0 & -100 & nA & V_{GS} = \pm 20V, V_{DS} = 0V \\ \hline I_{DSS} & Zero gate voltage drain current & - & - & -10 & \muA & V_{GS} = 0V, V_{DS} = Max Rating \\ \hline V_{GS} = 0.8 Max Rating, \\ V_{GS} = 0.8 Max Rating, \\ V_{GS} = 0.8 Max Rating, \\ V_{GS} = 0.7 & A & V_{GS} = -10V, V_{DS} = -25V \\ \hline I_{D(ON)} & On-state drain current & -0.6 & - & - & A & V_{GS} = -10V, V_{DS} = -25V \\ \hline R_{DS(ON)} & Static drain-to-source on-state \\ resistance & - & 0.6 & - & - & 0.5 \\ \hline R_{DS(ON)} & Change in R_{DS(ON)} with temperature & - & 0.55 & 1.0 & 90''C & V_{GS} = -10V, I_{D} = -500mA \\ \hline \Delta R_{DS(ON)} & Change in R_{DS(ON)} with temperature & - & 0.55 & 1.0 & 90''C & V_{GS} = -10V, I_{D} = -500mA \\ \hline G_{FS} & Forward transconductance & 150 & 200 & - & mmho & V_{DS} = -25V, I_{D} = -500mA \\ \hline G_{SS} & Common source output capacitance & - & 35 & 60 \\ \hline C_{CSS} & Common source output capacitance & - & 8.0 & 10 \\ \hline I_{d(ON)} & Turn-on delay time & - & 4.0 & 8.0 \\ \hline I_{(OFF)} & Turm-off delay time & - & 4.0 & 8.0 \\ \hline I_{(OFF)} & Turn-off delay time & - & 5.0 & 9.0 \\ \hline I_{V} & Fall time & - & 5.0 & 8.0 \\ \hline V_{SD} & Diode forward voltage drop & - & -1.2 & -2.0 & V & V_{GS} = 0V, I_{SD} = -500mA \\ \hline \end{array}$	$\Delta V_{\rm GS(th)}$	Change in $V_{_{GS(th)}}$ with temperature	-	5.8	6.5	mV/ºC	$V_{GS} = V_{DS}, I_{D} = -1.0 \text{mA}$
$ \begin{array}{c c c c c c c } I_{\text{DSS}} & Zero gate voltage drain current & - & - & - & - & - & - & - & - & - & $		Gate body leakage	-	-1.0	-100	nA	$V_{GS} = \pm 20V, V_{DS} = 0V$
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $				-	-10	μA	$V_{GS}$ = 0V, $V_{DS}$ = Max Rating
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	I <sub>DSS</sub>	Zero gate voltage drain current	-	-	-1.0	mA	$V_{DS} = 0.8$ Max Rating, $V_{GS} = 0V$ , $T_A = 125^{\circ}C$
$ \begin{array}{c c c c c c c } \hline R_{\text{DS(ON)}} & \begin{array}{c} \text{Static drain-to-source on-state} \\ \text{resistance} & - & 10 \\ \hline & & 6.0 \end{array} & \begin{array}{c} V_{\text{GS}} = -4.5 \text{V}, \text{I}_{\text{D}} = -50\text{mA} \\ \hline & V_{\text{GS}} = -10 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = -10 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = -10 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = -10 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = -10 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = -10 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = -10 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = -10 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = -10 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = -25 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = -25 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = 0 \text{V}, \text{V}_{\text{S}} = -25 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = 0 \text{V}, \text{V}_{\text{S}} = -25 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = 0 \text{V}, \text{V}_{\text{S}} = -25 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = 0 \text{V}, \text{V}_{\text{S}} = -25 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = 0 \text{V}, \text{V}_{\text{S}} = -25 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = 0 \text{V}, \text{V}_{\text{S}} = -25 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = 0 \text{V}, \text{V}_{\text{S}} = -25 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = 0 \text{V}, \text{V}_{\text{S}} = -25 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = 0 \text{V}, \text{V}_{\text{S}} = -25 \text{V}, \text{I}_{\text{D}} = -500\text{mA} \\ \hline & V_{\text{GS}} = -25 \text{V}, \text{I}_{\text{D}} = -500\text{mA}, \\ \hline & V_{\text{GS}} = -500\text{mA}, \text{R}_{\text{GEN}} = 25 \Omega \\ \hline & V_{\text{SD}} = -500\text{mA}, \text{R}_{\text{S}} = 25 \Omega \\ \hline & V_{\text{SD}} = -500\text{mA}, \text{R}_{\text{S}} = 25 \Omega \\ \hline & V_{\text{SD}} = -500\text{mA}, \text{R}_{\text{S}} = -500\text{mA} \\ \hline & V_{\text{SD}} = 0 \text{V}, \text{I}_{\text{SD}} = -500\text{mA} \\ \hline & V_{\text{SD}} = -500\text{mA} \\ \hline & V_{\text{SD}} = -500\text{mA} \\ \hline & V_{\text{SD}} = 0 \text{V}, \text{I}_{\text{SD}} = -500\text{mA} \\ \hline & V_{\text{SD}} = 0 \text{V}, \text{I}_{\text{SD}} = -500\text{mA} \\ \hline & V_{\text{SD}} = 0 \text{V}, \text{I}_{\text{SD}} = -500\text{mA} \\ \hline & V_{\text{SD}} = 0 \text{V}, \text{I}_{\text{SD}} = -500\text{mA} \\ \hline & V_{\text{SD}} = 0 \text{V}, \text{I}_{\text{SD}} = -500\text{mA} \\ \hline & V_{\text{SD}} = 0 V$	I <sub>D(ON)</sub>	On-state drain current	-0.6	-	-	А	
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$		Static drain-to-source on-state	-	-	10	0	V <sub>GS</sub> = -4.5V, I <sub>D</sub> = -50mA
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	DS(ON)	resistance		-	6.0		V <sub>GS</sub> = -10V, I <sub>D</sub> = -500mA
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	$\Delta R_{DS(ON)}$	Change in $R_{DS(ON)}$ with temperature	-	0.55	1.0	%/°C	V <sub>GS</sub> = -10V, I <sub>D</sub> = -500mA
		Forward transconductance	150	200	-	mmho	V <sub>DS</sub> = -25V, I <sub>D</sub> = -500mA
	C <sub>ISS</sub>	Input capacitance	-	35	60		$V_{00} = 0V.$
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	C <sub>oss</sub>	Common source output capacitance	-	22	30	pF	$V_{DS}^{0} = -25V,$
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	C <sub>RSS</sub>	Reverse transfer capacitance	-	8.0	10		f = 1.0 MHz
		Turn-on delay time	-	4.0	6.0		
$t_{d(OFF)}$ Turn-off delay time-5.09.0Ins $I_D^{-}$ = -500 mA, $R_{GEN}$ = 25Ω $t_f$ Fall time-5.08.0- $V_{SD}$ Diode forward voltage drop1.2-2.0V $V_{GS}$ = 0V, $I_{SD}$ = -500 mA		Rise time	-	4.0	8.0		$V_{DD} = -25V,$
$t_{\rm f}$ Fall time-5.08.0GEN $V_{\rm SD}$ Diode forward voltage drop1.2-2.0V $V_{\rm GS}$ = 0V, $I_{\rm SD}$ = -500mA		Turn-off delay time	-	5.0	9.0	ns	$R_{D} = -500 \text{ mA},$ R = 25Ω
		Fall time	-	5.0	8.0		GEN
	V <sub>SD</sub>	Diode forward voltage drop	-	-1.2	-2.0	V	V <sub>GS</sub> = 0V, I <sub>SD</sub> = -500mA
$I_{\rm m}$ reverse recovery time - 400 - 115 $V_{\rm GS}$ - 00, $I_{\rm SD}$ - 50011A	t <sub>rr</sub>	Reverse recovery time	-	400	-	ns	V <sub>GS</sub> = 0V, I <sub>SD</sub> = -500mA

Notes:

1. All D.C. parameters 100% tested at 25°C unless otherwise stated. (Pulse test: 300µs pulse, 2% duty cycle.)

2. All A.C. parameters sample tested.

# **Switching Waveforms and Test Circuit**



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# **TP2104**

 $V_{GS} = -10V$ 

-8V

-6V

4\

-3\

-10

-8

100

125

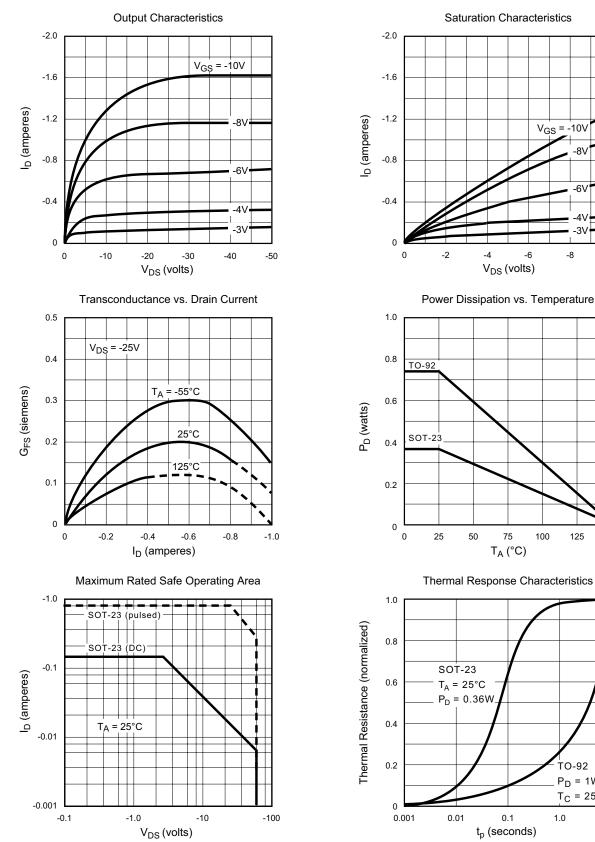
TO-92  $P_D = 1W$ T<sub>C</sub> = 25°C

10

1.0

150

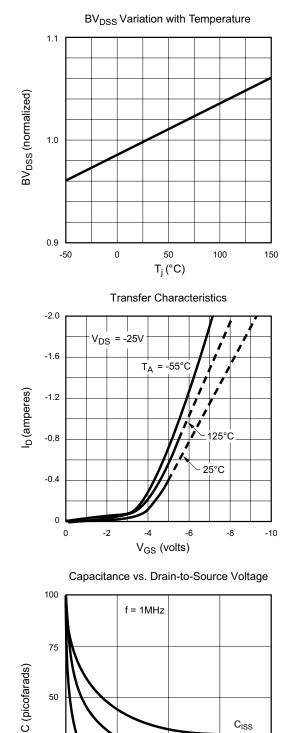
### **Typical Performance Curves**



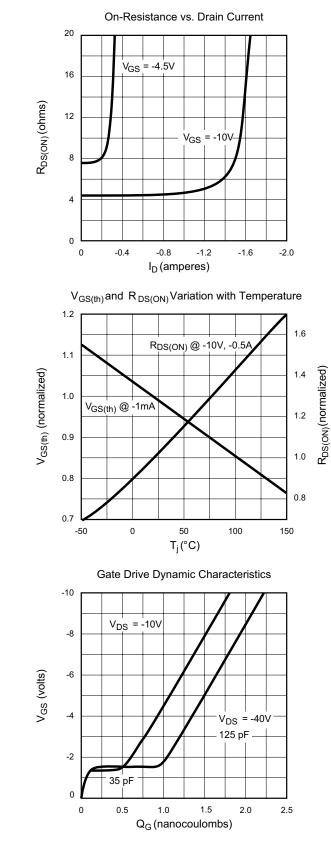
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3

# **TP2104**



# Typical Performance Curves (cont.)



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 $C_{\text{ISS}}$ 

-40

Coss

-30

 $C_{RSS}$ 

-20

V<sub>DS</sub> (volts)

-10

50

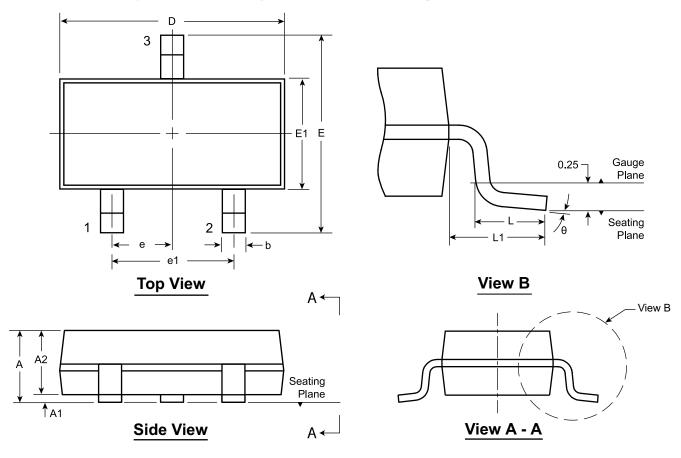
25

0

0

4

# 3-Lead TO-236AB (SOT-23) Package Outline (K1) 2.90x1.30mm body, 1.12mm height (max), 1.90mm pitch



Symb	ol	Α	A1	A2	b	D	E	E1	е	e1	L	L1	θ			
(mm) –	MIN	0.89	0.01	0.88	0.30	2.80	2.10	1.20	0.05	1.90 BSC	5 1.90 C BSC 0.5			0.20†	0.54	<b>0</b> 0
	NOM	-	-	0.95	-	2.90	-	1.30	0.95 BSC			0.50	0.54 REF	-		
	MAX	1.12	0.10	1.02	0.50	3.04	2.64	1.40	000			BSC	0.60		<b>8</b> 0	

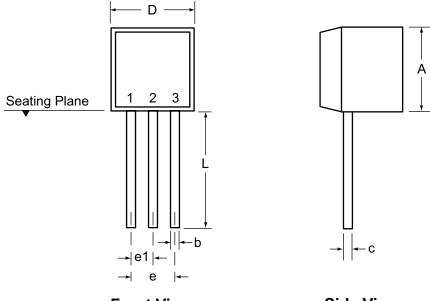
JEDEC Registration TO-236, Variation AB, Issue H, Jan. 1999.

† This dimension is a non-JEDEC dimension.

Drawings not to scale.

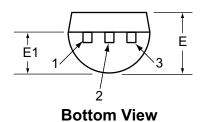
Supertex Doc.#: DSPD-3TO236ABK1, Version B072208.

# 3-Lead TO-92 Package Outline (N3)



Front View

**Side View** 



Symbol		Α	b	С	D	E	E1	е	e1	L
Dimensions (inches)	MIN	.170	.014 <sup>†</sup>	.014†	.175	.125	.080	.095	.045	.500
	NOM	-	-	-	-	-	-	-	-	-
	MAX	.210	.022†	.022†	.205	.165	.105	.105	.055	.610*

JEDEC Registration TO-92.

\* This dimension is not specified in the original JEDEC drawing. The value listed is for reference only.

*†* This dimension is a non-JEDEC dimension.

Drawings not to scale.

Supertex Doc.#: DSPD-3TO92N3, Version D080408.

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