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FAIRCHILD™

June 2015

LM431SA / LM431SB / LM431SC
Programmable Shunt Regulator

Features

- Programmable Output Voltage to 36 V
- Low Dynamic Output Impedance: 0.2 Ω (Typical)
- Sink Current Capability: 1.0 to 100 mA
- Equivalent Full-Range Temperature Coefficient of 50 ppm/°C (Typical)
- Temperature Compensated for Operation Over Full Rated Operating Temperature Range
- Low Output Noise Voltage
- Fast Turn-on Response

Description

The LM431SA / LM431SB / LM431SC are three-terminal the output adjustable regulators with thermal stability over operating temperature range. The output voltage can be set any value between V_{REF} (approximately 2.5 V) and 36 V with two external resistors. These devices have a typical dynamic output impedance of 0.2 Ω. Active output circuit provides a sharp turn-on characteristic, making these devices excellent replacement for zener diodes in many applications.

SOT-89

1

1. Ref 2. Anode 3. Cathode

SOT-23F

3

1 2

1. Cathode 2. Ref 3. Anode

SOT-23

3

1 2

M32 - 1. Ref 2. Cathode 3. Anode
M3 - 1. Cathode 2. Ref 3. Anode

Ordering Information

Product Number	Output Voltage Tolerance	Operating Temperature	Top Mark(1)	Package	Packing Method
LM431SACMFX	2%	-25 to +85°C	43A □	SOT-23F 3L	Tape and Reel
LM431SACM3X			43L ◎	SOT-23 3L	
LM431SACM32X			43G ◎	SOT-23 3L	
LM431SBCMLX	1%		43B	SOT-89 3L	
LM431SBCMFX			43B □	SOT-23F 3L	
LM431SBCM3X			43M ◎	SOT-23 3L	
LM431SBCM32X			43H ◎	SOT-23 3L	
LM431SCCMLX	0.5%		43C	SOT-89 3L	
LM431SCCMFX			43C □	SOT-23F 3L	
LM431SCCM3X			43N ◎	SOT-23 3L	
LM431SCCM32X			43J ◎	SOT-23 3L	
LM431SAIMFX	2%	-40 to +85°C	43AI	SOT-23F 3L	

Note:

1. SOT-23 and SOT-23F have basically four-character marking except LM431SAIMFX.
   (3 letters for device code + 1 letter for date code)
   SOT-23F date code is composed of 1 digit numeric or alphabetic week code adding bar-type year code.
   > Week code: Change in every two weeks
   > Year code (additional bar): Rotate in three year cycle

Week	01~02	03~04	05~06	07~08	09~10	11~12	13~14	15~16	17~18	19~20	21~22	23~24	25~26
Code	1	2	3	4	5	6	7	8	9	A	D	E	F
Week	27~28	29~30	31~32	33~34	35~36	37~38	39~40	41~42	43~44	45~46	47~48	49~50	51~52
Code	H	J	K	L	N	O	P	R	S	T	U	V	X

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Code	$\square$	$\overline{\square}$	$\underline{\square}$	$\square$	$\overline{\square}$	$\underline{\square}$	$\square$	$\overline{\square}$	$\underline{\square}$	$\square$	$\overline{\square}$

Block Diagram

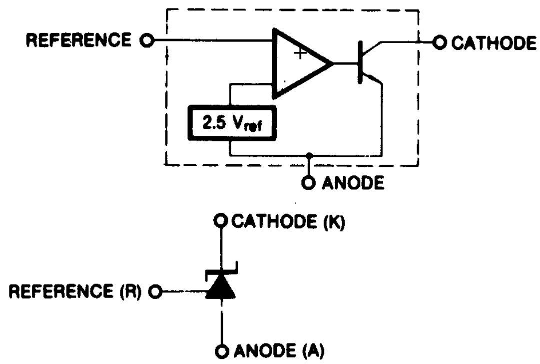


Figure 1. Block Diagram

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only. Values are at T_A = 25°C unless otherwise noted.

Symbol	Parameter		Value	Unit
V_{KA}	Cathode Voltage		37	V
I_{KA}	Cathode current Range (Continuous)		-100 to +150	mA
I_{REF}	Reference Input Current Range		-0.05 to +10.00	mA
$R_{\theta JA}$	Thermal Resistance Junction-Air (2,3)	ML Suffix Package (SOT-89)	220	°C/W
		MF Suffix Package (SOT-23F)	350	
		M32, M3 Suffix Package (SOT-23)	400	
P_D	Power Dissipation (4,5)	ML Suffix Package (SOT-89)	560	mW
		MF Suffix Package (SOT-23F)	350	
		M32, M3 Suffix Package (SOT-23)	310	
T_J	Junction Temperature		150	°C
T_{OPR}	Operating Temperature Range	All products except LM431SAIMFX	-25 to +85	°C
		LM431SAIMFX	-40 to +85	
T_{STG}	Storage Temperature Range		-65 to +150	°C

Notes:

2. Thermal resistance test board
   Size: 1.6 mm x 76.2 mm x 114.3 mm (1S0P)
   JEDEC Standard: JESD51-3, JESD51-7.
3. Assume no ambient airflow.
4. T_{JMAX} = 150°C; ratings apply to ambient temperature at 25°C.
5. Power dissipation calculation: $P_D = (T_J - T_A) / R_{\theta JA}$.

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameter	Min.	Max.	Unit
V_{KA}	Cathode Voltage	V_{REF}	36	V
I_{KA}	Cathode Current	1	100	mA

Electrical Characteristics[6]

Values are at T_A = 25°C unless otherwise noted.

Symbol	Parameter	Conditions		LM431SA			LM431SB			LM431SC			Unit
				Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{REF}	Reference Input Voltage	$V_{KA} = V_{REF}$, I_{KA} = 10 mA		2.450	2.500	2.550	2.470	2.495	2.520	2.482	2.495	2.508	V
$\Delta V_{REF} / \Delta T$	Deviation of Reference Input Voltage Over-Temperature	$V_{KA} = V_{REF}$, I_{KA} = 10 mA $T_{MIN} \leq T_A \leq T_{MAX}$	SOT-89 SOT-23F		4.5	17.0		4.5	17.0		4.5	17.0	mV
			SOT-23		6.6	24		6.6	24		6.6	24	mV
$\Delta V_{REF} / \Delta V_{KA}$	Ratio of Change in Reference Input Voltage to the Change in Cathode Voltage	I_{KA} =10 mA	ΔV_{KA} = 10 V-V_{REF}		-1.0	-2.7		-1.0	-2.7		-1.0	-2.7	mV/V
			ΔV_{KA} = 36 V-10 V		-0.5	-2.0		-0.5	-2.0		-0.5	-2.0	mV/V
I_{REF}	Reference Input Current	I_{KA} = 10 mA, R_1 = 10 KΩ, $R_2 = \infty$			1.5	4.0		1.5	4.0		1.5	4.0	µA
$\Delta I_{REF} / \Delta T$	Deviation of Reference Input Current Over Full Temperature Range	I_{KA} = 10 mA, R_1 = 10 KΩ, $R_2 = \infty$, T_A = Full Range	SOT-89 SOT-23F		0.4	1.2		0.4	1.2		0.4	1.2	µA
			SOT-23		0.8	2.0		0.8	2.0		0.8	2.0	µA
$I_{KA(MIN)}$	Minimum Cathode Current for Regulation	$V_{KA} = V_{REF}$			0.45	1.00		0.45	1.00		0.45	1.00	mA
$I_{KA(OFF)}$	Off -Stage Cathode Current	V_{KA} = 36 V, V_{REF} = 0			0.05	1.00		0.05	1.00		0.05	1.00	µA
Z_{KA}	Dynamic Impedance	$V_{KA} = V_{REF}$, I_{KA} = 1 to 100 mA, f ≥ 1.0 kHz			0.15	0.50		0.15	0.50		0.15	0.50	Ω

Note:

6. T_{MIN} = -25°C, T_{MAX} = +85°C.

Electrical Characteristics[7, 8] (Continued)

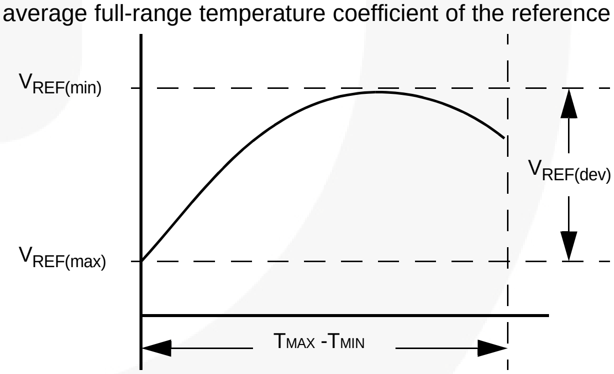
Values are at T_A = 25°C unless otherwise noted.

Symbol	Parameter	Conditions		LM431SAI Min.	LM431SAI Typ.	LM431SAI Max.	Unit
V_{REF}	Reference Input Voltage	$V_{KA} = V_{REF}$, I_{KA} = 10 mA		2.450	2.500	2.550	V
$V_{REF(dev)}$	Deviation of Reference Input Voltage Over-Temperature	$V_{KA} = V_{REF}$, I_{KA} = 10 mA, $T_{MIN} \le T_A \le T_{MAX}$			5	20	mV
$\Delta V_{REF}/\Delta V_{KA}$	Ratio of Change in Reference Input Voltage to Change in Cathode Voltage	I_{KA} = 10 mA	ΔV_{KA} = 10 V - V_{REF}		-1.0	-2.7	mV/V
			ΔV_{KA} = 36 V - 10 V		-0.5	-2.0	
I_{REF}	Reference Input Current	I_{KA} = 10 mA, R_1 =10 KΩ, $R_2 = \infty$			1.5	4.0	µA
$I_{REF(dev)}$	Deviation of Reference Input Current Over Full Temperature Range	I_{KA} = 10 mA, R_1 = 10 KΩ, $R_2 = \infty$, $T_{MIN} \le T_A \le T_{MAX}$			0.8	2.0	µA
$I_{KA(MIN)}$	Minimum Cathode Current for Regulation	$V_{KA} = V_{REF}$			0.45	1.00	mA
$I_{KA(OFF)}$	Off -Stage Cathode Current	V_{KA} = 36 V, V_{REF} = 0			0.05	1.00	µA
Z_{KA}	Dynamic Impedance	$V_{KA} = V_{REF}$, I_{KA} = 1 to 100 mA, f ≥ 1.0 kHz			0.15	0.50	Ω

Notes:

7. T_{MIN} = -40°C, T_{MAX} = +85°C.
8. The deviation parameters $V_{REF(dev)}$ and $I_{REF(dev)}$ are defined as the differences between the maximum and minimum values obtained over the rated temperature range. The average full-range temperature coefficient of the reference input voltage, αV_{REF}, is defined as:

$$\left|\alpha V_{REF}\right|\left(\frac{ppm}{°C}\right) = \frac{\left(\frac{V_{REF(dev)}}{V_{REF}(at25°C)}\right)\cdot 10^6}{T_{MAX} - T_{MIN}}$$



where T_{MAX} -T_{MIN} is the rated operating free-air temperature range of the device.
αV_{REF} can be positive or negative, depending on whether minimum V_{REF} or maximum V_{REF}, respectively, occurs at the lower temperature.

Example: $V_{REF(dev)}$ = 4.5 mV, V_{REF} = 2500 mV at 25 °C, T_{MAX} -T_{MIN} = 125 °C for LM431SAI.

$$\left|\alpha V_{REF}\right| = \frac{\left(\frac{4.5mV}{2500mV}\right)\cdot 10^6}{125°C} = 14.4ppm/°C$$

Because minimum V_{REF} occurs at the lower temperature, the coefficient is positive.

Test Circuits

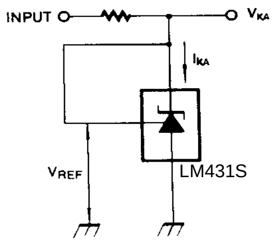


Figure 2. Test Circuit for $V_{KA} = V_{REF}$

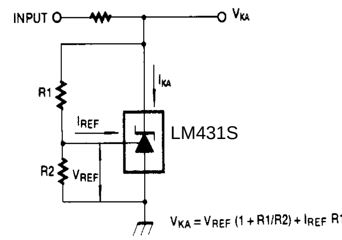


Figure 3. Test Circuit for $V_{KA} \geq V_{REF}$

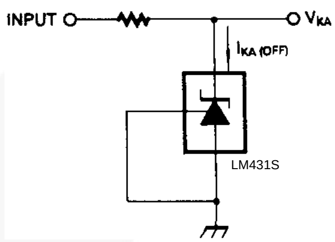


Figure 4. Test Circuit for $I_{KA(OFF)}$

Typical Applications

$$V_O = \left(1 + \frac{R_1}{R_2}\right) V_{ref}$$

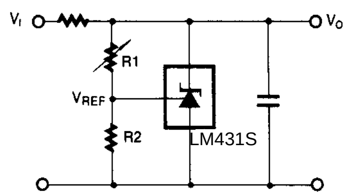


Figure 5. Shunt Regulator

$$V_O = V_{ref}\left(1 + \frac{R_1}{R_2}\right)$$

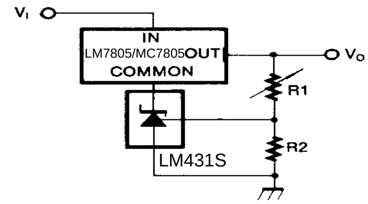


Figure 6. Output Control for Three- Terminal Fixed Regulator

$$V_O = \left(1 + \frac{R_1}{R_2}\right) V_{ref}$$

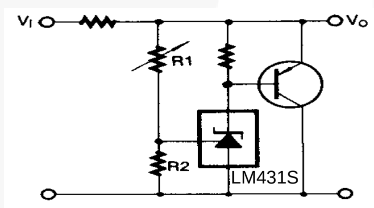


Figure 7. High Current Shunt Regulator

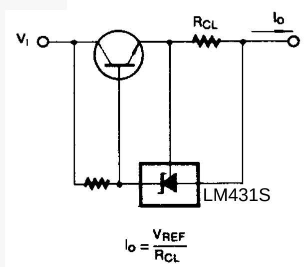


Figure 8. Current Limit or Current Source

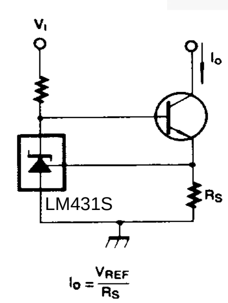


Figure 9. Constant-Current Sink

Typical Performance Characteristics

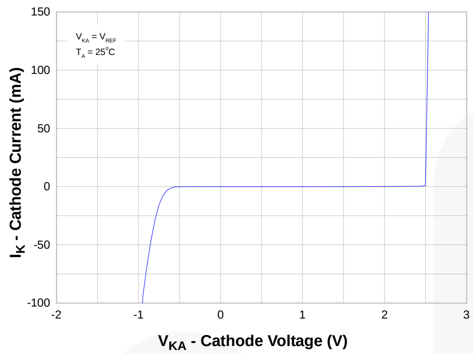


Figure 10. Cathode Current vs. Cathode Voltage

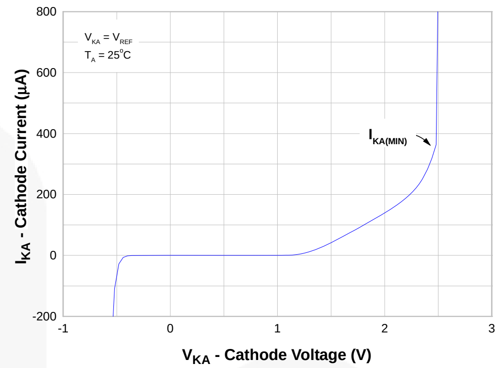


Figure 11. Cathode Current vs. Cathode Voltage

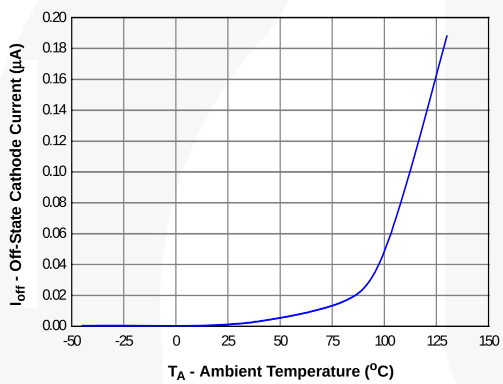


Figure 12. OFF-State Cathode Current vs. Ambient Temperature

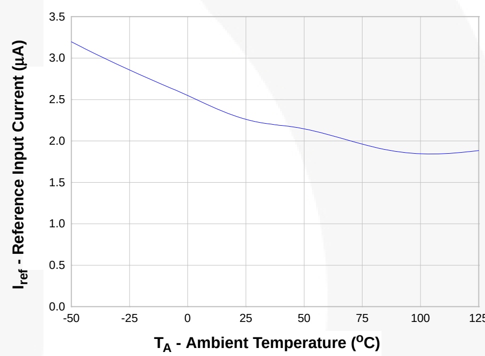


Figure 13. Reference Input Current vs. Ambient Temperature

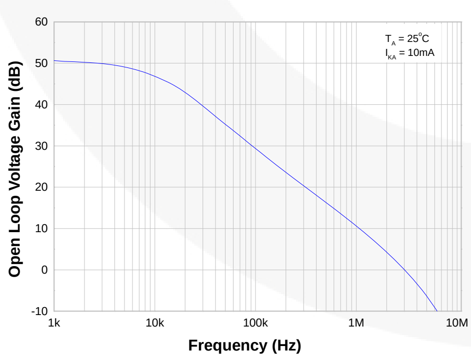


Figure 14. Frequency vs. Small Signal Voltage Amplification

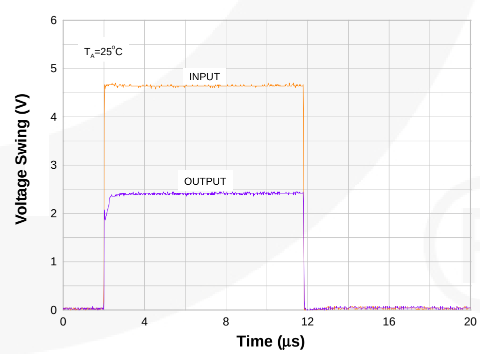


Figure 15. Pulse Response

Typical Performance Characteristics (Continued)

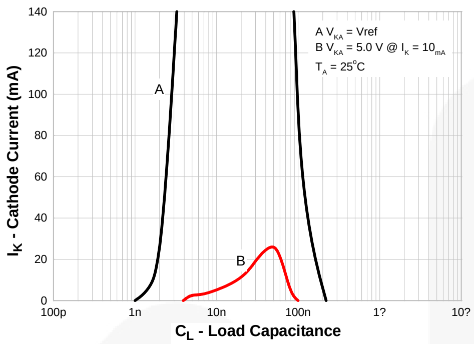


Figure 16. Stability Boundary Conditions

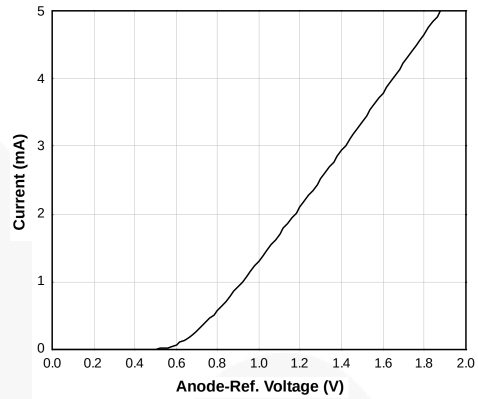


Figure 17. Anode-Reference Diode Curve

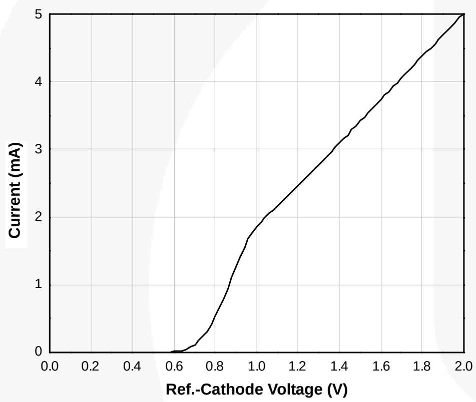


Figure 18. Reference-Cathode Diode Curve

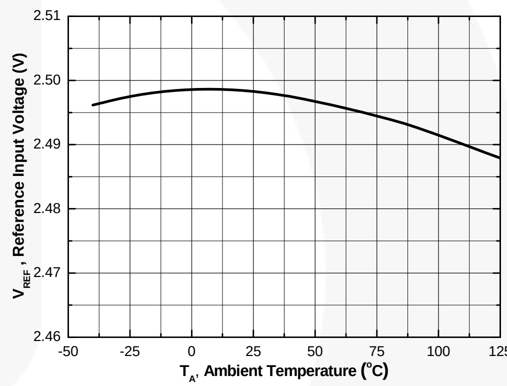
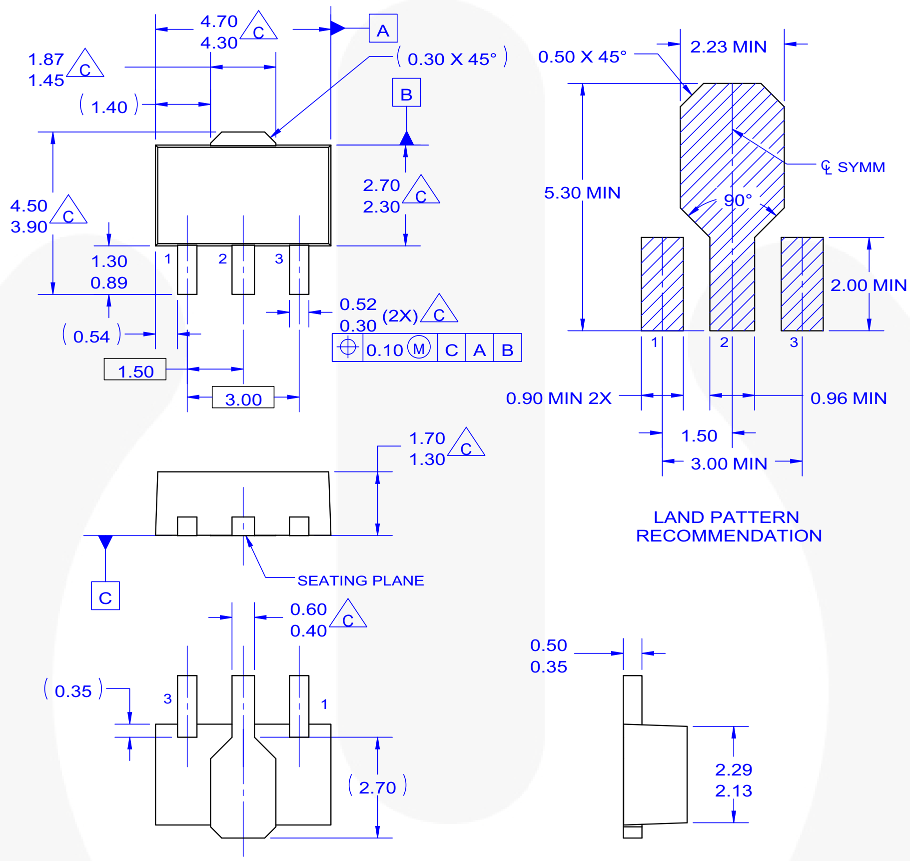


Figure 19. Reference Input Voltage vs. Ambient Temperature

Physical Dimensions

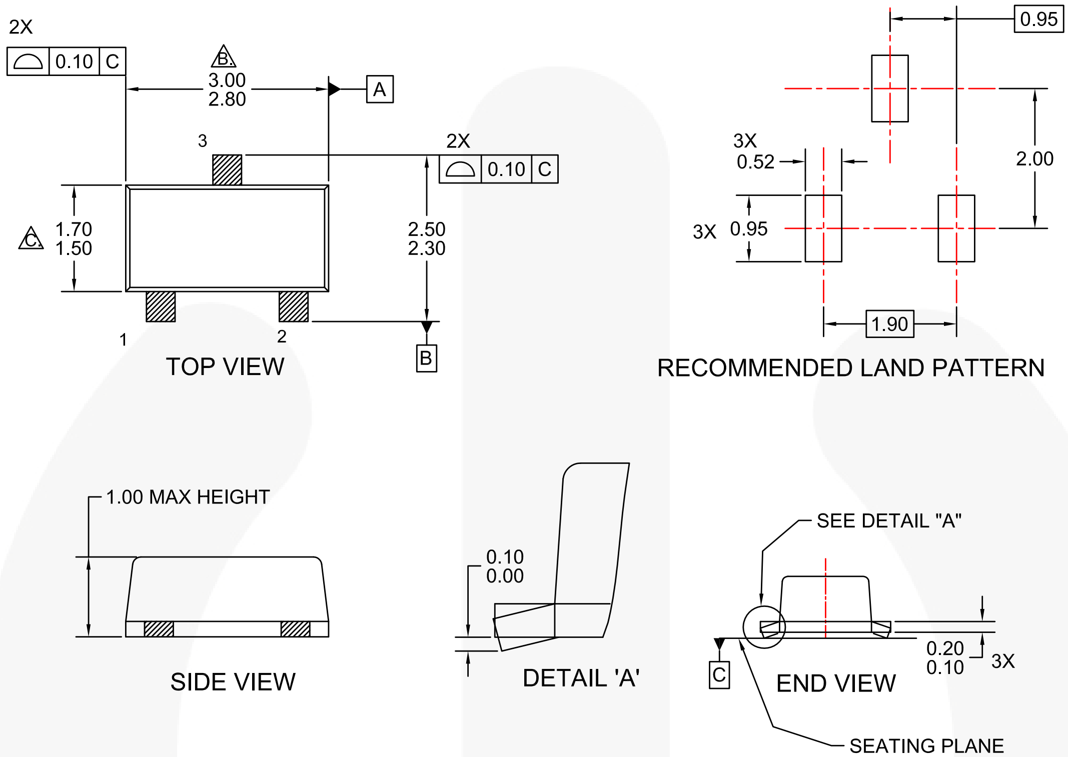


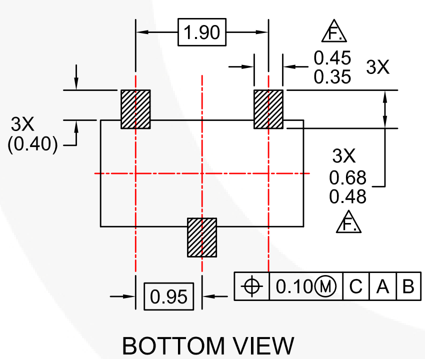
NOTES: UNLESS OTHERWISE SPECIFIED.

A. REFERENCE TO JEDEC TO-243 VARIATION AA.
B. ALL DIMENSIONS ARE IN MILLIMETERS.
C. DOES NOT COMPLY JEDEC STANDARD VALUE.
D. DIMENSIONS ARE EXCLUSIVE OF BURRS, MOLD FLASH AND TIE BAR PROTRUSION.
E. DIMENSION AND TOLERANCE AS PER ASME Y14.5-1994.
F. DRAWING FILE NAME: MA03CREV3

Figure 20. 3-LEAD, SOT-89, JEDEC TO-243, OPTION AA

Physical Dimensions (Continued)





NOTES:

A. ALL DIMENSIONS ARE IN MILLIMETERS.

B. DIMENSION DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15mm PER END.

C. DIMENSION DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.15mm PER SIDE.

D. DIMENSIONS B AND C ARE DETERMINED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY EXCLUSIVE OF MOLD FLASH, TIE BAR BURRS, GATE BURRS AND INTERLEAD FLASH. BUT INCLUDING ANY MISMATCH BETWEEN THE TOP AND BOTTOM OF THE PLASTIC BODY.

E. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.

F. THESE DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN 0.08mm AND 0.15mm FROM THE LEAD TIP.

G. LANDPATTERN RECOMMENDATION PER IPC SOTFL95P240X100-4N (ADAPTED TO 3LD)

H. DRAWING FILE NUMBER AND REVISION: MKT-MA03EREV1.DWG

Figure 21. 3-LEAD, SOT23F, FLAT LEAD, LOW PROFILE

Physical Dimensions (Continued)

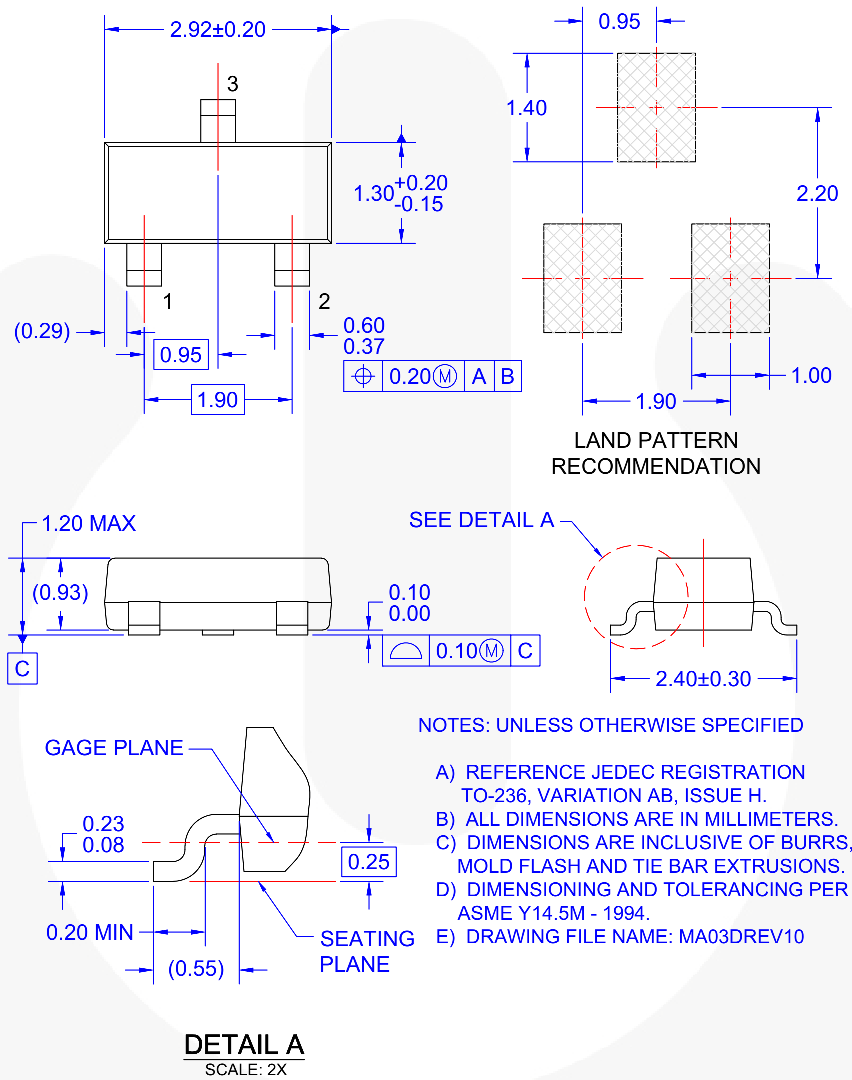


Figure 22. 3-LEAD, SOT-23, JEDEC TO-236, LOW PROFILE

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MegaBuck™
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MotionMax™
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™
Saving our world, 1mW/W/kW at a time™
SignalWise™
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SuperSOT™-6
SuperSOT™-8
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TinyPWM™
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2. A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

ANTI-COUNTERFEITING POLICY

Fairchild Semiconductor Corporation's Anti-Counterfeiting Policy. Fairchild's Anti-Counterfeiting Policy is also stated on our external website, www.fairchildsemi.com, under Sales Support.

Counterfeiting of semiconductor parts is a growing problem in the industry. All manufacturers of semiconductor products are experiencing counterfeiting of their parts. Customers who inadvertently purchase counterfeit parts experience many problems such as loss of brand reputation, substandard performance, failed applications, and increased cost of production and manufacturing delays. Fairchild is taking strong measures to protect ourselves and our customers from the proliferation of counterfeit parts. Fairchild strongly encourages customers to purchase Fairchild parts either directly from Fairchild or from Authorized Fairchild Distributors who are listed by country on our web page cited above. Products customers buy either from Fairchild directly or from Authorized Fairchild Distributors are genuine parts, have full traceability, meet Fairchild's quality standards for handling and storage and provide access to Fairchild's full range of up-to-date technical and product information. Fairchild and our Authorized Distributors will stand behind all warranties and will appropriately address any warranty issues that may arise. Fairchild will not provide any warranty coverage or other assistance for parts bought from Unauthorized Sources. Fairchild is committed to combat this global problem and encourage our customers to do their part in stopping this practice by buying direct or from authorized distributors.

PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative / In Design	Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
No Identification Needed	Full Production	Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.
Obsolete	Not In Production	Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.

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PUBLICATION ORDERING INFORMATION

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For additional information, please contact your local Sales Representative