chanhvinh.com

LR645

High-Input Voltage SMPS, Start-up/Linear Regulator

Features

- Accepts Inputs from 15 to 450V
- Output Currents: Up to 3.0 mA Continuous, 30 mA Peak
- Supply Current Typically 50 µA
- Line Regulation Typically 0.1 mV/V
- Output Can Be Trimmed from 8.0 to 12V
- Output Current Can be Increased to 150 mA with External FET

Applications

- Off-line SMPS Startup Circuits (Pulse Loads)
- Low Power Off-Line Regulators
- Regulators for Noisy Inputs

Description

LR645 is a high-input voltage, low-output current, linear regulator that is available in two versions. A 3-terminal, fixed-output voltage version is available in TO-92, TO-220 and SOT-89 packages, as well as an adjustable voltage version available in an 8-lead SOIC package.

The 3-terminal version of LR645 functions like any other low-voltage, 3-terminal regulator except it allows the use of much higher-input voltages. When used in a Switched-mode Power Supply (SMPS), start-up circuit, LR645 eliminates the need for large power resistors. In this application, current is drawn from the high voltage line only during start-up. Only leakage current flows after start-up, thereby reducing the continuous power dissipation to a few milliwatts.

The adjustable-voltage version allows trimming of the output voltage from 8.0V to 12V. This version can also be connected to an external depletion mode metal-oxide-semiconductor field-effect transistor (MOSFET) for increased output current. When used in conjunction with depletion mode MOSFET DN2540N5, an output current of up to 150 mA is achieved.

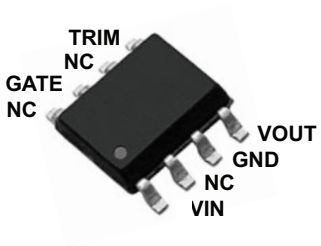
WARNING

The LR645 does NOT provide galvanic isolation. When operated from an AC line, potentially lethal voltages can be present on the IC. Adequate means of protecting the end user from such voltages must be provided by the circuit developer.

© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

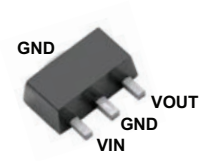
Package Type



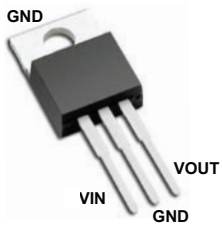
8-Lead SOIC



TO-92



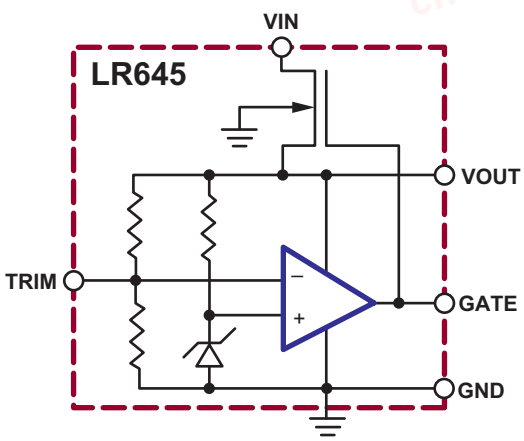
TO-243AA (SOT-89)



TO-220

See Table 2-1 for pin information

Block Diagram



chanhvinh.com

LR645

1.0 ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS†

Input Voltage 450V
Output voltage 15.5V
Operating and storage temperature ..... -55°C to +150°C

† **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 listings of this specification, is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

1.1 ELECTRICAL SPECIFICATIONS

TABLE 1-1: ELECTRICAL CHARACTERISTICS [1]

Symbol	Parameter	Min	Typ	Max	Units	Conditions
V_{OUT}	Output voltage	9.3	10	10.7	V	No load
	Output voltage over temperature[2]	9.0	10	11.5	V	T_J = -40 to +125°C, No load
ΔV_{OUT}	Line regulation	—	40	200	mV	V_{IN} = 15 to 400V, No load
	Load regulation	—	150	400	mV	V_{IN} = 50V, I_{OUT} = 0 to 3.0 mA
V_{IN}	Operating input voltage range	15	—	450	V	
I_{INQ}	Input quiescent current	—	50	150	µA	No Load
I_{OFF}	VIN off-state leakage current	—	0.1	10	µA	$V_{AUX} \geq V_{OUT}$ +1V applied to V_{OUT} pin
I_{AUX}	Input current to V_{OUT}	—	—	200	µA	$V_{AUX} \geq V_{OUT}$ +1V applied to V_{OUT} pin
$\Delta V_{OUT}/\Delta V_{IN}$	Ripple rejection ratio[2]	50	60	—	dB	120 Hz, No Load
e_n	Noise voltage[2]	—	25	—	µV	0.01 to 100 kHz
I_{PEAK}	Output peak current[3]	—	30	—	mA	C_{OUT} = 10 µF, V_{IN} = 400V
V_{AUX}	External voltage applied to V_{OUT}	—	—	13.2	V	
8-lead, adjustable voltage version only						
V_{OUT}	Output regulation trim range[2]	8	—	12	V	No load
ΔV_{OUT}	Load regulation at 8V trim[2]	—	200	400	mV	V_{IN} = 15V, I_{OUT} = 0 to 1.0 mA
	Load regulation at 12V trim	—	100	400	mV	V_{IN} = 50V, I_{OUT} = 0 to 3.0 mA

Note 1: Test[2] Conditions unless otherwise specified: T_A = 25°C, V_{IN} = 15V-450V, C_{OUT} = 0.01 µF.
2: Ensured by design.
3: Pulse test duration <1.0 msec, duty cycle <2%Determined by characterization, not production tested.

TABLE 1-2: THERMAL CHARACTERISTICS[1]

Package	θja	Power Dissipation @T_A=25°C
8-lead SOIC	101°C/W	0.31
TO-92	132°C/W	0.74
TO-220	29°C/W	1.8
TO-243AA (SOT-89)	133°C/W	1.6

Note 1: Mounted on FR5 board; 25mm x 25mm x 1.57mm. Significant P_D increase possible on ceramic substrate.

© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

2.0 PIN DESCRIPTION

The locations of the pins are listed in Package Type.

TABLE 2-1: PIN DESCRIPTION

Function	Description
VIN	Regulator input.
GND	Ground return for all internal circuitry. This pin must be electrically connected to circuit common.
GATE	Output GATE driver for an external N-channel depletion.
TRIM	A voltage divider from V_{OUT} to this pin adjusts the output voltage.
VOUT	Regulator output.
NC	No connection.

chanhvinh.com

chanhvinh.com

3.0 FUNCTIONAL DESCRIPTION

3.1 SMPS Start-Up Circuit

One of the main applications for LR645 is a start-up circuit for off-line, switch-mode power supplies (SMPS), as shown in Figure 3-1. A minimum output capacitance of 10 nF is recommended for stability. The wide operating, input voltage range of LR645 allows the SMPS to operate and start-up from rectified AC, or a DC voltage of 15 to 450V, without adjustment.

During start-up, the LR645 powers the V_{CC} line of the Pulse-Width Modulation (PWM) IC with a nominal output voltage of 10V. The auxiliary voltage connected through a diode to the V_{OUT} pin of LR645 will start to increase. When the auxiliary voltage becomes larger than the output voltage LR645 turns OFF both its internal high voltage input line and output voltage, allowing the auxiliary voltage to power the V_{CC} line of the PWM IC. After startup, LR645 doesn't draw any input current from the high-voltage line other than the leakage current of the internal MOSFET switch, which is typically 0.1 µA.

The 3-terminal version shown in Figure 3-1 has load regulation guaranteed from 0 to 3.0 mA at a fixed nominal output voltage of 10V. Applications requiring higher output current and/or a different output voltage can use the 8 pin adjustable version.

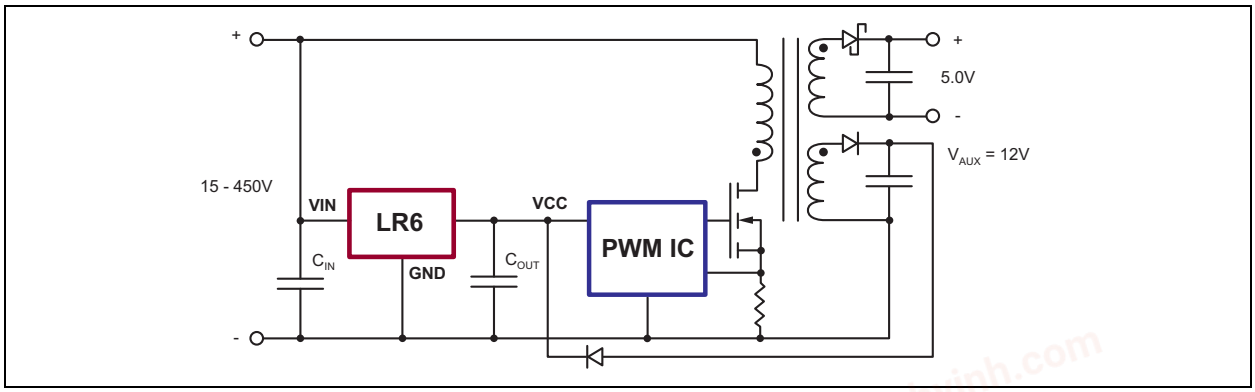


FIGURE 3-1: *SMPS Start-up Circuit.*

3.2 High-Current SMPS Start-Up Circuit

The 8-lead version of LR645 has connections for an external depletion-mode MOSFET for higher-output current and external resistors for adjustable-output voltage. As shown in Figure 3-2, the output current is increased to 150 mA by using the DN2540, a 400V depletion-mode MOSFET. The maximum operating input voltage will be limited by the drain-to-source, breakdown voltage of the external MOSFET, but cannot exceed the 450V rating of LR645.

The output voltage can be adjusted from 8 to 12V with two external resistors: R1 and R2. The ratio of R2/R1 determines the output voltage. R2 is connected between the V_{OUT} and TRIM pins; R1 is connected between TRIM and GND pins. Figure 3-3 is a curve showing output voltage versus resistor ratio R2/R1. The optimum range for R1 + R2 is 200 kΩ to 300 kΩ. This minimizes loading and optimizes accuracy of the output voltage. Figure 3-3 uses an R1 + R2 of 250 kΩ.

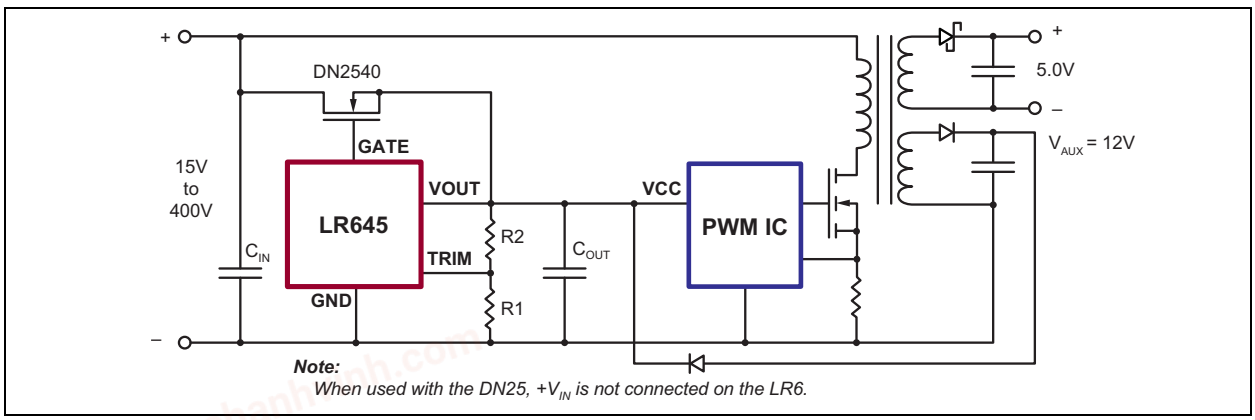


FIGURE 3-2: *High-Current SMPS Start-up Circuit.*

© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

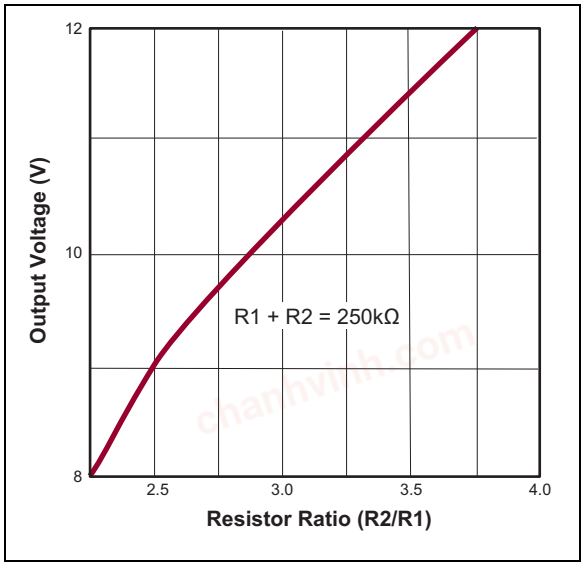


FIGURE 3-3: *Typical Output Voltage vs Resistor Ratio.*

3.3 Off Line Linear Regulator

Circuits that require low voltages to operate logic and analog circuits benefit from LR645. The conventional use of step-down transformers can be eliminated, thereby saving space and cost. Some examples of low-voltage applications are: proximity controlled light switches, street lamp controls, and low-voltage power supplies for appliances such as washing machines, dishwashers, and refrigerators.

The wide operating-input voltage range of 15 to 450V, as well as the ripple rejection ratio of 50 dB minimum, allows the use of a small, high-voltage input capacitor.

The input AC line can be either full-wave or half-wave rectified. A minimum output capacitance of 0.01 µF is recommended for output stability.

Figure 3-4 shows the LR645 as a pre-regulator to a precision regulator for high precision regulation. Higher output current is also possible by using an external depletion-mode MOSFET DN2540N5 as shown in Figure 3-5.

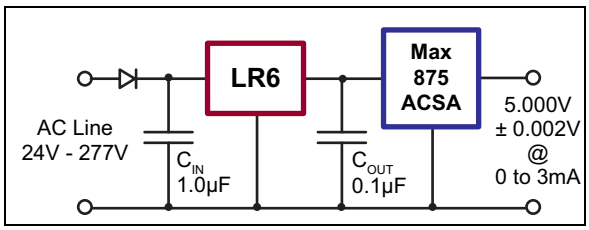


FIGURE 3-4: *Cascading for Precision.*

3.4 Power Dissipation Considerations

LR645 is a true linear regulator. Its power dissipation is therefore a function of input voltage and output load current. For example, if the LR645 provides a continuous load current of 3 mA at 10V, while its input voltage is 400V, total dissipation in the LR645 can be calculated using Equation 3-1.

The 1.23 watts is for continuous operation. This is within the dissipation capabilities of the TO-220 and SOT-89 packages. See Table 1-2 on Page 3 for deratings. For SMPS start-up applications, the output current is usually required only during start-up. This duration depends upon the auxiliary supply output capacitor and C_{OUT}, but is typically a few hundred milliseconds. All package types of the LR645 have been characterized for use with a C_{OUT} of at least 10 µF, and an AC line of 277V.

EQUATION 3-1:

$$P_{DISS} = (V_{IN} - V_{OUT}) \times (I_{OUT} + I_{MAXQuiescent}) = (400V - 10V) \times (3.0\ mA + 150\ \mu A)$$
$$= 1.23\ Watts$$

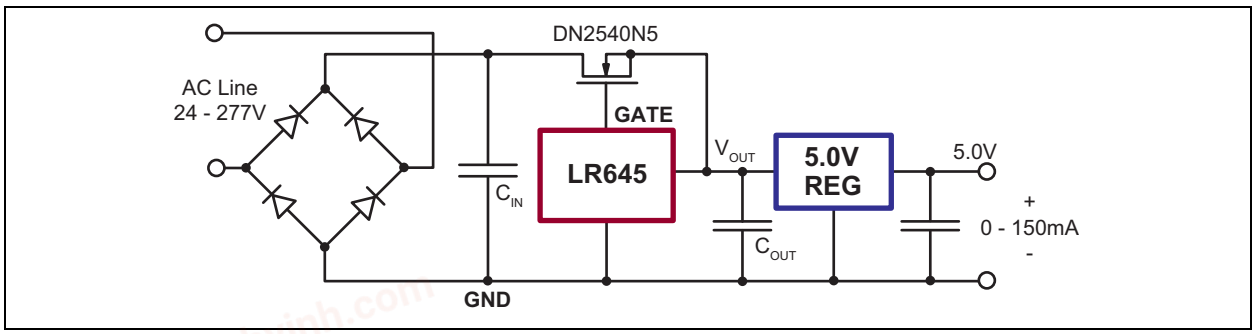


FIGURE 3-5: *High-Current Regulation.*

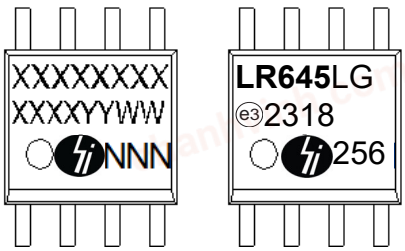
© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

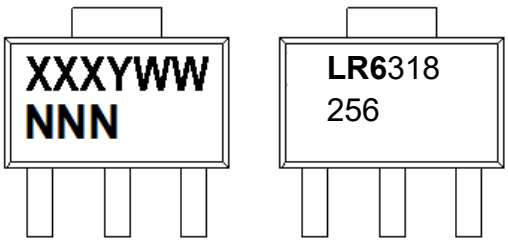
4.0 PACKAGING INFORMATION

4.1 Package Marking Information

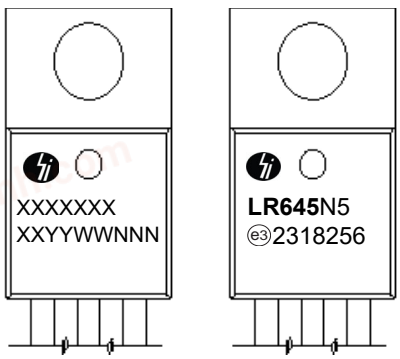
8-Lead SOIC: Example:



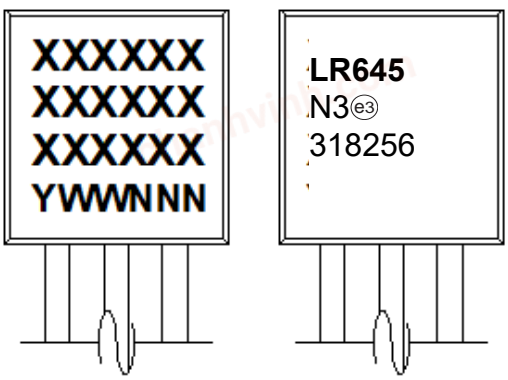
3-Lead TO-243AA* (SOT-89): Example:



3-Lead TO-220: Example:



3-Lead TO-92: 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.

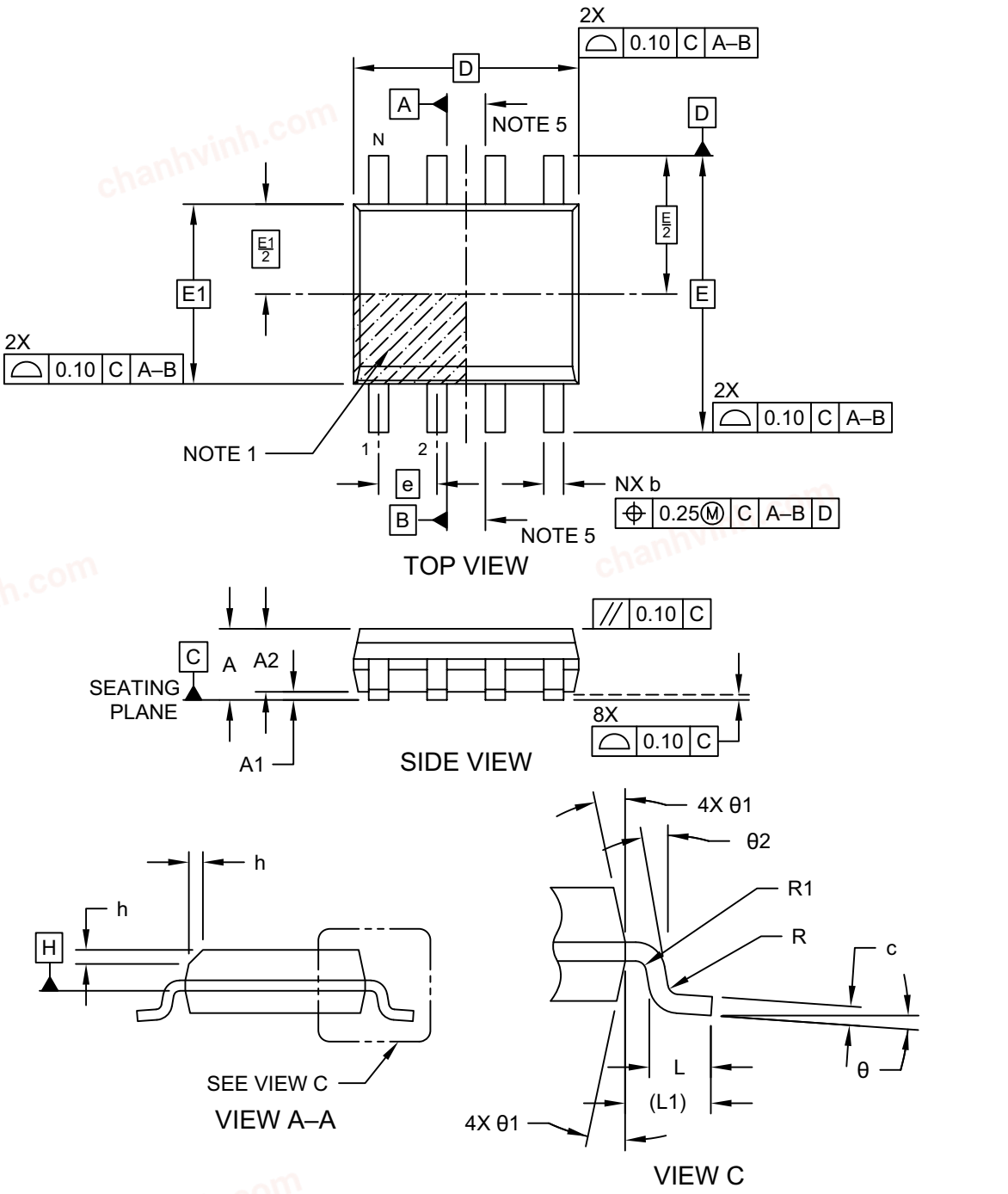
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or not include the corporate logo.

© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

8-Lead Plastic Small Outline (C2X) - Narrow, 3.90 mm (.150 In.) Body [SOIC]
Atmel Legacy Global Package Code SWB

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



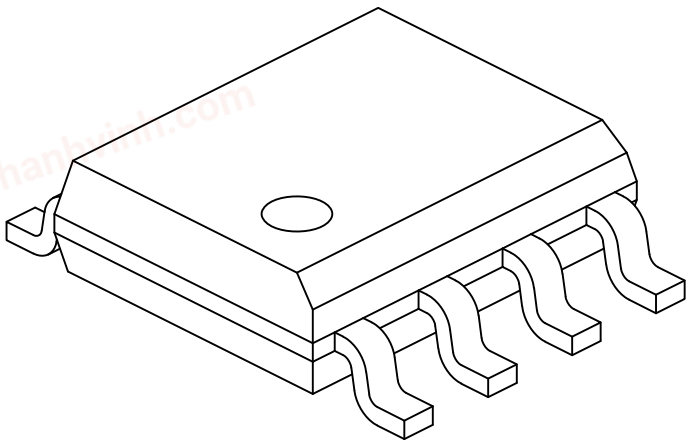
Microchip Technology Drawing No. C04-057-C2X Rev K Sheet 1 of 2

© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

8-Lead Plastic Small Outline (C2X) - Narrow, 3.90 mm (.150 In.) Body [SOIC]
Atmel Legacy Global Package Code SWB

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 Pins	N		8	
Pitch	e		1.27 BSC	
Overall Height	A	–	–	1.75
Molded Package Thickness	A2	1.25	–	-
Standoff §	A1	0.10	–	0.25
Overall Width	E		6.00 BSC	
Molded Package Width	E1		3.90 BSC	
Overall Length	D		4.90 BSC	
Chamfer (Optional)	h	0.25	–	0.50
Foot Length	L	0.40	–	1.27
Footprint	L1		1.04 REF	
Lead Thickness	c	0.17	–	0.25
Lead Width	b	0.31	–	0.51
Lead Bend Radius	R	0.07	–	–
Lead Bend Radius	R1	0.07	–	–
Foot Angle	θ	0°	–	8°
Mold Draft Angle	θ1	5°	–	15°
Lead Angle	θ2	0°	–	–

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm per side.
4. 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.
5. Datums A & B to be determined at Datum H.

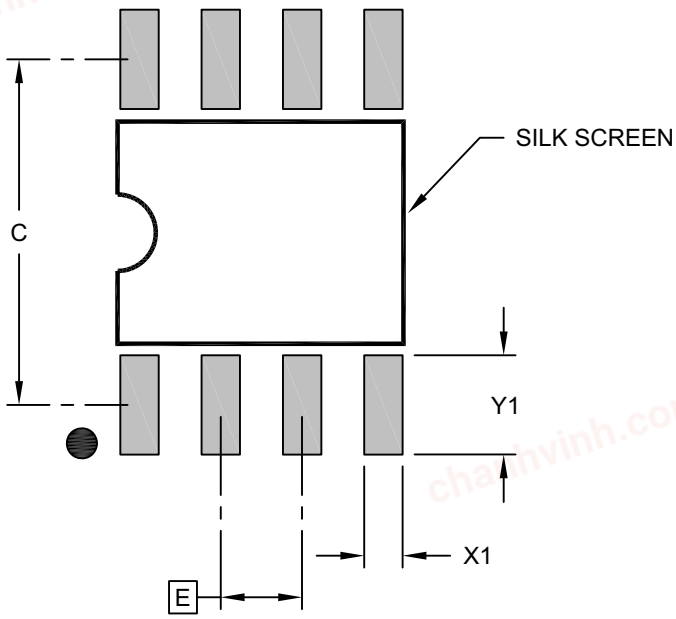
Microchip Technology Drawing No. C04-057-C2X Rev K Sheet 2 of 2

© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

8-Lead Plastic Small Outline (C2X) - Narrow, 3.90 mm (.150 In.) Body [SOIC]

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		1.27 BSC	
Contact Pad Spacing	C		5.40	
Contact Pad Width (X8)	X1			0.60
Contact Pad Length (X8)	Y1			1.55

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

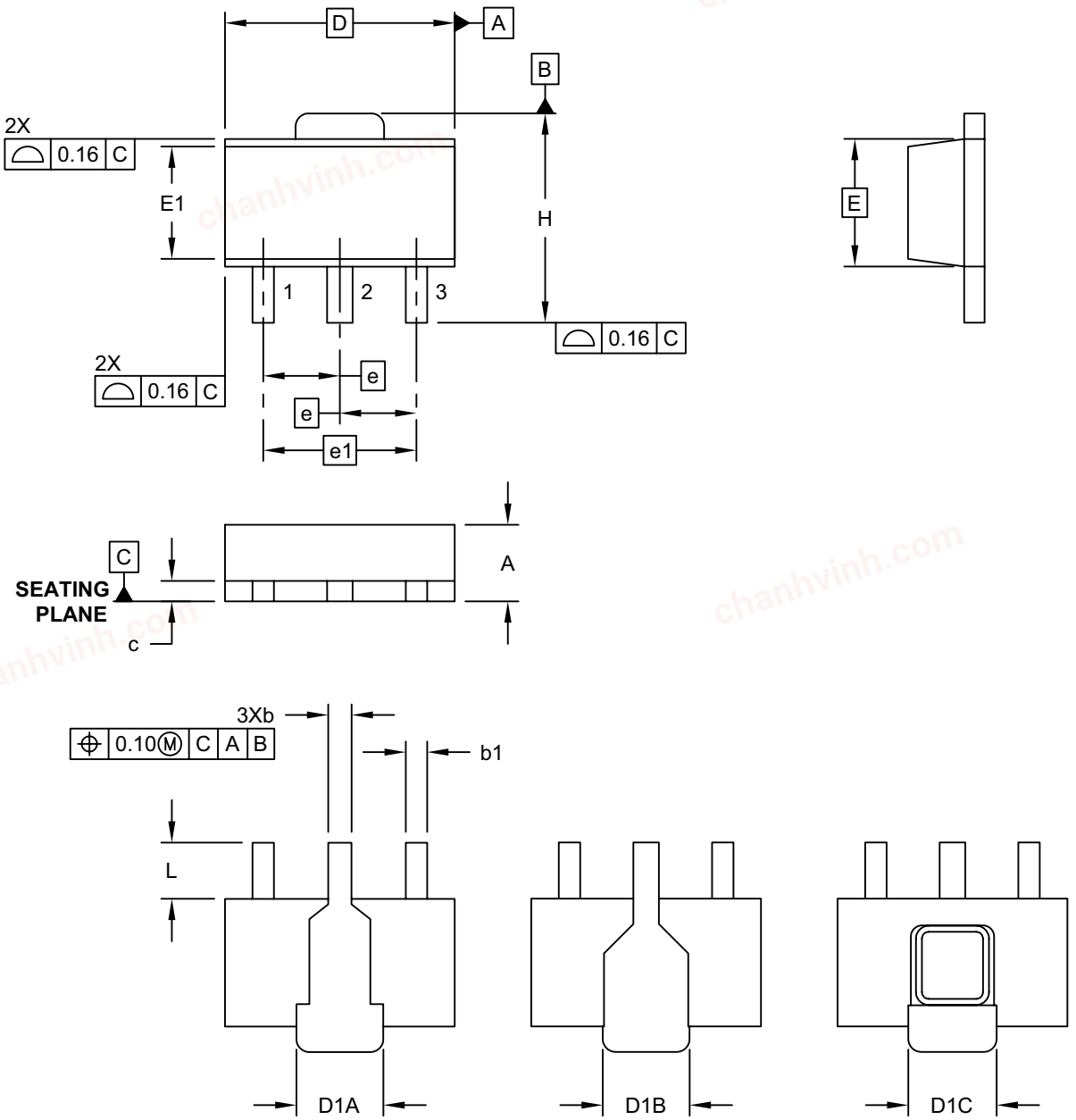
Microchip Technology Drawing C04-2057-C2X Rev K

© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

3-Lead Plastic Small Outline Transistor (MB) - [SOT-89]

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



OPTIONAL BACKSIDE PATTERNS — PARTS MAY BE SUPPLIED WITH ANY PATTERN SHOWN

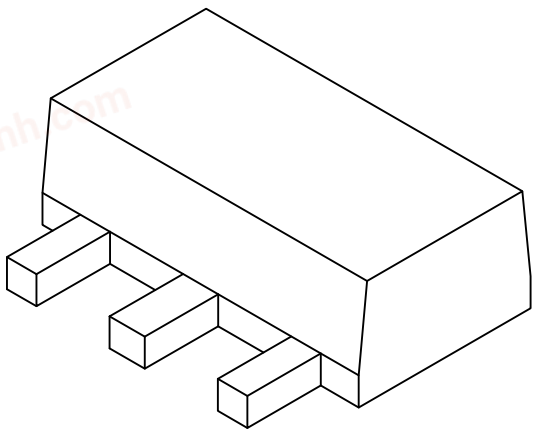
Microchip Technology Drawing C04-029C Sheet 1 of 2

© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

3-Lead Plastic Small Outline Transistor (MB) - [SOT-89]

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 Leads	N		3	
Pitch	e		1.50 BSC	
Outside Lead Pitch	e1		3.00 BSC	
Overall Height	A	1.40	1.50	1.60
Overall Width	H	3.94	4.10	4.25
Molded Package Width at Base	E		2.50 BSC	
Molded Package Width at Top	E1	2.13	2.20	2.29
Overall Length	D		4.50 BSC	
Tab Length (Option A)	D1A	1.63	1.73	1.83
Tab Length (Option B)	D1B	1.40	1.60	1.75
Tab Length (Option C)	D1C	1.62	1.73	1.83
Foot Length	L	0.79	1.10	1.20
Lead Thickness	c	0.35	0.40	0.44
Lead 2 Width	b	0.41	0.50	0.56
Leads 1 & 3 Width	b1	0.36	0.42	0.48

Notes:

1. Dimensions D and E do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.127mm per side.
2. Dimensioning and tolerancing per ASME Y14.5M

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

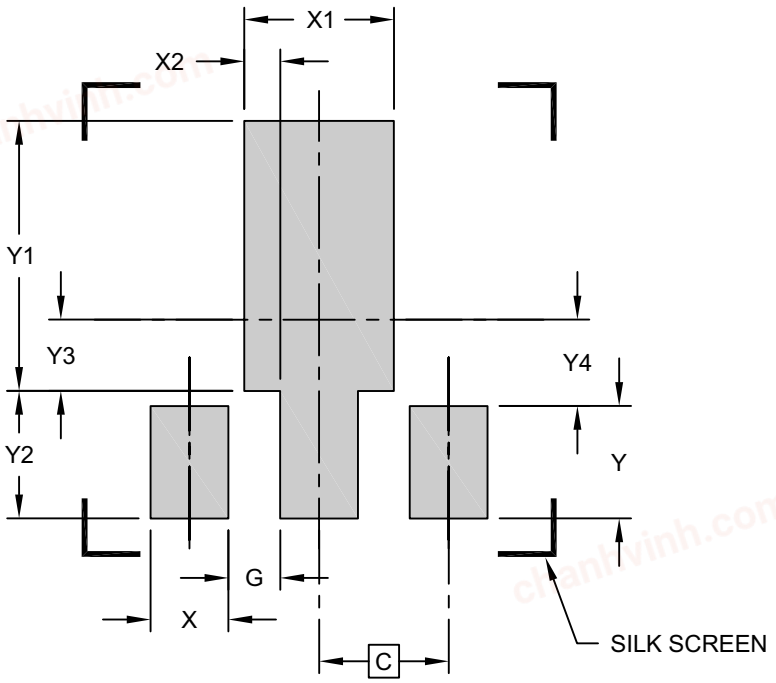
Microchip Technology Drawing C04-029C Sheet 2 of 2

© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

3-Lead Plastic Small Outline Transistor (MB) - [SOT-89]

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
C		1.50 (BSC)	
X (3 PLACES)		0.900	
X1		1.733	
X2 (2 PLACES)		0.416	
G (2 PLACES)		0.600	
Y (2 PLACES)		1.300	
Y1		3.125	
Y2		1.475	
Y3		0.825	
Y4		1.000	

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

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

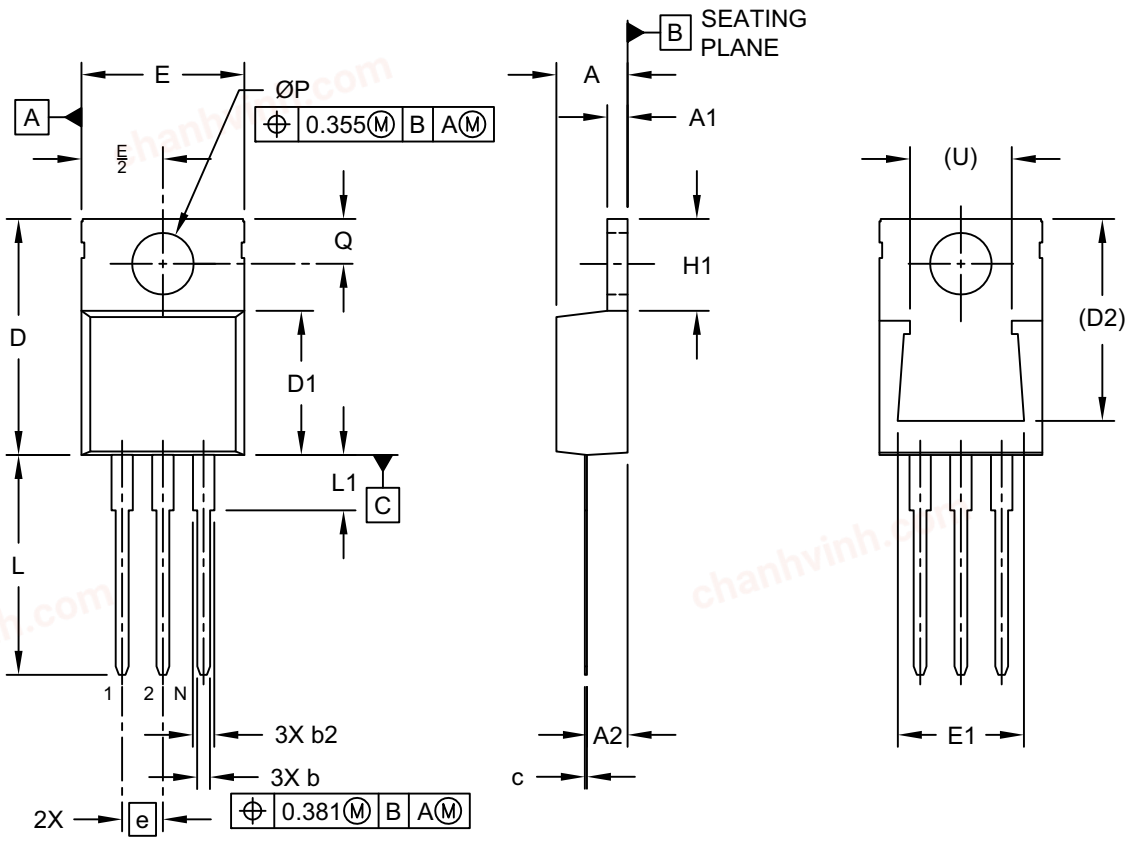
Microchip Technology Drawing C04-2029C

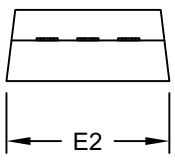
© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

3-Lead Transistor Outline Package (Supertex N5) - [TO-220]
Supertex Legacy

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



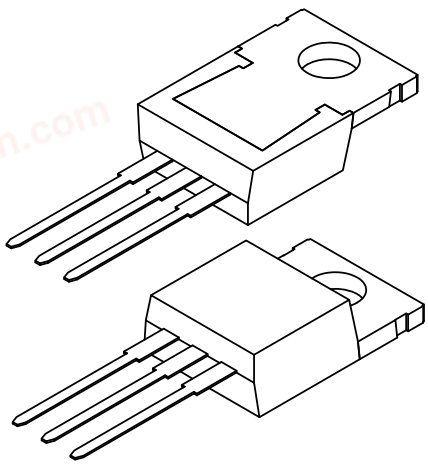


© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

3-Lead Transistor Outline Package (Supertex N5) - [TO-220]
Supertex Legacy

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	
Terminal Pitch	e		2.54 BSC	
Overall Height	A	4.064	4.445	4.826
Tab Thickness	A1	1.143	1.270	1.397
Base to Lead	A2	2.032	2.540	3.048
Terminal Width	b	0.635	0.826	1.016
Shoulder Width	b2	1.143	1.334	1.524
Terminal Thickness	c	0.305	0.432	0.559
Overall Length	D	13.730	14.730	15.730
Molded Package Length	D1	8.850	9.000	9.150
Exposed Pad Length	D2		12.6 REF	
Overall Width	E	9.652	10.160	10.668
Exposed Pad Width	U		6.35 REF	
Exposed Pad Width	E1	6.858	7.874	8.890
Body Width	E2	9.779	10.224	10.668
Tab Length	H1	5.842	6.350	6.858
Terminal Length	L	12.700	13.716	14.732
Terminal Shoulder Length	L1	3.050	3.455	3.860
Mounting Hole Diameter	P	3.708	3.835	3.962
Mounting Hole Center	Q	2.540	2.794	3.048

Notes:

1. 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.

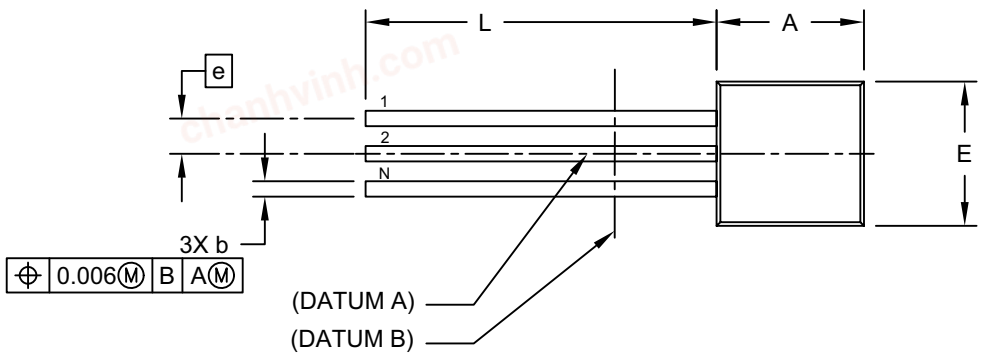
Microchip Technology Drawing C04-034-N5 Rev C Sheet 2 of 2

© 2015-2023 Microchip Technology Inc. and its subsidiaries

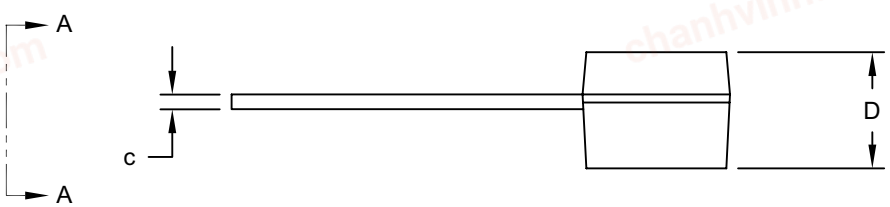
chanhvinh.com

3-Lead Plastic Transistor Outline (TO) [TO-92]

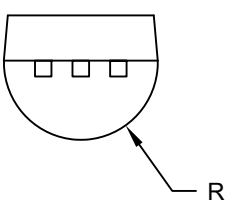
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



TOP VIEW



SIDE VIEW



VIEW A-A

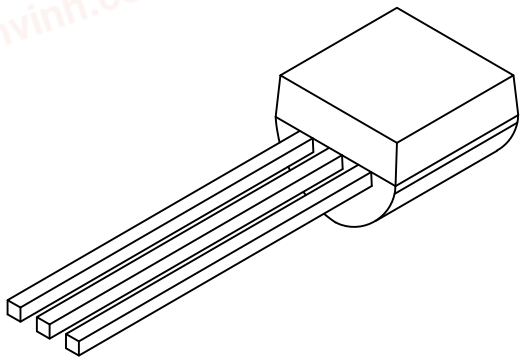
Microchip Technology Drawing C04-101-TO Rev D Sheet 1 of 2

© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

3-Lead Plastic Transistor Outline (TO) [TO-92]

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



Units		INCHES		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		3	
Pitch	e		.050 BSC	
Bottom to Package Flat	D	.125	-	.165
Overall Width	E	.175	-	.205
Overall Length	A	.170	-	.210
Molded Package Radius	R	.080	-	.105
Tip to Seating Plane	L	.500	-	-
Lead Thickness	c	.014	-	.021
Lead Width	b	.014	-	.022

Notes:

1. Dimensions D and E do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .005" per side.
2. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing C04-101-TO Rev D Sheet 2 of 2

© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

NOTES:

chanhvinh.com

chanhvinh.com

APPENDIX A: REVISION HISTORY

Revision B (October 2023)

- Minor style edits.
- Updated **Section 4.0 "Packaging Information"**.

Revision A (April 2015)

- Converted Supertex Document # DSFP-LR645 A062113 to Microchip Data Sheet DS20005384A.

chanhvinh.com

chanhvinh.com

NOTES:

chanhvinh.com

© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

PART NO.	XX	-X	-XXXX
Device	Package Type	Environmental	Media Type

Device:	LR645	=	High-Input, Voltage SMPS, Start-up/Linear Regulator
Package:	LG	=	8-lead SOIC (adjustable voltage)
	N3	=	TO-92 (fixed voltage)
	N5	=	TO-220 (fixed voltage)
	N8	=	TO-243AA (SOT-89) (fixed voltage)
Environmental:	G	=	Lead (Pb)-free/ROHS-compliant package
Media Type:	(blank)	=	3300/Reel for LG package
		=	1000/Bag for N3 package
		=	50/Tube for N5 package
		=	2000/Reel for N8 package
	P003	=	2000/Reel for N3 package
	P013	=	2000/Ammo Pack for N3 package

Examples:

a) LR645LG-G: Tape and Reel, 8-lead SOIC package, Adjustable voltage

b) LR645N3-G TO-92 package, Bag, Fixed voltage

c) LR645N3-G-P003: Tape and Reel, TO-92 package, Fixed voltage

d) LR645N3-G-P013: AMMO Pack, TO-92 package, Fixed voltage

e) LR645N5-G TO-220 package, Tube, Fixed voltage

f) LR645N8-G Tape and Reel, TO-243AA package, Fixed voltage

Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

© 2015-2023 Microchip Technology Inc. and its subsidiaries

chanhvinh.com

NOTES:

chanhvinh.com

chanhvinh.com

Note the following details of the code protection feature on Microchip products:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner, within operating specifications, and under normal conditions.
- Microchip values and aggressively protects its intellectual property rights. Attempts to breach the code protection features of Microchip product is strictly prohibited and may violate the Digital Millennium Copyright Act.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is "unbreakable" Code protection is constantly evolving. Microchip is committed to continuously improving the code protection features of our products.

This publication and the information herein may be used only with Microchip products, including to design, test, and integrate Microchip products with your application. Use of this information in any other manner violates these terms. Information regarding device applications is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. Contact your local Microchip sales office for additional support or, obtain additional support at https://www.microchip.com/en-us/support/design-help/client-support-services.

THIS INFORMATION IS PROVIDED BY MICROCHIP "AS IS". MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE, OR WARRANTIES RELATED TO ITS CONDITION, QUALITY, OR PERFORMANCE.

IN NO EVENT WILL MICROCHIP BE LIABLE FOR ANY INDIRECT, SPECIAL, PUNITIVE, INCIDENTAL, OR CONSEQUENTIAL LOSS, DAMAGE, COST, OR EXPENSE OF ANY KIND WHATSOEVER RELATED TO THE INFORMATION OR ITS USE, HOWEVER CAUSED, EVEN IF MICROCHIP HAS BEEN ADVISED OF THE POSSIBILITY OR THE DAMAGES ARE FORESEEABLE. TO THE FULLEST EXTENT ALLOWED BY LAW, MICROCHIP'S TOTAL LIABILITY ON ALL CLAIMS IN ANY WAY RELATED TO THE INFORMATION OR ITS USE WILL NOT EXCEED THE AMOUNT OF FEES, IF ANY, THAT YOU HAVE PAID DIRECTLY TO MICROCHIP FOR THE INFORMATION.

Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, CryptoMemory, CryptoRF, dsPIC, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Kleer, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AgileSwitch, APT, ClockWorks, The Embedded Control Solutions Company, EtherSynch, Flashtec, Hyper Speed Control, HyperLight Load, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet- Wire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePictra, TimeProvider, TrueTime, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, Augmented Switching, BlueSky, BodyCom, Clockstudio, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, Espresso T1S, EtherGREEN, GridTime, IdealBridge, In-Circuit Serial Programming, ICSP, INICnet, Intelligent Paralleling, IntelliMOS, Inter-Chip Connectivity, JitterBlocker, Knob-on-Display, KoD, maxCrypto, maxView, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, RTAX, RTG4, SAM-ICE, Serial Quad I/O, simpleMAP, SimpliPHY, SmartBuffer, SmartHLS, SMART-I.S., storClad, SQI, SuperSwitcher, SuperSwitcher II, Switchtec, SynchroPHY, Total Endurance, Trusted Time, TSHARC, USBCheck, VariSense, VectorBlox, VeriPHY, ViewSpan, WiperLock, XpressConnect, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, and Symmcom are registered trademarks of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2015-2023, Microchip Technology Incorporated and its subsidiaries.

All Rights Reserved.

ISBN: 978-1-6683-3277-1

chanhvinh.com

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://www.microchip.com/support
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Austin, TX
Tel: 512-257-3370

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Novi, MI
Tel: 248-848-4000

Houston, TX
Tel: 281-894-5983

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

Raleigh, NC
Tel: 919-844-7510

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110
Tel: 408-436-4270

Canada - Toronto
Tel: 905-695-1980
Fax: 905-695-2078

ASIA/PACIFIC

Australia - Sydney
Tel: 61-2-9868-6733

China - Beijing
Tel: 86-10-8569-7000

China - Chengdu
Tel: 86-28-8665-5511

China - Chongqing
Tel: 86-23-8980-9588

China - Dongguan
Tel: 86-769-8702-9880

China - Guangzhou
Tel: 86-20-8755-8029

China - Hangzhou
Tel: 86-571-8792-8115

China - Hong Kong SAR
Tel: 852-2943-5100

China - Nanjing
Tel: 86-25-8473-2460

China - Qingdao
Tel: 86-532-8502-7355

China - Shanghai
Tel: 86-21-3326-8000

China - Shenyang
Tel: 86-24-2334-2829

China - Shenzhen
Tel: 86-755-8864-2200

China - Suzhou
Tel: 86-186-6233-1526

China - Wuhan
Tel: 86-27-5980-5300

China - Xian
Tel: 86-29-8833-7252

China - Xiamen
Tel: 86-592-2388138

China - Zhuhai
Tel: 86-756-3210040

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444

India - New Delhi
Tel: 91-11-4160-8631

India - Pune
Tel: 91-20-4121-0141

Japan - Osaka
Tel: 81-6-6152-7160

Japan - Tokyo
Tel: 81-3-6880- 3770

Korea - Daegu
Tel: 82-53-744-4301

Korea - Seoul
Tel: 82-2-554-7200

Malaysia - Kuala Lumpur
Tel: 60-3-7651-7906

Malaysia - Penang
Tel: 60-4-227-8870

Philippines - Manila
Tel: 63-2-634-9065

Singapore
Tel: 65-6334-8870

Taiwan - Hsin Chu
Tel: 886-3-577-8366

Taiwan - Kaohsiung
Tel: 886-7-213-7830

Taiwan - Taipei
Tel: 886-2-2508-8600

Thailand - Bangkok
Tel: 66-2-694-1351

Vietnam - Ho Chi Minh
Tel: 84-28-5448-2100

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4485-5910
Fax: 45-4485-2829

Finland - Espoo
Tel: 358-9-4520-820

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Garching
Tel: 49-8931-9700

Germany - Haan
Tel: 49-2129-3766400

Germany - Heilbronn
Tel: 49-7131-72400

Germany - Karlsruhe
Tel: 49-721-625370

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Germany - Rosenheim
Tel: 49-8031-354-560

Israel - Ra'anana
Tel: 972-9-744-7705

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Italy - Padova
Tel: 39-049-7625286

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Norway - Trondheim
Tel: 47-7288-4388

Poland - Warsaw
Tel: 48-22-3325737

Romania - Bucharest
Tel: 40-21-407-87-50

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

Sweden - Gothenberg
Tel: 46-31-704-60-40

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820

© 2015-2023 Microchip Technology Inc. and its subsidiaries