



November 1995

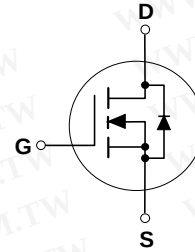
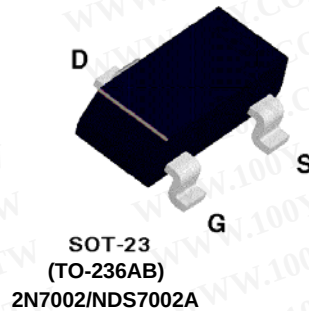
2N7000 / 2N7002 / NDS7002A N-Channel Enhancement Mode Field Effect Transistor

General Description

These N-Channel enhancement mode field effect transistors are produced using Fairchild's proprietary, high cell density, DMOS technology. These products have been designed to minimize on-state resistance while provide rugged, reliable, and fast switching performance. They can be used in most applications requiring up to 400mA DC and can deliver pulsed currents up to 2A. These products are particularly suited for low voltage, low current applications such as small servo motor control, power MOSFET gate drivers, and other switching applications.

Features

- High density cell design for low $R_{DS(ON)}$.
- Voltage controlled small signal switch.
- Rugged and reliable.
- High saturation current capability.



Absolute Maximum Ratings $T_A = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	2N7000	2N7002	NDS7002A	Units
V _{DSS}	Drain-Source Voltage	60			V
V _{DGR}	Drain-Gate Voltage (R _{GS} ≤ 1 MΩ)	60			V
V _{GSS}	Gate-Source Voltage - Continuous	±20			V
	- Non Repetitive (tp < 50μs)	±40			
I _D	Maximum Drain Current - Continuous	200	115	280	mA
	- Pulsed	500	800	1500	
P _D	Maximum Power Dissipation	400	200	300	mW
	Derated above 25°C	3.2	1.6	2.4	mW/°C
T _J ,T _{STG}	Operating and Storage Temperature Range	-55 to 150			°C
T _L	Maximum Lead Temperature for Soldering Purposes, 1/16" from Case for 10 Seconds	300			°C

THERMAL CHARACTERISTICS

$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient	312.5	625	417	$^\circ\text{C/W}$
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Electrical Characteristics $T_A = 25^{\circ}\text{C}$ unless otherwise noted

Symbol	Parameter	Conditions	Type	Min	Typ	Max	Units
OFF CHARACTERISTICS							
BV _{DSS}	Drain-Source Breakdown Voltage	V _{GS} = 0 V, I _D = 10 μA	All	60			V
I _{DSS}	Zero Gate Voltage Drain Current	V _{DS} = 48 V, V _{GS} = 0 V	2N7000			1	μA
		T _J =125°C				1	mA
		V _{DS} = 60 V, V _{GS} = 0 V	2N7002			1	μA
		T _J =125°C	NDS7002A			0.5	mA
I _{GSSF}	Gate - Body Leakage, Forward	V _{GS} = 15 V, V _{DS} = 0 V	2N7000			10	nA
		V _{GS} = 20 V, V _{DS} = 0 V	2N7002 NDS7002A			100	nA
I _{GSSR}	Gate - Body Leakage, Reverse	V _{GS} = -15 V, V _{DS} = 0 V	2N7000			-10	nA
		V _{GS} = -20 V, V _{DS} = 0 V	2N7002 NDS7002A			-100	nA
ON CHARACTERISTICS (Note 1)							
V _{GS(th)}	Gate Threshold Voltage	V _{DS} = V _{GS} , I _D = 1 mA	2N7000	0.8	2.1	3	V
		V _{DS} = V _{GS} , I _D = 250 μA	2N7002 NDS7002A	1	2.1	2.5	
R _{DS(on)}	Static Drain-Source On-Resistance	V _{GS} = 10 V, I _D = 500 mA	2N7000		1.2	5	Ω
		T _J =125°C			1.9	9	
		V _{GS} = 4.5 V, I _D = 75 mA			1.8	5.3	
		V _{GS} = 10 V, I _D = 500 mA	2N7002		1.2	7.5	
		T _J =100°C			1.7	13.5	
		V _{GS} = 5.0 V, I _D = 50 mA			1.7	7.5	
		T _J =100C			2.4	13.5	
		V _{GS} = 10 V, I _D = 500 mA	NDS7002A		1.2	2	
		T _J =125°C			2	3.5	
V _{DS(on)}	Drain-Source On-Voltage	V _{GS} = 10 V, I _D = 500 mA	2N7000		0.6	2.5	V
		V _{GS} = 4.5 V, I _D = 75 mA			0.14	0.4	
		V _{GS} = 10 V, I _D = 500mA	2N7002		0.6	3.75	
		V _{GS} = 5.0 V, I _D = 50 mA			0.09	1.5	
		V _{GS} = 10 V, I _D = 500mA	NDS7002A		0.6	1	
		V _{GS} = 5.0 V, I _D = 50 mA			0.09	0.15	

Electrical Characteristics $T_A = 25^\circ\text{C}$ unless otherwise noted

Symbol	Parameter	Conditions	Type	Min	Typ	Max	Units
ON CHARACTERISTICS Continued (Note 1)							
I _{D(ON)}	On-State Drain Current	V _{GS} = 4.5 V, V _{DS} = 10 V	2N7000	75	600		mA
		V _{GS} = 10 V, V _{DS} ≥ 2 V _{DS(on)}	2N7002	500	2700		
		V _{GS} = 10 V, V _{DS} ≥ 2 V _{DS(on)}	NDS7002A	500	2700		
g _{FS}	Forward Transconductance	V _{DS} = 10 V, I _D = 200 mA	2N7000	100	320		mS
		V _{DS} ≥ 2 V _{DS(on)} , I _D = 200 mA	2N7002	80	320		
		V _{DS} ≥ 2 V _{DS(on)} , I _D = 200 mA	NDS7002A	80	320		
DYNAMIC CHARACTERISTICS							
C _{iss}	Input Capacitance	V _{DS} = 25 V, V _{GS} = 0 V, f = 1.0 MHz	All		20	50	pF
C _{oss}	Output Capacitance		All		11	25	pF
C _{rss}	Reverse Transfer Capacitance		All		4	5	pF
t _{on}	Turn-On Time	V _{DD} = 15 V, R _L = 25 Ω, I _D = 500 mA, V _{GS} = 10 V, R _{GEN} = 25	2N7000			10	ns
		V _{DD} = 30 V, R _L = 150 Ω, I _D = 200 mA, V _{GS} = 10 V, R _{GEN} = 25 Ω	2N700 NDS7002A			20	
t _{off}	Turn-Off Time	V _{DD} = 15 V, R _L = 25 Ω, I _D = 500 mA, V _{GS} = 10 V, R _{GEN} = 25	2N7000			10	ns
		V _{DD} = 30 V, R _L = 150 Ω, I _D = 200 mA, V _{GS} = 10 V, R _{GEN} = 25 Ω	2N700 NDS7002A			20	
DRAIN-SOURCE DIODE CHARACTERISTICS AND MAXIMUM RATINGS							
I _S	Maximum Continuous Drain-Source Diode Forward Current		2N7002			115	mA
			NDS7002A			280	
I _{SM}	Maximum Pulsed Drain-Source Diode Forward Current		2N7002			0.8	A
			NDS7002A			1.5	
V _{SD}	Drain-Source Diode Forward Voltage	V _{GS} = 0 V, I _S = 115 mA (Note 1)	2N7002		0.88	1.5	V
		V _{GS} = 0 V, I _S = 400 mA (Note 1)	NDS7002A		0.88	1.2	

Note:
 1. Pulse Test: Pulse Width $\leq 300\ \mu\text{s}$, Duty Cycle $\leq 2.0\%$.

Typical Electrical Characteristics

2N7000 / 2N7002 / NDS7002A

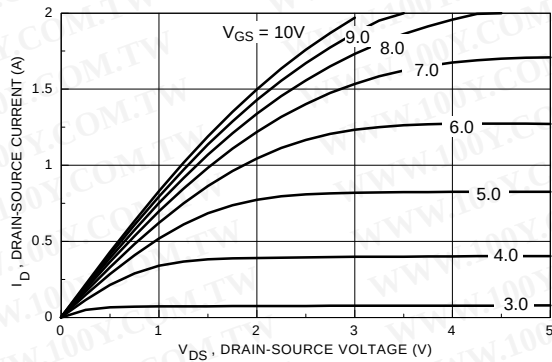


Figure 1. On-Region Characteristics

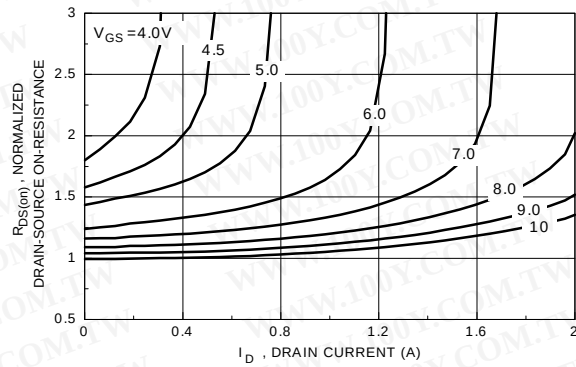


Figure 2. On-Resistance Variation with Gate Voltage and Drain Current

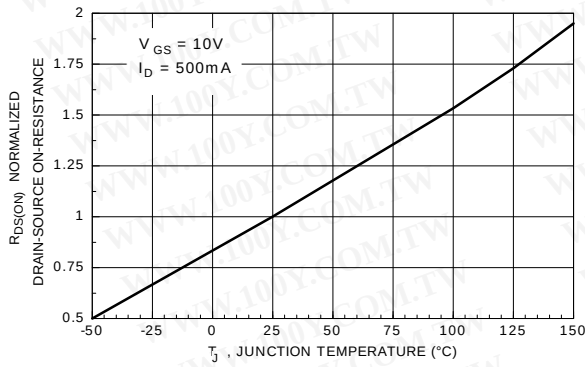


Figure 3. On-Resistance Variation with Temperature

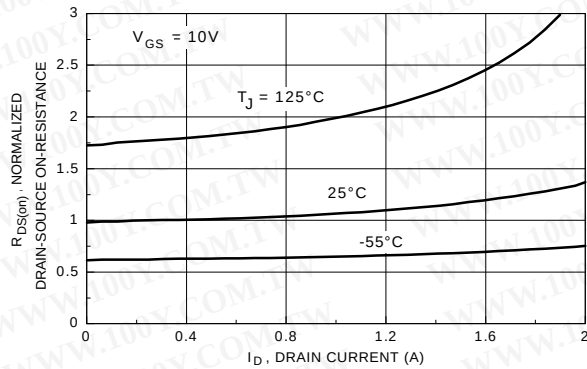


Figure 4. On-Resistance Variation with Drain Current and Temperature

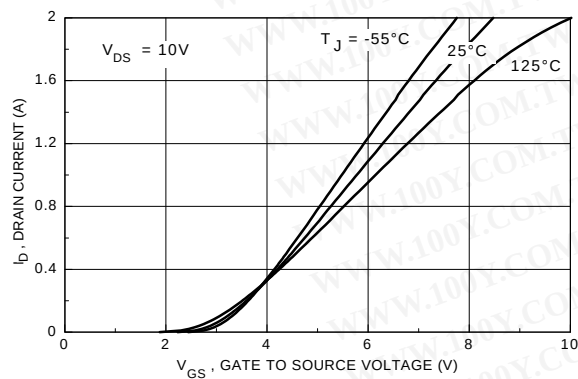


Figure 5. Transfer Characteristics

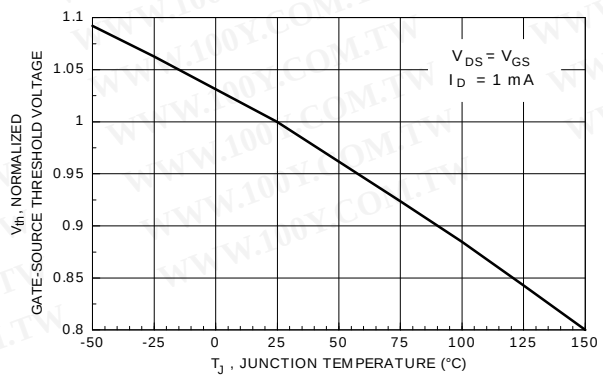


Figure 6. Gate Threshold Variation with Temperature

Typical Electrical Characteristics (continued)

2N7000 / 2N7002 / NDS7002A

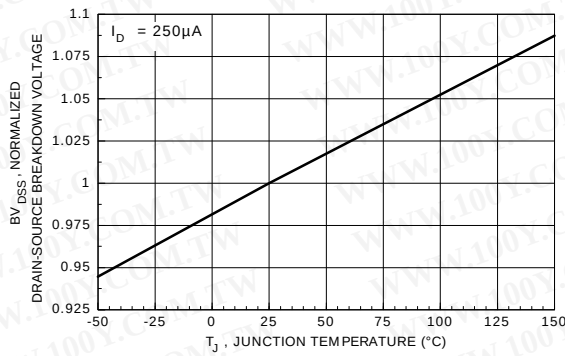


Figure 7. Breakdown Voltage Variation with Temperature

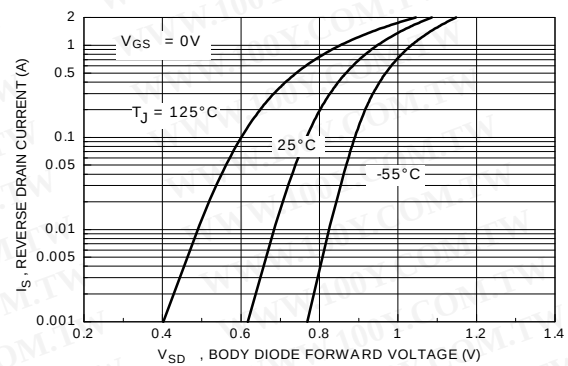


Figure 8. Body Diode Forward Voltage Variation with Temperature

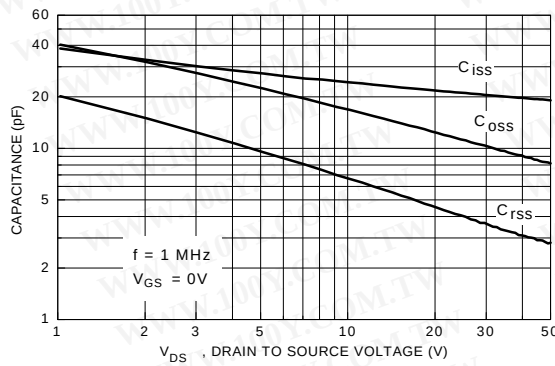


Figure 9. Capacitance Characteristics

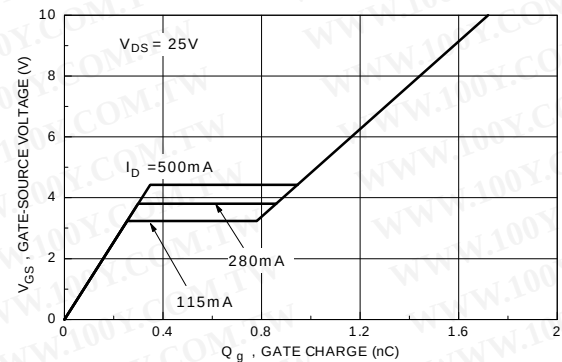


Figure 10. Gate Charge Characteristics

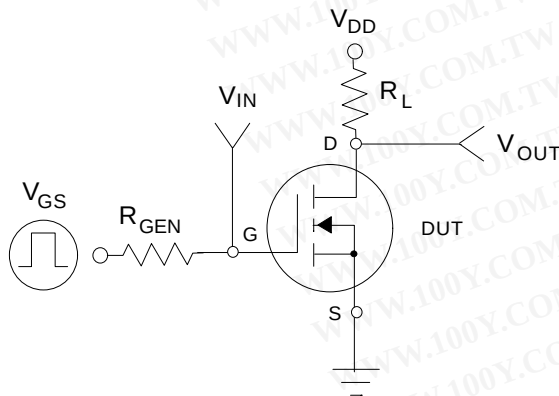


Figure 11.

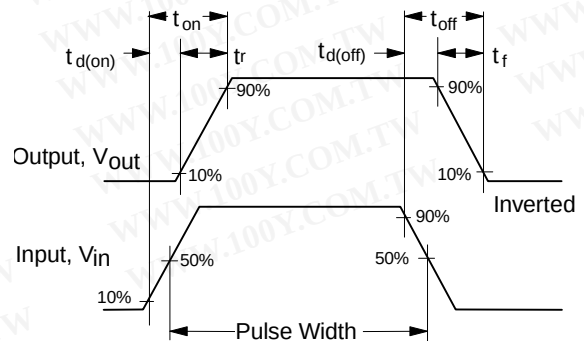


Figure 12. Switching Waveforms

Typical Electrical Characteristics (continued)

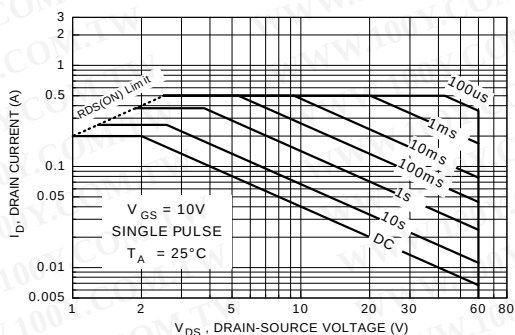


Figure 13. 2N7000 Maximum Safe Operating Area

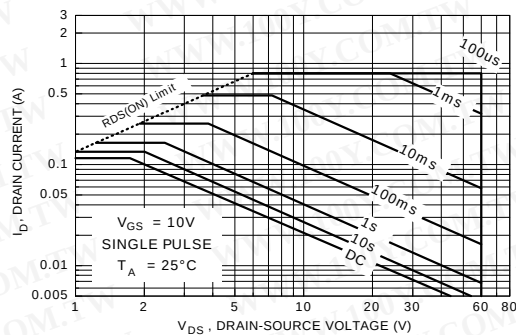


Figure 14. 2N7002 Maximum Safe Operating Area

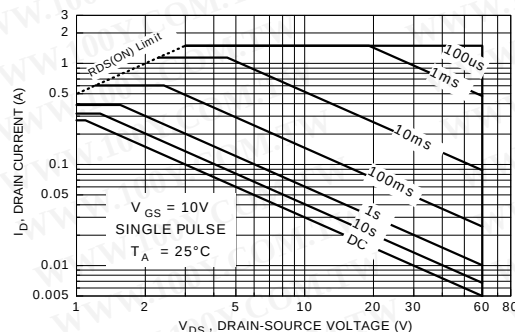


Figure 15. NDS7000A Maximum Safe Operating Area

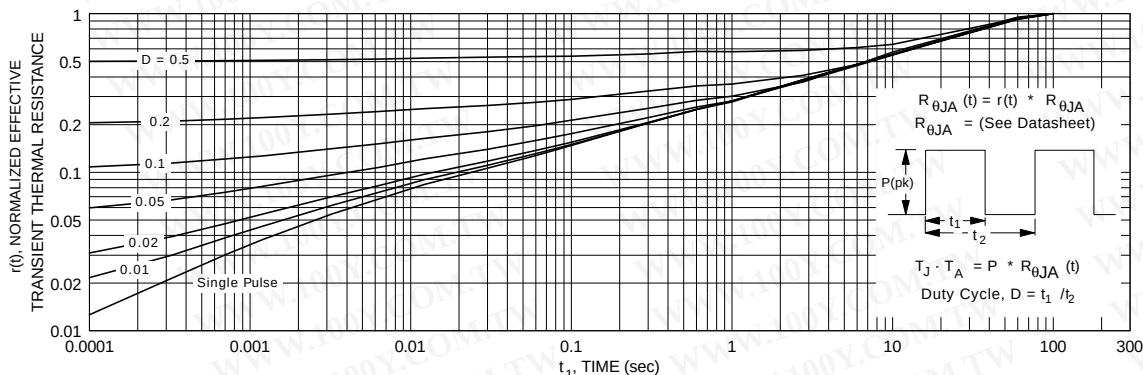


Figure 16. TO-92, 2N7000 Transient Thermal Response Curve

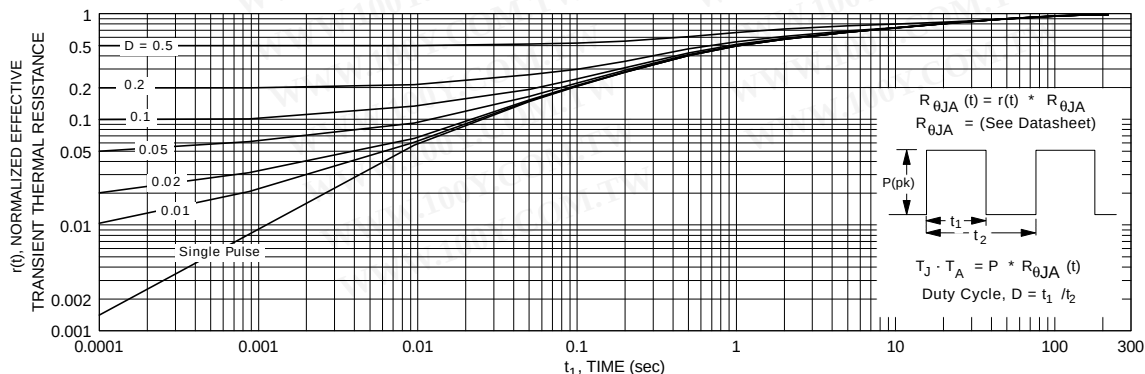


Figure 17. SOT-23, 2N7002 / NDS7002A Transient Thermal Response Curve

TO-92 Tape and Reel Data



TO-92 Packaging Configuration: Figure 1.0

FSCINT Label sample



F63TNR Label sample



TO-92 TNR/AMMO PACKING INFORMATION

Packing	Style	Quantity	EOL code
Reel	A	2,000	D26Z
	E	2,000	D27Z
Ammo	M	2,000	D74Z
	P	2,000	D75Z

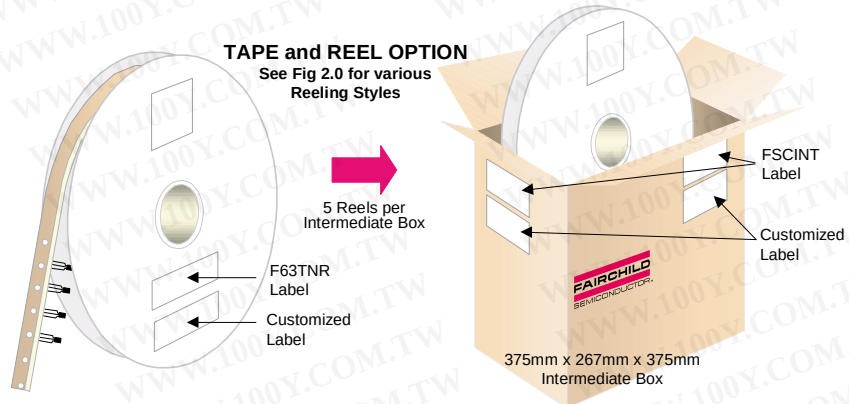
Unit weight = 0.22 gm
 Reel weight with components = 1.04 kg
 Ammo weight with components = 1.02 kg
 Max quantity per intermediate box = 10,000 units

(TO-92) BULK PACKING INFORMATION

EOL CODE	DESCRIPTION	LEADCLIP DIMENSION	QUANTITY
J18Z	TO-18 OPTION STD	NO LEAD CLIP	2.0 K / BOX
J05Z	TO-5 OPTION STD	NO LEAD CLIP	1.5 K / BOX
NO EOL CODE	TO-92 STANDARD STRAIGHT FOR: PKG 92, 94 (NON PROELECTRON SERIES), 96	NO LEADCLIP	2.0 K / BOX
L34Z	TO-92 STANDARD STRAIGHT FOR: PKG 94 (PROELECTRON SERIES BCXXX, BFXXX, BSRXXX), 97, 98	NO LEADCLIP	2.0 K / BOX

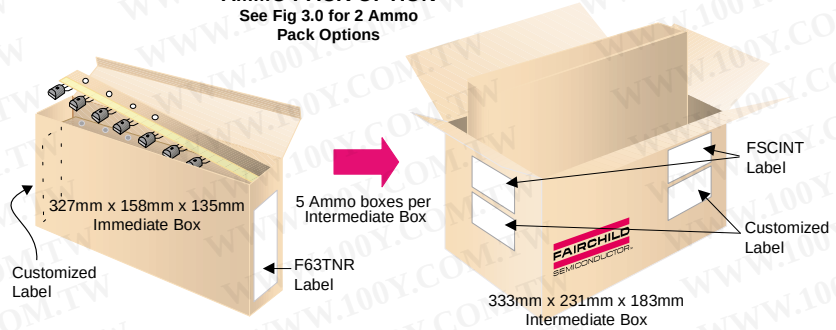
TAPE and REEL OPTION

See Fig 2.0 for various Reeling Styles



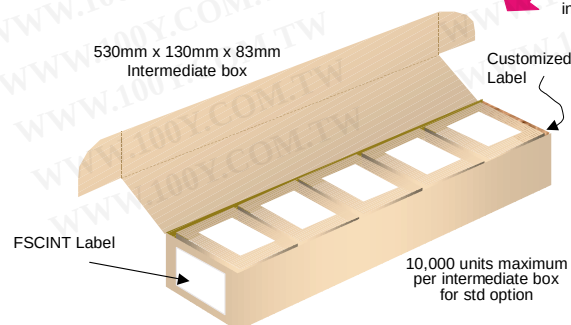
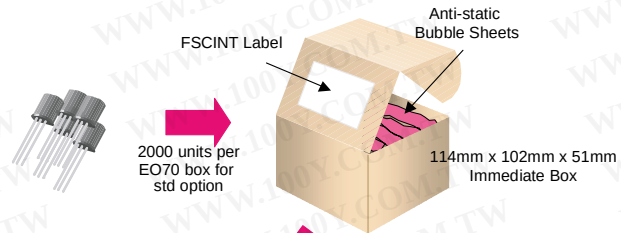
AMMO PACK OPTION

See Fig 3.0 for 2 Ammo Pack Options



BULK OPTION

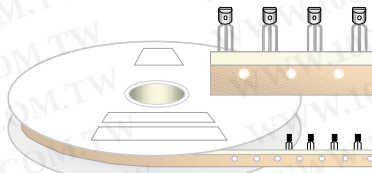
See Bulk Packing Information table



TO-92 Tape and Reel Data, continued

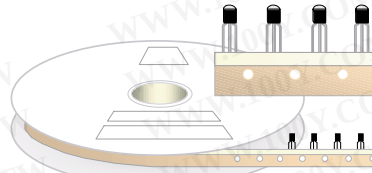
TO-92 Reeling Style Configuration: Figure 2.0

Machine Option "A" (H)



Style "A", D26Z, D70Z (s/h)

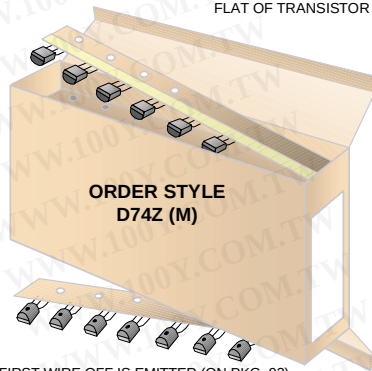
Machine Option "E" (J)



Style "E", D27Z, D71Z (s/h)

TO-92 Radial Ammo Packaging Configuration: Figure 3.0

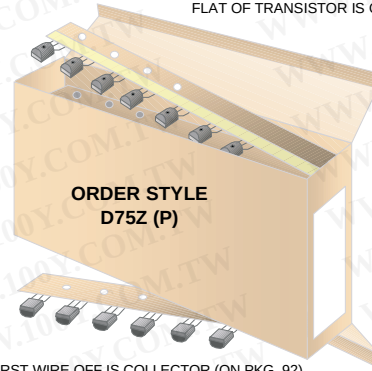
FIRST WIRE OFF IS COLLECTOR
 ADHESIVE TAPE IS ON THE TOP SIDE
 FLAT OF TRANSISTOR IS ON TOP



ORDER STYLE
 D74Z (M)

FIRST WIRE OFF IS EMITTER (ON PKG. 92)
 ADHESIVE TAPE IS ON BOTTOM SIDE
 FLAT OF TRANSISTOR IS ON BOTTOM

FIRST WIRE OFF IS EMITTER
 ADHESIVE TAPE IS ON THE TOP SIDE
 FLAT OF TRANSISTOR IS ON BOTTOM



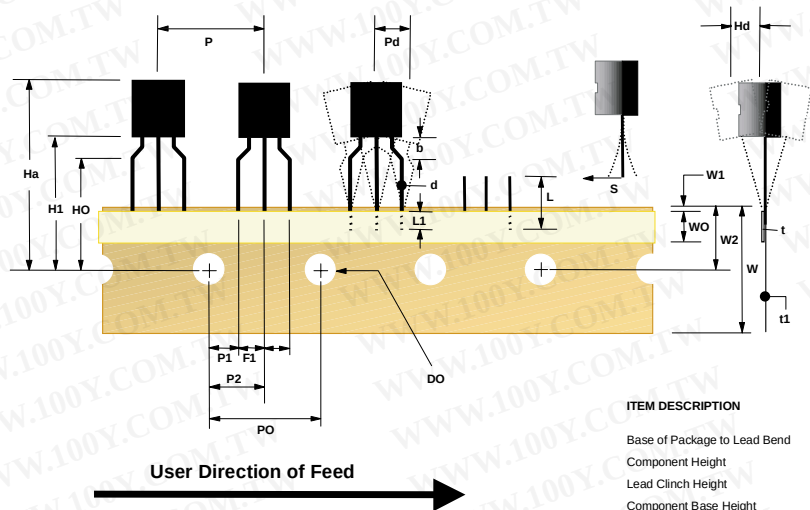
ORDER STYLE
 D75Z (P)

FIRST WIRE OFF IS COLLECTOR (ON PKG. 92)
 ADHESIVE TAPE IS ON BOTTOM SIDE
 FLAT OF TRANSISTOR IS ON TOP

TO-92 Tape and Reel Data, continued

TO-92 Tape and Reel Taping

Dimension Configuration: Figure 4.0

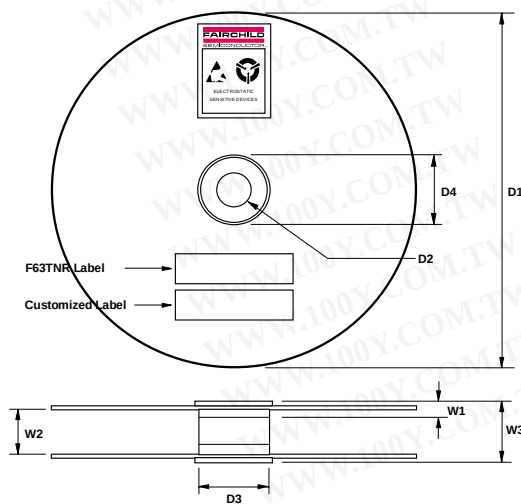


ITEM DESCRIPTION	SYMBOL	DIMENSION
Base of Package to Lead Bend	b	0.098 (max)
Component Height	Ha	0.928 (+/- 0.025)
Lead Clinch Height	HO	0.630 (+/- 0.020)
Component Base Height	H1	0.748 (+/- 0.020)
Component Alignment (side/side)	Pd	0.040 (max)
Component Alignment (front/back)	Hd	0.031 (max)
Component Pitch	P	0.500 (+/- 0.020)
Feed Hole Pitch	PO	0.500 (+/- 0.008)
Hole Center to First Lead	P1	0.150 (+0.009, -0.010)
Hole Center to Component Center	P2	0.247 (+/- 0.007)
Lead Spread	F1/F2	0.104 (+/- 0.010)
Lead Thickness	d	0.018 (+0.002, -0.003)
Cut Lead Length	L	0.429 (max)
Taped Lead Length	L1	0.209 (+0.051, -0.052)
Taped Lead Thickness	t	0.032 (+/- 0.006)
Carrier Tape Thickness	t1	0.021 (+/- 0.006)
Carrier Tape Width	W	0.708 (+0.020, -0.019)
Hold - down Tape Width	WO	0.236 (+/- 0.012)
Hold - down Tape position	W1	0.035 (max)
Feed Hole Position	W2	0.360 (+/- 0.025)
Sprocket Hole Diameter	DO	0.157 (+0.008, -0.007)
Lead Spring Out	S	0.004 (max)

Note : All dimensions are in inches.

TO-92 Reel

Configuration: Figure 5.0



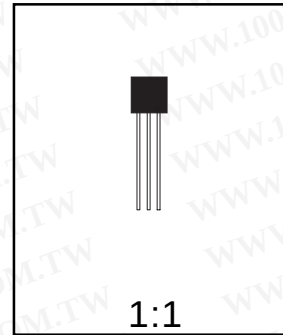
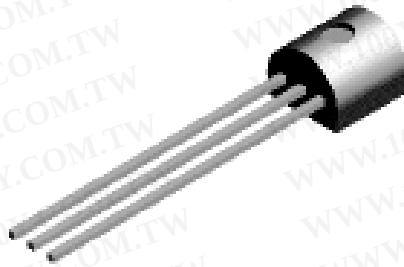
ITEM DESCRIPTION	SYMBOL	MINIMUM	MAXIMUM
Reel Diameter	D1	13.975	14.025
Arbor Hole Diameter (Standard)	D2	1.160	1.200
(Small Hole)	D2	0.650	0.700
Core Diameter	D3	3.100	3.300
Hub Recess Inner Diameter	D4	2.700	3.100
Hub Recess Depth	W1	0.370	0.570
Flange to Flange Inner Width	W2	1.630	1.690
Hub to Hub Center Width	W3		2.090

Note: All dimensions are in inches

TO-92 Package Dimensions



TO-92 (FS PKG Code 92, 94, 96)



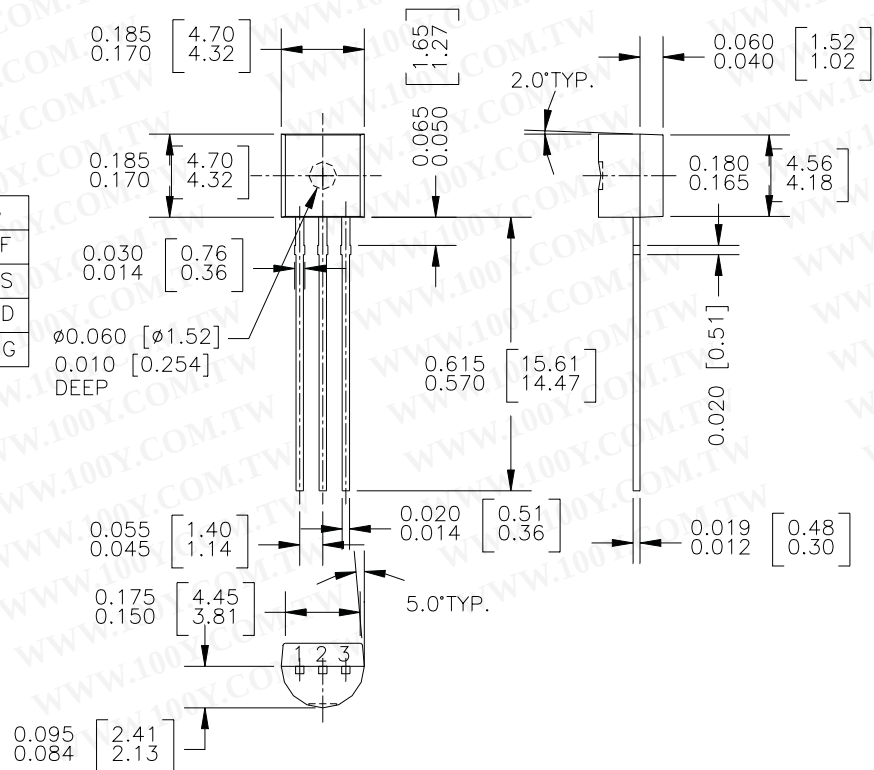
Scale 1:1 on letter size paper

Dimensions shown below are in:
 inches [millimeters]

Part Weight per unit (gram): 0.1977

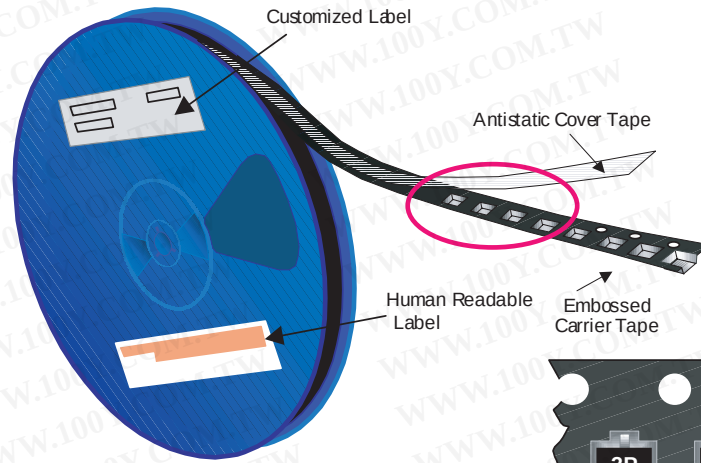
TO-92 (92,94,96)

PIN	92		94		96	
	B	F	B	F	B	F
1	E	D	E	D	B	S
2	B	S	C	G	E	D
3	C	G	B	S	C	G



SOT-23 Tape and Reel Data

SOT-23 Packaging Configuration: Figure 10



Packaging Description:

SOT-23 parts are shipped in tape. The carrier tape is made from a dissipative (carbon filled) polycarbonate resin. The cover tape is a multilayer film (Heat Activated Adhesive in nature) primarily composed of polyester film, adhesive layer, sealant, and anti-static sprayed agent. These reeled parts in standard option are shipped with 3,000 units per 7" or 177mm diameter reel. The reels are dark blue in color and is made of polystyrene plastic (anti-static coated). Other option comes in 10000 units per 13" or 330mm diameter reel. This and some other options are described in the Packaging Information table.

These full reels are individually labeled and placed inside a standard intermediate made of recyclable corrugated brown paper with a Fairchild logo printing. One pizza box contains eight reels maximum. And these intermediate boxes are placed inside a labeled shipping box which comes in different sizes depending on the number of parts shipped.

SOT-23 Packaging Information		
Packaging Option	Standard (no flow code)	D87Z
Packaging type	TNR	TNR
Qty per Reel/Tube/Bag	3,000	10,000
Reel Size	7" Dia	13"
Box Dimension (mm)	187x107x183	343x343x64
Max qty per Box	24,000	30,000
Weight per unit (gm)	0.0082	0.0082
Weight per Reel (kg)	0.1175	0.4006
Note/Comments		

SOT-23 Unit Orientation

343mm x 342mm x 64mm
Intermediate box for L87Z Option

Human Readable Label

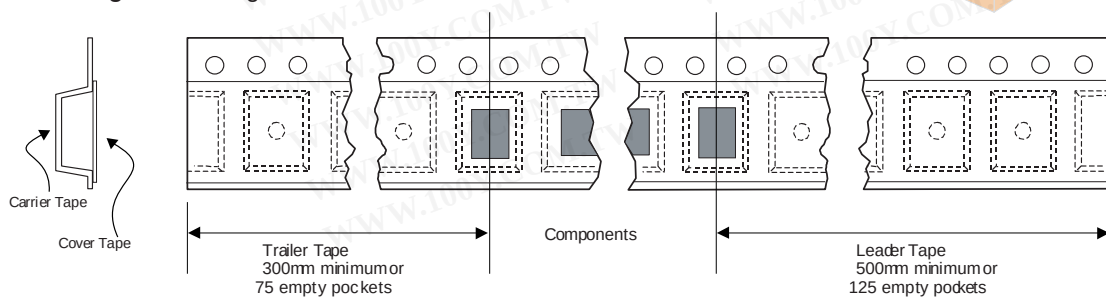
Human Readable Label sample



Human readable Label

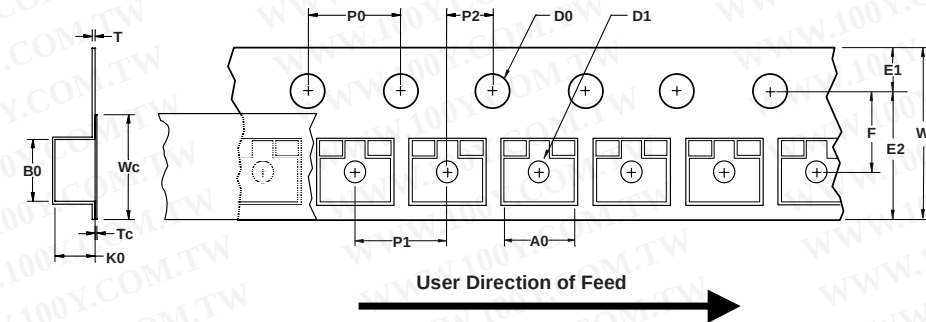
187mm x 107mm x 183mm
Intermediate Box for Standard Option

SOT-23 Tape Leader and Trailer Configuration: Figure 20



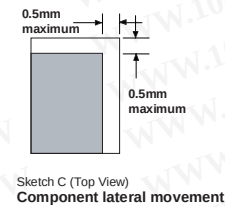
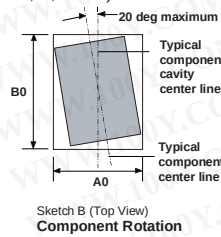
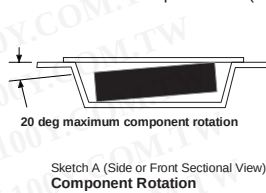
SOT-23 Tape and Reel Data, continued

SOT-23 Embossed Carrier Tape Configuration: Figure 3.0

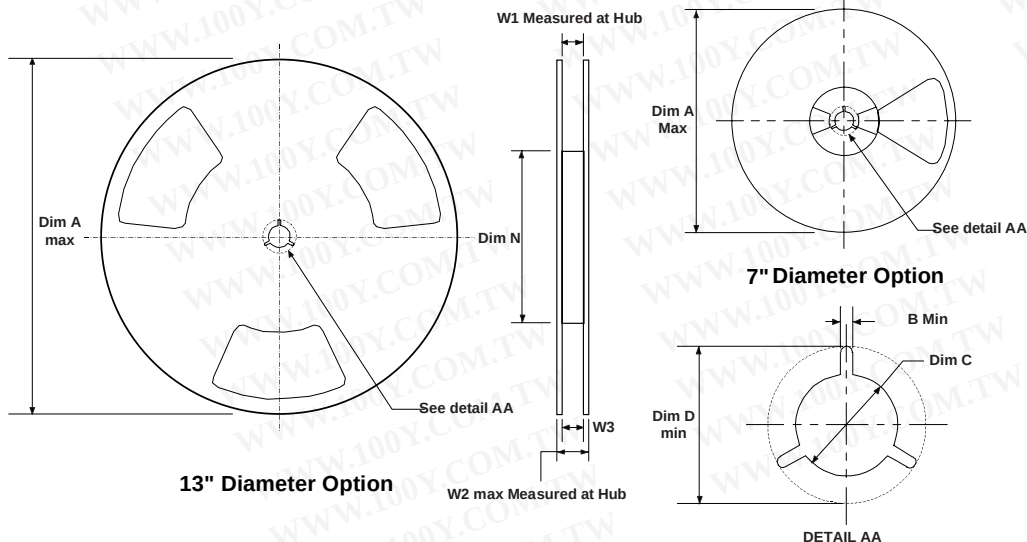


Dimensions are in millimeter														
Pkg type	A0	B0	W	D0	D1	E1	E2	F	P1	P0	K0	T	Wc	Tc
SOT-23 (8mm)	3.15 +/-0.10	2.77 +/-0.10	8.0 +/-0.3	1.55 +/-0.05	1.125 +/-0.125	1.75 +/-0.10	6.25 min	3.50 +/-0.05	4.0 +/-0.1	4.0 +/-0.1	1.30 +/-0.10	0.228 +/-0.013	5.2 +/-0.3	0.06 +/-0.02

Notes: A0, B0, and K0 dimensions are determined with respect to the EIA/Jedec RS-481 rotational and lateral movement requirements (see sketches A, B, and C).



SOT-23 Reel Configuration: Figure 4.0

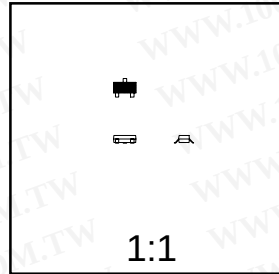
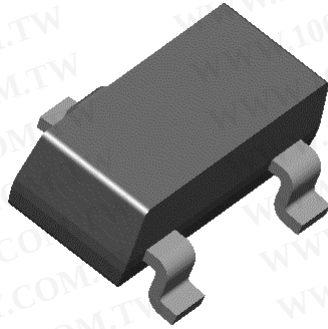


Dimensions are in inches and millimeters									
Tape Size	Reel Option	Dim A	Dim B	Dim C	Dim D	Dim N	Dim W1	Dim W2	Dim W3 (LSL-USL)
8mm	7" Dia	7.00 177.8	0.059 1.5	512 +0.020/-0.008 13 +0.5/-0.2	0.795 20.2	2.165 55	0.331 +0.059/-0.000 8.4 +1.5/0	0.567 14.4	0.311 - 0.429 7.9 - 10.9
8mm	13" Dia	13.00 330	0.059 1.5	512 +0.020/-0.008 13 +0.5/-0.2	0.795 20.2	4.00 100	0.331 +0.059/-0.000 8.4 +1.5/0	0.567 14.4	0.311 - 0.429 7.9 - 10.9

SOT-23 Package Dimensions



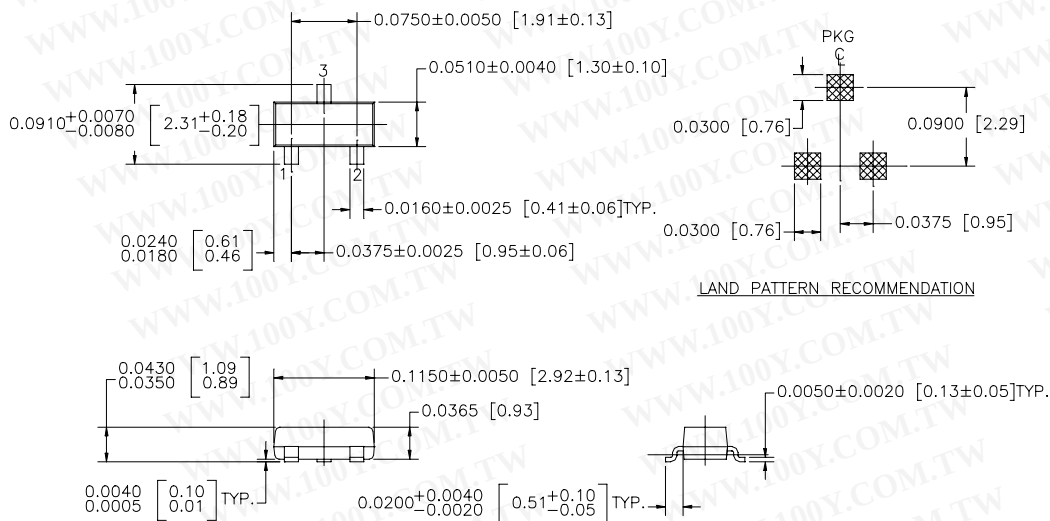
SOT-23 (FS PKG Code 49)



Scale 1:1 on letter size paper

Dimensions shown below are in:
 inches [millimeters]

Part Weight per unit (gram): 0.0082



LAND PATTERN RECOMMENDATION

CONTROLLING DIMENSION IS INCH
 VALUES IN [] ARE MILLIMETERS

SOT 23, 3 LEADS LOW PROFILE

NOTE : UNLESS OTHERWISE SPECIFIED

1. STANDARD LEAD FINISH 150 MICROINCHES / 3.81 MICROMETERS
 MINIMUM TIN / LEAD (SOLDER) ON ALLOY 42
2. REFERENCE JEDEC REGISTRATION TO-236, VARIATION AB, ISSUE G, DATED JUL 1993

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CROSSVOLT™	HiSeC™	QT Optoelectronics™	VCX™
DOVE™	ISOPPLANAR™	Quiet Series™	
E ² CMOS™	MICROWIRE™	SILENT SWITCHER®	
EnSigna™	OPTOLOGIC™	SMART START™	
FACT™	OPTOPLANAR™	SuperSOT™-3	
FACT Quiet Series™	PACMAN™	SuperSOT™-6	
FAST®	POP™	SuperSOT™-8	

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