TN2130

N-Channel Enhancement-Mode Vertical DMOS FET

Features

- Free from Secondary Breakdown
- Low Power Drive Requirement
- Ease of Paralleling
- Low C_{ISS} and Fast Switching Speeds
- Excellent Thermal Stability
- Integral Source-Drain Diode
- High Input Impedance and High Gain

Applications

- Logic-Level Interfaces (Ideal for TTL and CMOS)
- Solid-State Relays
- Battery-Operated Systems
- Photovoltaic Drives
- Analog Switches
- General Purpose Line Drivers
- Telecommunication Switches

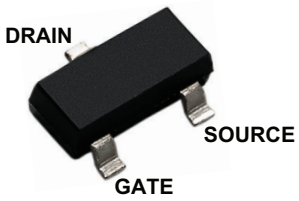
General Description

The TN2130 low-threshold, Enhancement-mode (normally-off) transistor uses a vertical DMOS structure and a well-proven silicon-gate manufacturing process. This combination produces a device with the power handling capabilities of bipolar transistors and 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 thermally induced secondary breakdown.

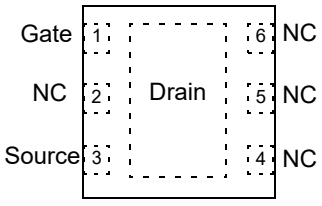
Microchip's vertical DMOS FETs are ideally suited to a wide range of switching and amplifying applications where very low threshold voltage, high breakdown voltage, high input impedance, low input capacitance, and fast switching speeds are desired.

Package Type

3-lead SOT-23
(Top view)



6-lead DFN
(Top view)



See Table 3-1 for pin information.

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings(†)

Drain-to-Source Voltage ..... BV_{DSS}
Drain-to-Gate Voltage ..... BV_{DGS}
Gate-to-Source Voltage ..... ±20V
Operating Ambient Temperature, T_A ..... -55°C to +150°C
Storage Temperature, T_S ..... -55°C to +150°C
ESD Protection (HBM) TN2130MF-G
- Drain-to-Source ..... ±8 kV
- Gate-to-Drain ..... -500V
- Gate-to-Source ..... <±250V

ESD Protection (CDM) TN2130MF-G ..... ±1 kV

† **Notice:** Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

DC ELECTRICAL CHARACTERISTICS – COMMERCIAL

Electrical Specifications: $T_A = T_J = 25°C$ unless otherwise specified. All DC parameters are 100% tested at 25°C unless otherwise stated. (Pulse test: 300 µs pulse, 2% duty cycle)

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Drain-to-Source Breakdown Voltage	BV_{DSS}	300	—	—	V	V_{GS} = 0V, I_D = 1 mA
Gate Threshold Voltage	$V_{GS(th)}$	0.8	—	2.4	V	$V_{GS} = V_{DS}$, I_D = 1 mA
Change in $V_{GS(th)}$ with Temperature	$\Delta V_{GS(th)}$	—	—	-5.5	mV/°C	$V_{GS} = V_{DS}$, I_D = 1 mA (**Note 1**)
Gate Body Leakage Current	I_{GSS}	—	—	100	nA	V_{GS} = ± 20V, V_{DS} = 0V
Zero-Gate Voltage Drain Current	I_{DSS}	—	—	10	µA	V_{GS} = 0V, V_{DS} = Maximum rating
		—	—	100	µA	V_{DS} = 0.8 Maximum rating, V_{GS} = 0V, T_A = 125°C (**Note 1**)
On-State Drain Current	$I_{D(ON)}$	250	—	—	mA	V_{GS} = 10V, V_{DS} = 25V
Static Drain-to-Source On-State Resistance	$R_{DS(ON)}$	—	—	25	Ω	V_{GS} = 4.5V, I_D = 120 mA
Change in $R_{DS(ON)}$ with Temperature	$\Delta R_{DS(ON)}$	—	—	1.1	%/°C	V_{GS} = 4.5V, I_D = 120 mA (**Note 1**)

Note 1: Specification is obtained by characterization and is not 100% tested.

DC ELECTRICAL CHARACTERISTICS – AUTOMOTIVE

Electrical Specifications: Boldface specification limits apply over the full operating temperature range of $T_A = T_J$ = -55°C, 25°C, and 150°C unless otherwise specified. Non-boldfaced specification limits apply only to $T_A = T_J$ = 25°C unless otherwise specified. All DC parameters are 100% tested at all three temperatures unless otherwise specified. (Pulse test: 300 µs pulse, 2% duty cycle.)

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Drain-to-Source Breakdown Voltage	BV_{DSS}	**300**	—	—	V	V_{GS} = 0V, I_D = 1 mA
Gate Threshold Voltage	$V_{GS(th)}$	0.8	—	2.4	V	$V_{GS} = V_{DS}$, I_D = 1 mA
		0.7	—	**2.4**	V	$V_{DS} = V_{GS}$, I_D = 1 mA
Change in $V_{GS(th)}$ with Temperature	$\Delta V_{GS(th)}$	—	-3.6	—	mV/°C	$V_{GS} = V_{DS}$, I_D = 1 mA (**Note 1**)

Note 1: Specification is obtained by characterization and is not 100% tested.

DC ELECTRICAL CHARACTERISTICS – AUTOMOTIVE (CONTINUED)

Electrical Specifications: Boldface specification limits apply over the full operating temperature range of $T_A = T_J$ = -55°C, 25°C, and 150°C unless otherwise specified. Non-boldfaced specification limits apply only to $T_A = T_J$ = 25°C unless otherwise specified. All DC parameters are 100% tested at all three temperatures unless otherwise specified. (Pulse test: 300 µs pulse, 2% duty cycle.)

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Gate Body Leakage Current	I_{GSS}	—	—	100	nA	V_{GS} = ± 20V, V_{DS} = 0V
		—	—	**200**	nA	V_{GS} = ± 20V, V_{DS} = 0V
Zero-Gate Voltage Drain Current	I_{DSS}	—	—	10	µA	V_{GS} = 0V, V_{DS} = Maximum rating
		—	—	**100**	µA	V_{GS} = 0V, V_{DS} = Maximum rating
On-State Drain Current	$I_{D(ON)}$	**250**	—	—	mA	V_{GS} = 10V, V_{DS} = 25V
Static Drain-to-Source On-State Resistance	$R_{DS(ON)}$	—	—	25	Ω	V_{GS} = 4.5V, I_D = 120 mA
		—	—	**66**	Ω	V_{GS} = 4.5V, I_D = 120 mA
Change in $R_{DS(ON)}$ with Temperature	$\Delta R_{DS(ON)}$	—	1.1	—	%/°C	V_{GS} = 4.5V, I_D = 120 mA (**Note 1**)

Note 1: Specification is obtained by characterization and is not 100% tested.

AC ELECTRICAL CHARACTERISTICS – COMMERCIAL

Electrical Specifications: $T_A = T_J$ = 25°C unless otherwise specified. Specification is obtained by characterization and is not 100% tested.

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Forward Transconductance	G_{FS}	—	250	—	mmho	V_{DS} = 25V, I_D = 100 mA
Input Capacitance	C_{ISS}	—	—	50	pF	V_{GS} = 0V, V_{DS} = 25V, f = 1 MHz
Common Source Output Capacitance	C_{OSS}	—	—	15	pF	
Reverse Transfer Capacitance	C_{RSS}	—	—	5	pF	
Turn-On Delay Time	$t_{d(ON)}$	—	—	10	ns	V_{DD} = 25V, I_D = 120 mA, R_{GEN} = 25Ω
Rise Time	t_r	—	—	7	ns	
Turn-Off Delay Time	$t_{d(OFF)}$	—	—	12	ns	
Fall Time	t_f	—	—	15	ns	
DIODE PARAMETER						
Diode Forward Voltage Drop	V_{SD}	—	—	1.8	V	V_{GS} = 0V, I_{SD} = 120 mA (**Note 1**)
Reverse Recovery Time	t_{rr}	—	400	—	ns	V_{GS} = 0V, I_{SD} = 120 mA

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

AC ELECTRICAL CHARACTERISTICS – AUTOMOTIVE

Electrical Specifications: T_A = 25°C unless otherwise specified. All AC parameters are sample tested.

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Forward Transconductance	G_{FS}	—	205	—	mmho	V_{DS} = 25V, I_D = 100 mA
Input Capacitance	C_{ISS}	—	29	—	pF	V_{GS} = 0V, V_{DS} = 25V, f = 1 MHz
Common Source Output Capacitance	C_{OSS}	—	6	—	pF	
Reverse Transfer Capacitance	C_{RSS}	—	1.2	—	pF	

Note 1: 100% Production Tested at $T_A = T_J$ = (-55°C, 25°C, and 150°C).

AC ELECTRICAL CHARACTERISTICS – AUTOMOTIVE (CONTINUED)

Electrical Specifications: T_A = 25°C unless otherwise specified. All AC parameters are sample tested.						
Parameter	**Sym.**	**Min.**	**Typ.**	**Max.**	**Unit**	**Conditions**
Turn-On Delay Time	$t_{d(ON)}$	—	6.8	—	ns	V_{DD} = 25V, I_D = 120 mA, R_{GEN} = 25Ω
Rise Time	t_r	—	3	—	ns	
Turn-Off Delay Time	$t_{d(OFF)}$	—	12	—	ns	
Fall Time	t_f	—	7	—	ns	
DIODE PARAMETER						
Diode Forward Voltage Drop	V_{SD}	—	—	1.8	V	V_{GS} = 0V, I_{SD} = 120 mA (**Note 1**)
Reverse Recovery Time	t_{rr}	—	450	—	ns	V_{GS} = 0V, I_{SD} = 120 mA

Note 1: 100% Production Tested at $T_A = T_J$ = (-55°C, 25°C, and 150°C).

TEMPERATURE SPECIFICATIONS

Parameter	**Sym.**	**Min.**	**Typ.**	**Max.**	**Unit**	**Conditions**
TEMPERATURE RANGE						
Operating Ambient Temperature	T_A	-55	—	+150	°C	
Storage Temperature	T_S	-55	—	+150	°C	
PACKAGE THERMAL RESISTANCE						
3-lead SOT-23	θ_{JA}	—	203	—	°C/W	
6-lead DFN	θ_{JA}	—	102	—	°C/W	

THERMAL CHARACTERISTICS

Package	**I_D (Note 1) (Continuous) (mA)**	**I_D (Pulsed) (mA)**	**Power Dissipation at T_A = 25°C (W)**	**I_{DR} (Note 1) (mA)**	**I_{DRM} (mA)**
3-lead SOT-23	85	200	0.36	85	200

Note 1: I_D (continuous) is limited by maximum rated T_J.

2.0 TYPICAL PERFORMANCE CURVES

The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g. outside specified power supply range) and therefore outside the warranted range.

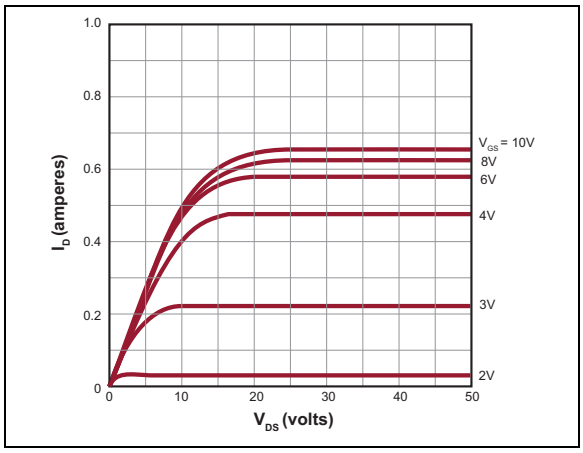


FIGURE 2-1: *Output Characteristics.*

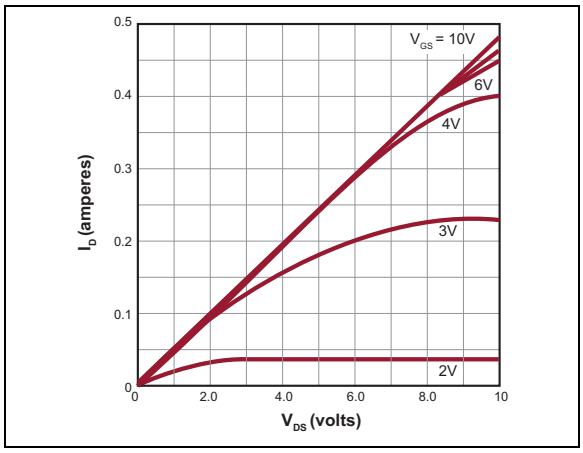


FIGURE 2-4: *Saturation Characteristics.*

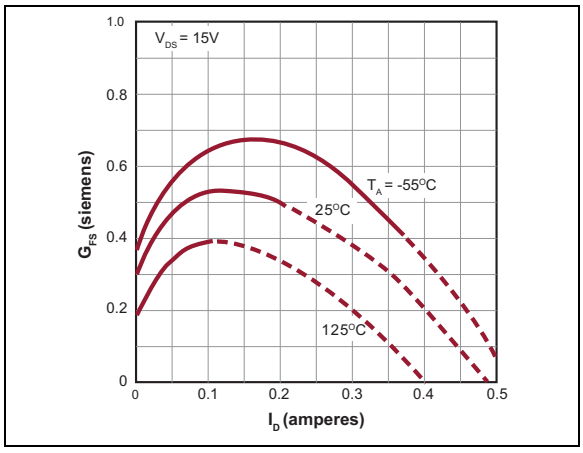


FIGURE 2-2: *Transconductance vs. Drain Current.*

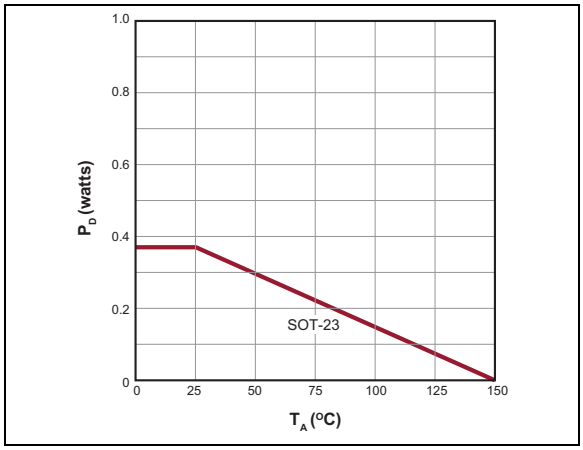


FIGURE 2-5: *Power DIssipation vs. Case Temperature.*

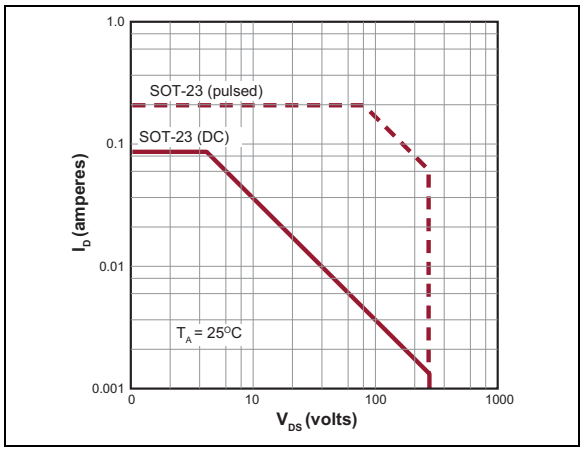


FIGURE 2-3: *Maximum Rated Safe Operating Area.*

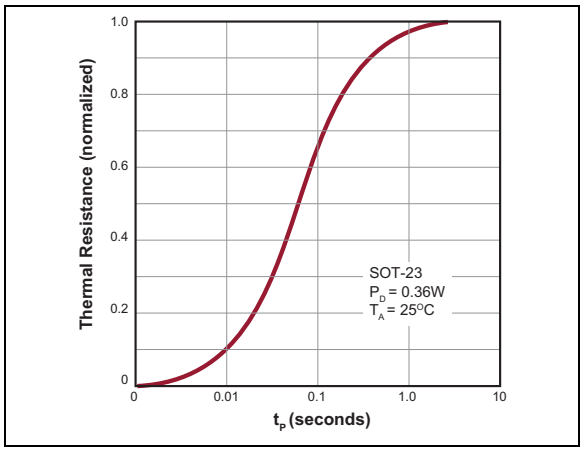


FIGURE 2-6: *Thermal Response Characteristics.*

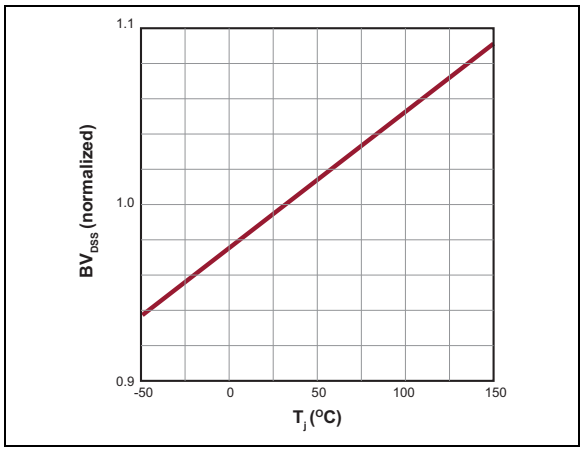


FIGURE 2-7: *BV_{DSS} Variation with Temperature.*

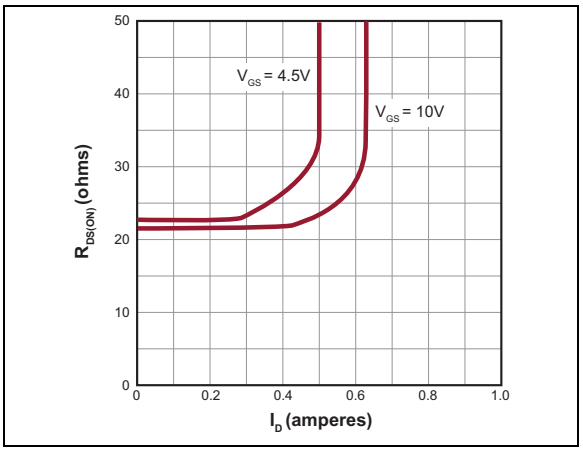


FIGURE 2-10: *On-Resistance vs. Drain Current.*

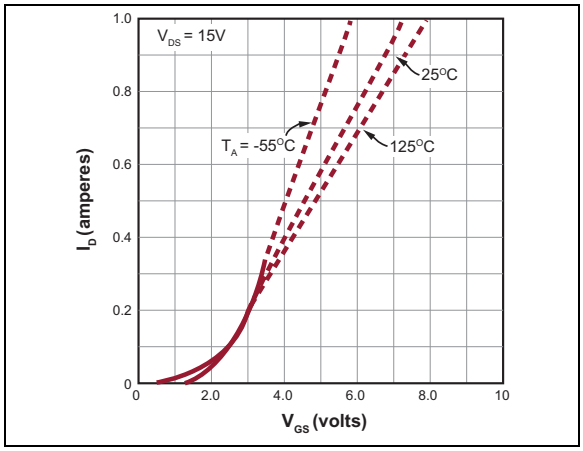


FIGURE 2-8: *Transfer Characteristics.*

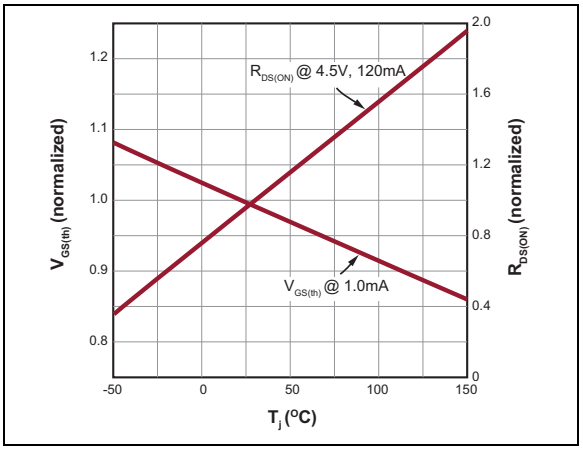


FIGURE 2-11: *$V_{GS(th)}$ and R_{DS} Variation with Temperature.*

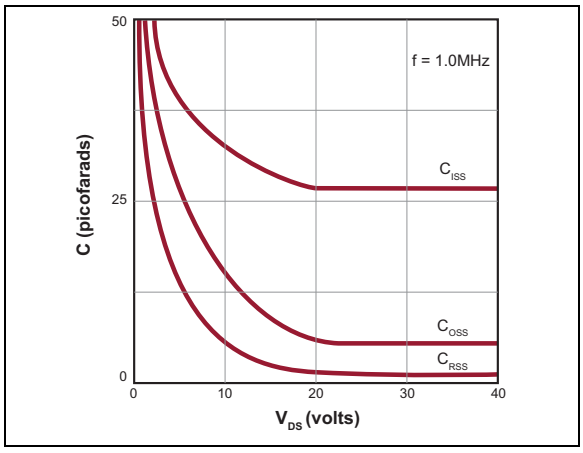


FIGURE 2-9: *Capacitance vs Drain-to-Source Voltage.*

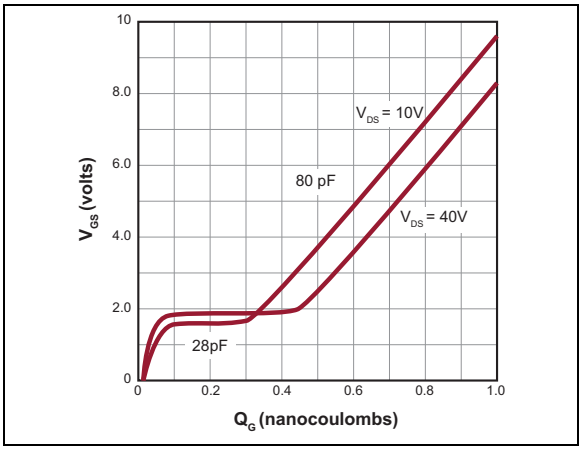


FIGURE 2-12: *Gate Drive Dynamic Characteristics.*

3.0 PIN DESCRIPTION

The details on the pins of TN2130 are listed in Table 3-1. Refer to **Package Type** for the location of pins.

TABLE 3-1: PIN FUNCTION TABLE

Pin Number		Name	Description
SOT-23	DFN		
1	1	Gate	Gate
2	3	Source	Source
3	4,5,6	NC	Not Connected. Recommended to connect to Drain.
—	2	NC	Not Connected.
—	Exposed Pad	Drain	Drain

4.0 FUNCTIONAL DESCRIPTION

Figure 4-1 illustrates the switching waveforms and test circuit for TN2130.

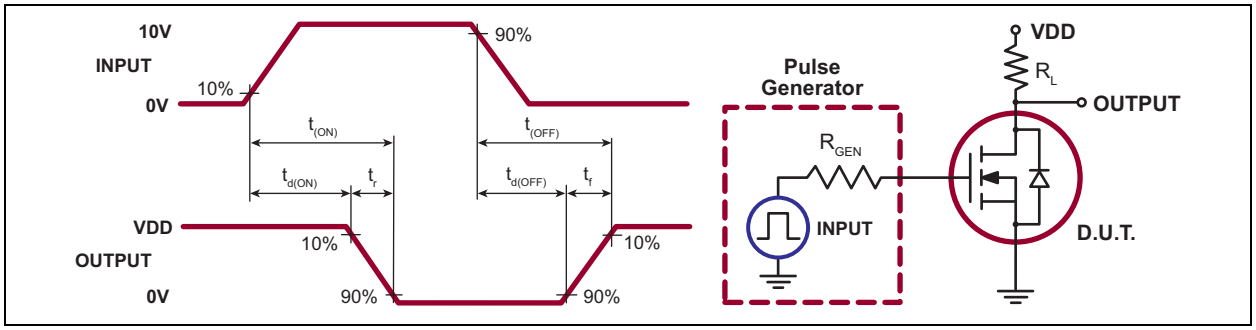


FIGURE 4-1: *Switching Waveforms and Test Circuit.*

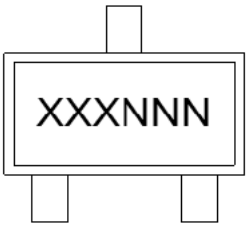
TABLE 4-1: PRODUCT SUMMARY

BV_{DSS}/BV_{DGS} (V)	$R_{DS(ON)}$ (Maximum) (Ω)	$V_{GS(th)}$ (Maximum) (V)
300	25	2.4

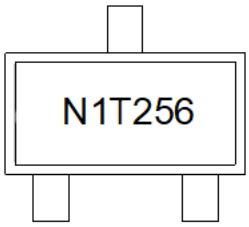
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

3-Lead SOT-23
(2.90 mm X 1.30 mm)

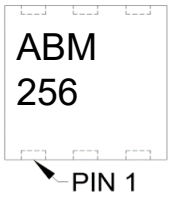


Example



6-Lead DFN
(2.00 mm X 2.00 mm)

Example

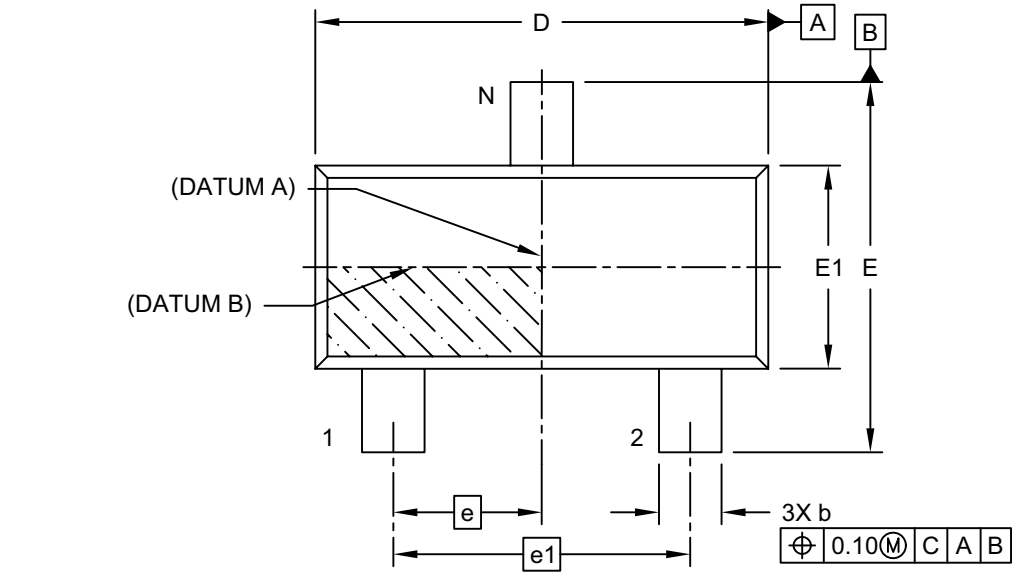


Legend:	XX...X	Product Code or Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

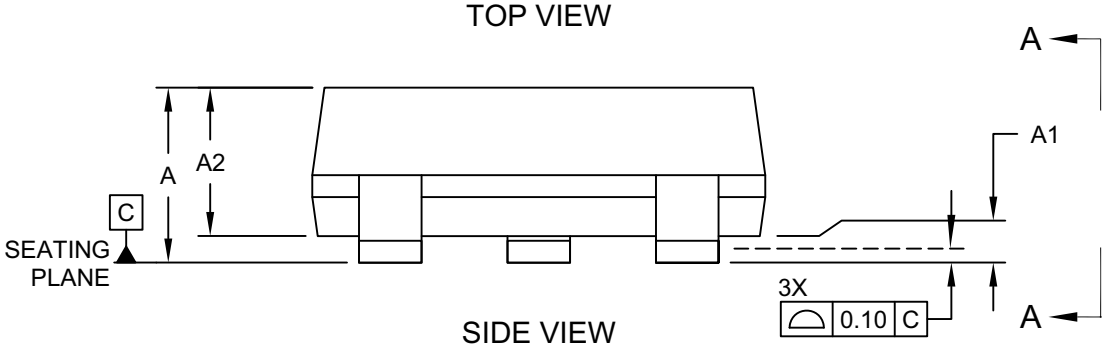
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or not include the corporate logo.

3-Lead Small Outline Transistor (C6X) - [SOT-23]
Supertex Legacy Package (K1/T)

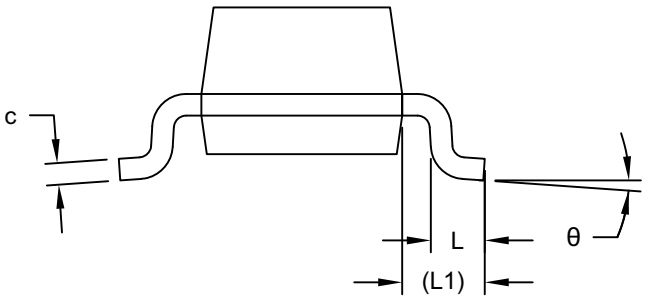
Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



TOP VIEW



SIDE VIEW

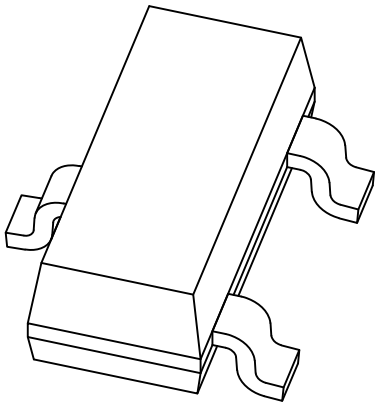


VIEW A–A

Microchip Technology Drawing C04-17458 Rev A Sheet 1 of 2

3-Lead Small Outline Transistor (C6X) - [SOT-23]
Supertex Legacy Package (K1/T)

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	N		3	
Pitch	e		0.95 BSC	
Overall Pitch	e1		1.90 BSC	
Overall Height	A	0.89	–	1.12
Standoff	A1	0.01	–	0.10
Molded Package Thickness	A2	0.88	0.95	1.02
Overall Length	D	2.80	2.90	3.04
Overall Width	E	2.10	–	2.64
Molded Package Width	E1	1.20	1.30	1.40
Terminal Width	b	0.30	–	0.50
Terminal Thickness	c	0.08	–	0.20
Terminal Length	L	0.20	0.50	0.60
Footprint	L1		0.54 REF	
Foot Angle	θ	0°	-	8°

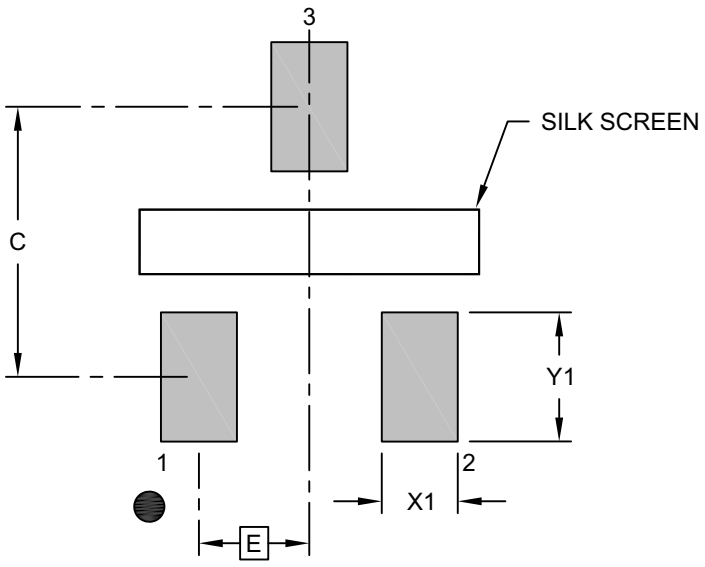
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-17458 Rev A Sheet 2 of 2

3-Lead Small Outline Transistor (C6X) - [SOT-23]
Supertex Legacy Package (K1/T)

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E	0.95 BSC		
Contact Pad Spacing	C		2.30	
Contact Pad Width (X3)	X1			0.65
Contact Pad Length (X3)	Y1			1.10

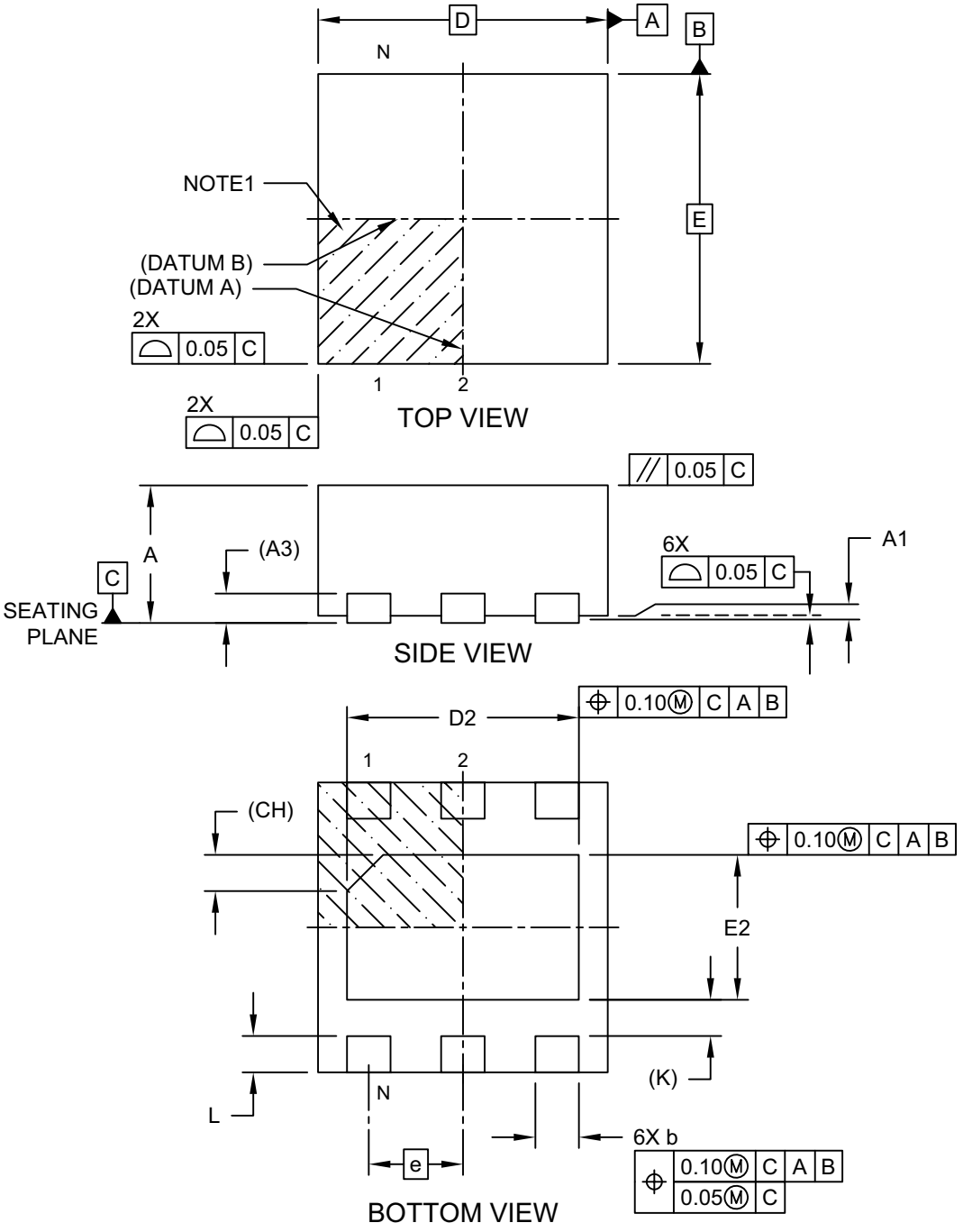
Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
2. For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process

Microchip Technology Drawing C04-19458 Rev A

6-Lead Plastic Dual Flat, No Lead Package (7AX) - 2x2x0.9 mm Body [DFN]

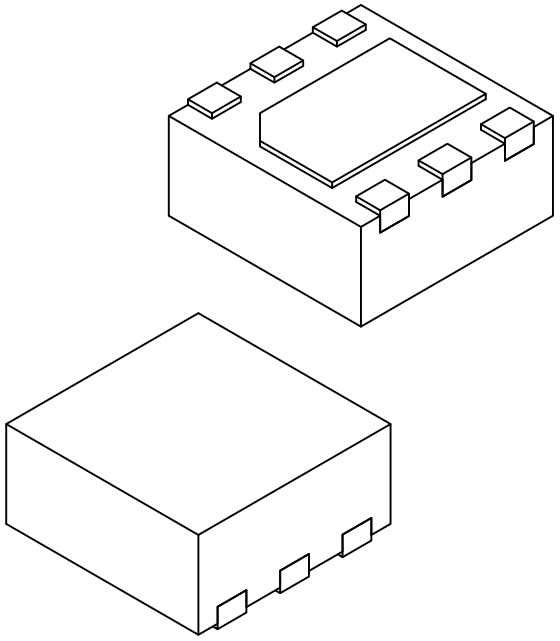
Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-120-7AX Rev D Sheet 1 of 2

6-Lead Plastic Dual Flat, No Lead Package (7AX) - 2x2x0.9 mm Body [DFN]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	N		6	
Pitch	e		0.65 BSC	
Overall Height	A	0.80	0.87	0.95
Standoff	A1	0.00	0.02	0.05
Terminal Thickness	A3		0.203 REF	
Overall Length	D		2.00 BSC	
Exposed Pad Length	D2	1.50	1.60	1.70
Overall Width	E		2.00 BSC	
Exposed Pad Width	E2	0.90	1.00	1.10
Chamfer	CH		0.25 REF	
Terminal Width	b	0.25	0.30	0.35
Terminal Length	L	0.20	0.25	0.30
Terminal-to-Exposed-Pad	K		0.25 REF	

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated
3. Dimensioning and tolerancing per ASME Y14.5M

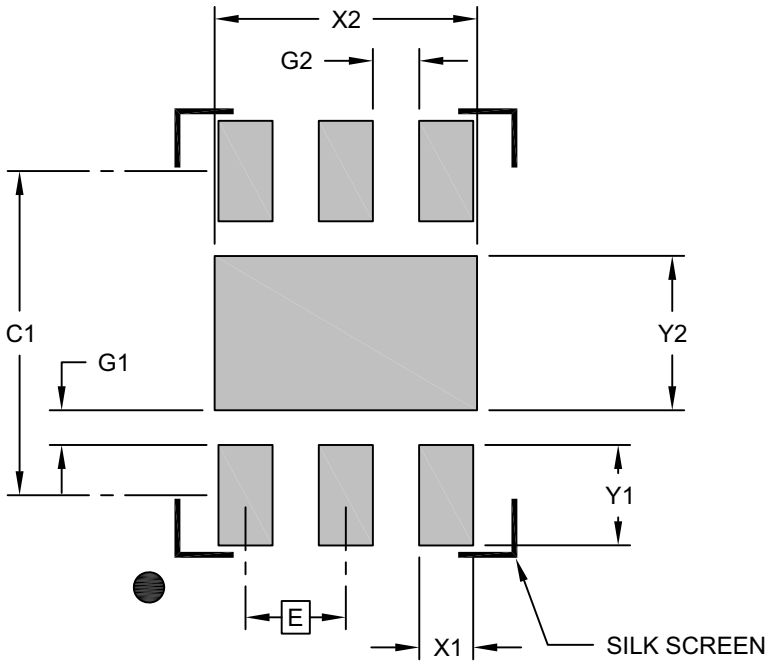
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-120-7AX Rev D Sheet 2 of 2

6-Lead Plastic Dual Flat, No Lead Package (7AX) - 2x2x0.9 mm Body [DFN]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E	0.65 BSC		
Center Pad Width	X2			1.70
Center Pad Length	Y2			1.00
Contact Pad Spacing	C1		1.70	
Contact Pad Width (X6)	X1			0.35
Contact Pad Length (X6)	Y1			0.65
Contact Pad to Center Pad (X6)	G1	0.20		
Contact Pad to Contact Pad (X4)	G2	0.25		

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
2. For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process

Microchip Technology Drawing C04-2120-7AX Rev D

NOTES:

APPENDIX A: REVISION HISTORY

Revision D (March 2023)

- Added 6-Lead DFN package to Package Type, Pin Function Table and Product Identification System.
- Updated Absolute Maximum Ratings(†).
- Updated Section 5.1, Package Marking Information.
- Made minor text changes throughout the document.

Revision C (March 2022)

- Updated tables DC Electrical Characteristics – Automotive and AC Electrical Characteristics – Automotive.
- Updated Section 5.1, Package Marking Information.
- Updated Product Identification System format.
- Updated legal and contact information.

Revision B (June 2020)

- Added automotive specifications to the Electrical Characteristics section.
- Added automotive specifications to the Product Information System section.
- Made minor text changes throughout the document.

Revision A (April 2019)

- Converted Supertex Doc# DSFP-TN2130 to Microchip DS20005944A.
- Changed the package marking format.
- Made minor text changes throughout the document.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

PART NO.	XX	-X	-XXX
Device	Package	Environmental	Qualification

Device:	TN2130:	N-Channel Enhancement-Mode Vertical DMOS FET
Package:	K1 MF	= 3-lead SOT-23 = 6-Lead DFN
Environmental:	G	= Lead (Pb)-free/RoHS-compliant Package
Media Type:	(Blank)	= 3000/Reel for both K1 and MF Packages
Qualification:	(Blank) VAO	= Standard Part = Automotive AEC-Q100 Qualified

Examples:

a) TN2130K1-G: N-Channel Enhancement-Mode, Vertical DMOS FET, 3-lead SOT-23 package, 3000/Reel

b) TN2130K1-G-VAO: N-Channel Enhancement-Mode Vertical DMOS FET, 3-lead SOT-23 package, 3000/Reel, Automotive Grade

c) TN2130MF-G-VAO: N-Channel Enhancement-Mode Vertical DMOS FET, 6-lead DFN package, 3000/Reel, Automotive Grade

d) TN2130MF-G: N-Channel Enhancement-Mode Vertical DMOS FET, 6-Lead DFN package, 3000/Reel

NOTES:

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