TL783 High-voltage Adjustable Regulator

1 Features

- Output Adjustable From 1.25 V to 125 V when Used with an External Resistor Divider
- 700-mA Output Current
- Full Short-Circuit, Safe-Operating-Area, and Thermal-Shutdown Protection
- 0.001%/V Typical Input Voltage Regulation
- 0.15% Typical Output Voltage Regulation
- 76-dB Typical Ripple Rejection

2 Applications

- Electronic Point of Sale
- Medical, Health, and Fitness Applications
- Printers
- Applications and White Goods

3 Description

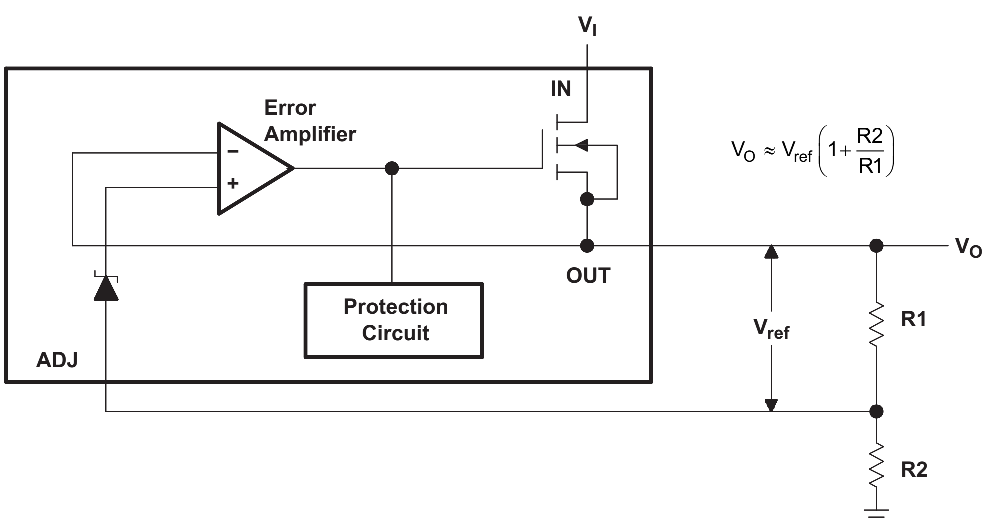
The TL783 device is an adjustable three-terminal high-voltage regulator with an output range of 1.25 V to 125 V and a DMOS output transistor capable of sourcing more than 700 mA. It is designed for use in high-voltage applications where standard bipolar regulators cannot be used. Excellent performance specifications, superior to those of most bipolar regulators, are achieved through circuit design and advanced layout techniques.

Device Information(1)

PART NUMBER	PACKAGE (PIN)	BODY SIZE (NOM)
TL783	TO-220 (3)	10.17 mm × 9.02 mm
		10.16 mm × 8.70 mm
	PFM (3)	9.40 mm × 8.00 mm
	TO-263 (3)	10.18 mm × 8.41 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

4 Simplified Schematic



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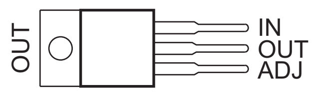
5 Revision History

Changes from Revision M (April 2008) to Revision N — **Page**

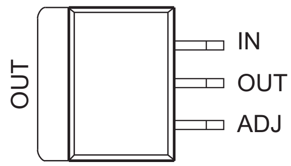
- Added *Applications*, *Device Information* table, *Pin Functions* table, *ESD Ratings* table, *Thermal Information* table, *Typical Characteristics*, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section. 1
- Deleted *Ordering Information* table. 1

6 Pin Configuration and Functions

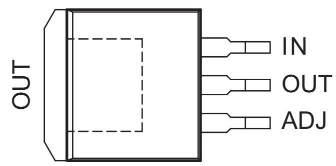
KC (TO-220) PACKAGE
(TOP VIEW)



KTE (PowerFLEX™) PACKAGE
(TOP VIEW)



KTT (TO-263) PACKAGE
(TOP VIEW)



Pin Functions

PIN				TYPE	DESCRIPTION
NAME	KC TO-220	KTE PowerFLEX™	KTT TO-263		
ADJ	1	1	1	I/O	Voltage adjustment pin. Connect a resistor divider to determine the output voltage.
IN	3	3	3	I	Supply Input
OUT	2	2	2	O	Voltage Output

7 Specifications

7.1 Absolute Maximum Ratings

over operating temperature range (unless otherwise noted)[1]

		MIN	MAX	UNIT
$V_I – V_O$	Input-to-output differential voltage		125	V
T_J	Operating virtual junction temperature		150	°C
T_{stg}	Storage temperature range	–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

7.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins[1]	2500	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins[2]	1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

		MIN	MAX	UNIT
$V_I – V_O$	Input-to-output differential voltage		125	V
I_O	Output current	15	700	mA
T_J	Operating virtual junction temperature	0	125	°C

7.4 Thermal Information

THERMAL METRIC[1]		TL783 KTE	TL783 KTT	TL783 KC	UNIT
		3 PINS	3 PINS	3 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	23	25.3	19	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	N/A	18	17	°C/W
$R_{\theta JP}$	Junction-to-exposed-pad thermal resistance	2.7	1.94	3	°C/W

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.

7.5 Electrical Characteristics

$V_I - V_O$ = 25 V, I_O = 0.5 A, T_J = 0°C to 125°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS(1)		MIN	TYP	MAX	UNIT
Input voltage regulation(2)	$V_I - V_O$ = 20 V to 125 V, P ≤ rated dissipation	T_J = 25°C		0.001	0.01	%/V
		T_J = 0°C to 125°C		0.004	0.02	
Ripple rejection	$\Delta V_{I(PP)}$ = 10 V, V_O = 10 V, f = 120 Hz		66	76		dB
Output voltage regulation	I_O = 15 mA to 700 mA, T_J = 25°C	V_O ≤ 5 V		7.5	25	mV
		V_O ≥ 5 V		0.15%	0.5%	—
	I_O = 15 mA to 700 mA, P ≤ rated dissipation	V_O ≤ 5 V		20	70	mV
		V_O ≥ 5 V		0.3%	1.5%	—
Output voltage change with temperature				0.4%		
Output voltage long-term drift	1000 hours at T_J = 125°C, $V_I - V_O$ = 125 V			0.2%		
Output noise voltage	f = 10 Hz to 10 kHz, T_J = 25°C			0.003%		
Minimum output current to maintain regulation	$V_I - V_O$ = 125 V				15	mA
Peak output current	$V_I - V_O$ = 25 V, t = 1 ms			1100		mA
	$V_I - V_O$ = 15 V, t = 30 ms			715		
	$V_I - V_O$ = 25 V, t = 30 ms		700	900		
	$V_I - V_O$ = 125 V, t = 30 ms		100	250		
ADJ input current				83	110	μA
Change in ADJ input current	$V_I - V_O$ = 15 V to 125 V, I_O = 15 mA to 700 mA, P ≤ rated dissipation			0.5	5	μA
Reference voltage (OUT to ADJ)(3)	$V_I - V_O$ = 10 V to 125 V, I_O = 15 mA to 700 mA, P ≤ rated dissipation		1.2	1.27	1.3	V

(1) Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately.
(2) Input voltage regulation is expressed here as the percentage change in output voltage per 1-V change at the input
(3) Due to the dropout voltage and output current-limiting characteristics of this device, output current is limited to less than 700 mA at input-to-output voltage differentials of less than 25 V.

7.6 Typical Characteristics

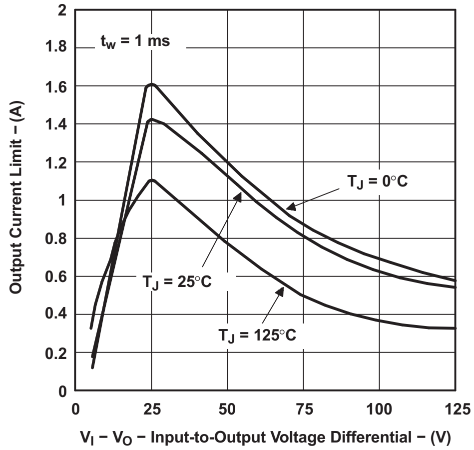


Figure 1. Output Current Limit vs Input-to-Output Voltage Differential

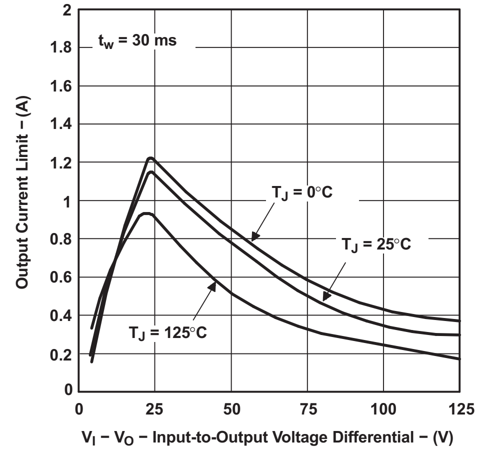


Figure 2. Output Current Limit vs Input-to-Output Voltage Differential

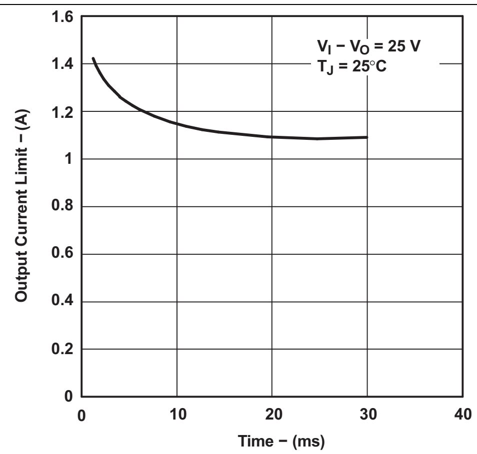


Figure 3. Output Current Limit vs Time

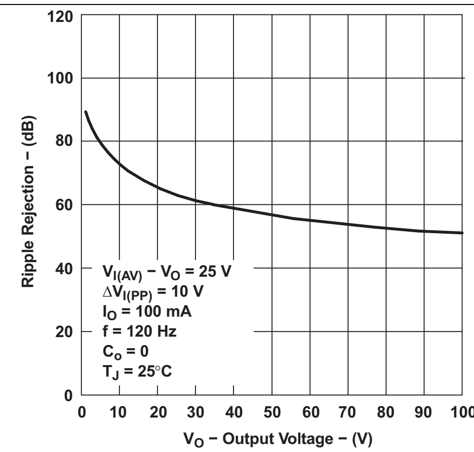


Figure 4. Ripple Rejection vs Output Voltage

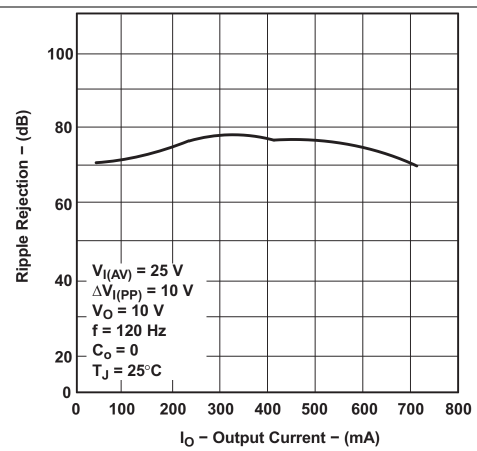


Figure 5. Ripple Rejection vs Output Current

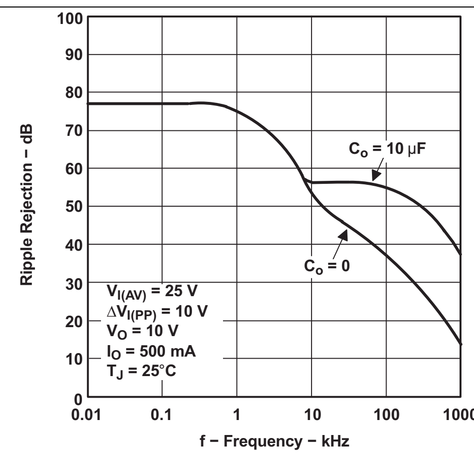


Figure 6. Ripple Rejection vs Frequency

Typical Characteristics (continued)

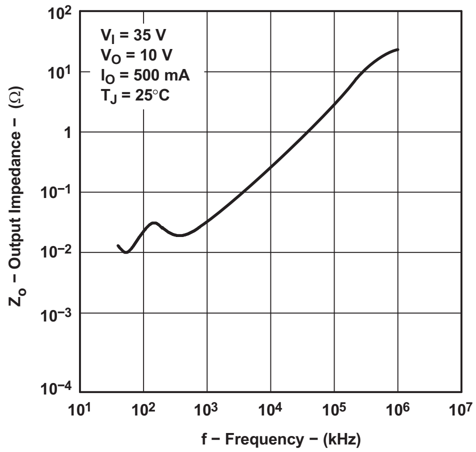


Figure 7. Output Impedance vs Frequency

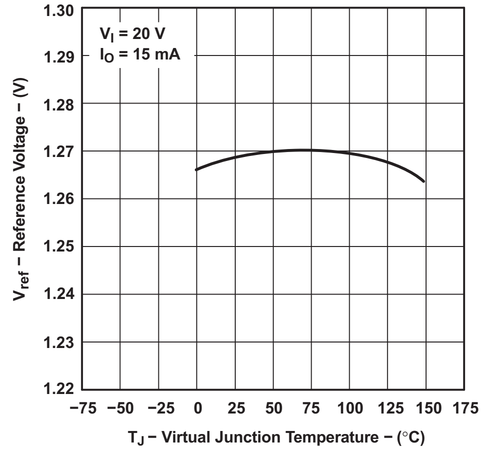


Figure 8. Reference Voltage vs Virtual Junction Temperature

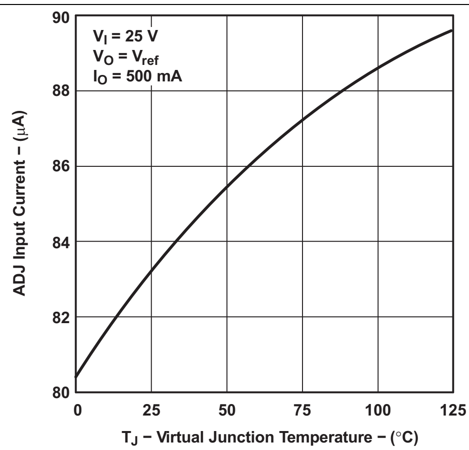


Figure 9. Input Current at ADJ vs Virtual Junction Temperature

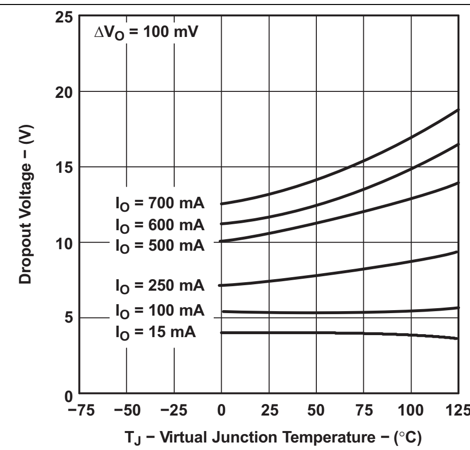


Figure 10. Dropout Voltage vs Virtual Junction Temperature

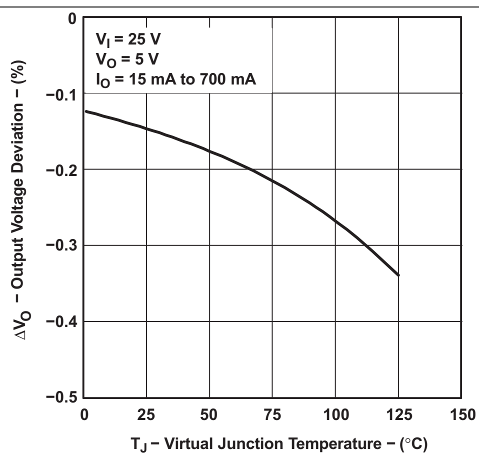
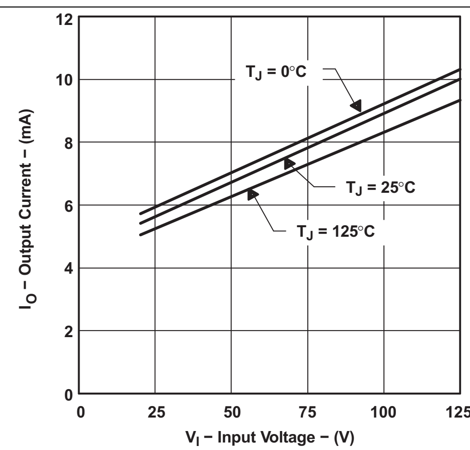


Figure 11. Output Voltage Deviation vs Virtual Junction Temperature



(1) This is the minimum current required to maintain voltage regulation.

Figure 12. Output Current vs Input Voltage

8 Detailed Description

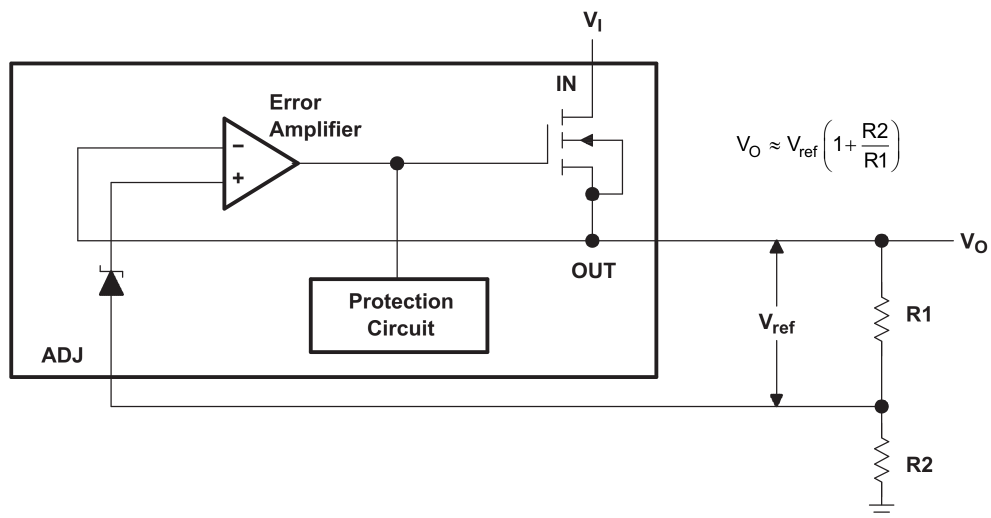
8.1 Overview

The TL783 device is an adjustable three-terminal high-voltage regulator with an output range of 1.25 V to 125 V and a DMOS output transistor capable of sourcing more than 700 mA. It is designed for use in high-voltage applications where standard bipolar regulators cannot be used. Excellent performance specifications, superior to those of most bipolar regulators, are achieved through circuit design and advanced layout techniques.

As a state-of-the-art regulator, the TL783 device combines standard bipolar circuitry with high-voltage double-diffused MOS transistors on one chip, to yield a device capable of withstanding voltages far higher than standard bipolar integrated circuits. Because of its lack of secondary-breakdown and thermal-runaway characteristics usually associated with bipolar outputs, the TL783 maintains full overload protection while operating at up to 125 V from input to output. Other features of the device include current limiting, safe-operating-area (SOA) protection, and thermal shutdown. Even if ADJ is disconnected inadvertently, the protection circuitry remains functional.

Only two external resistors are required to program the output voltage. An input bypass capacitor is necessary only when the regulator is situated far from the input filter. An output capacitor, although not required, improves transient response and protection from instantaneous output short circuits. Excellent ripple rejection can be achieved without a bypass capacitor at the adjustment terminal.

8.2 Functional Block Diagram



8.3 Feature Description

- Output Adjustable From 1.25 V to 125 V when Used with an External Resistor Divider
- 700-mA Output Current
- Full Short-Circuit, Safe-Operating-Area, and Thermal-Shutdown Protection
- 0.001%/V Typical Input Voltage Regulation
- 0.15% Typical Output Voltage Regulation
- 76-dB Typical Ripple Rejection

8.4 Device Functional Modes

8.4.1 Active Mode

The TL783 acts as a high-voltage adjustable regulator. The device works to keep the voltage at the OUT pin 1.25 V higher than the voltage at the ADJ pin. Therefore, a resistor divider can be used to set the output voltage.

9 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

9.1.1 General Configurations

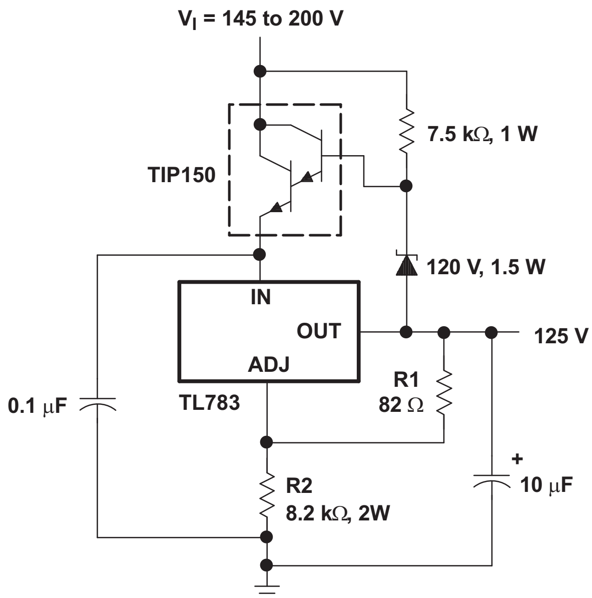


Figure 13. 125-V Short-Circuit-Protected Off-Line Regulator

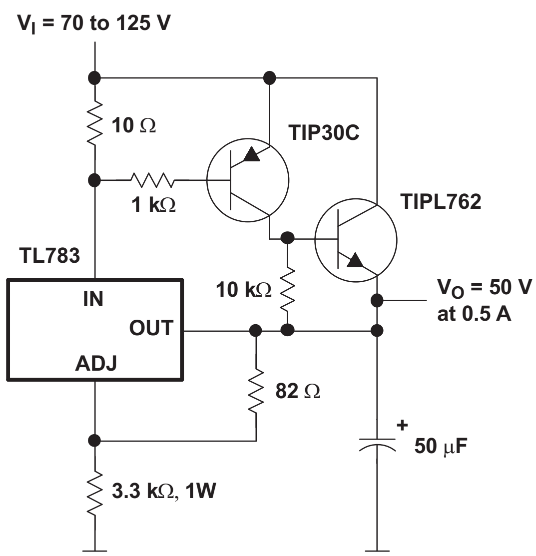


Figure 14. 50-V Regulator With Current Boost

Application Information (continued)

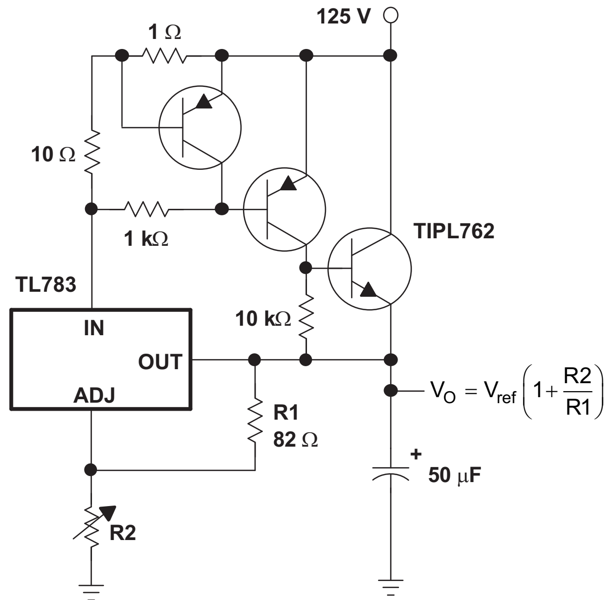


Figure 15. Adjustable Regulator With Current Boost and Current Limit

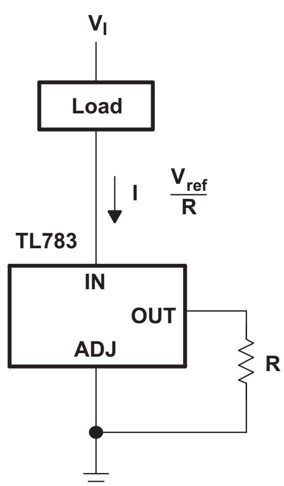


Figure 16. Current-Sinking Regulator

Application Information (continued)

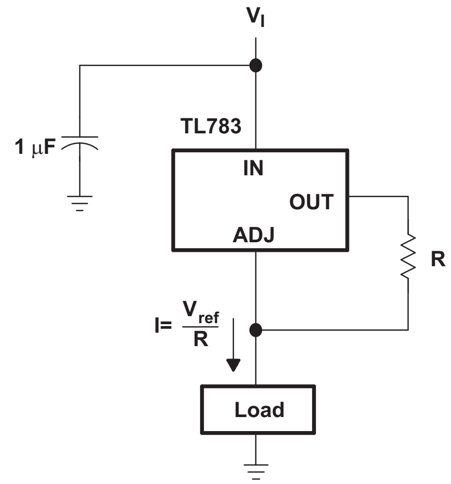


Figure 17. Current-Sourcing Regulator

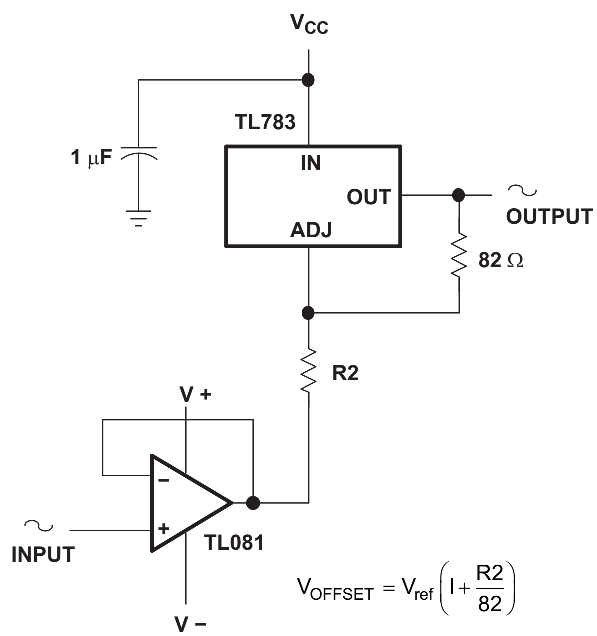


Figure 18. High-Voltage Unity-Gain Offset Amplifier

Application Information (continued)

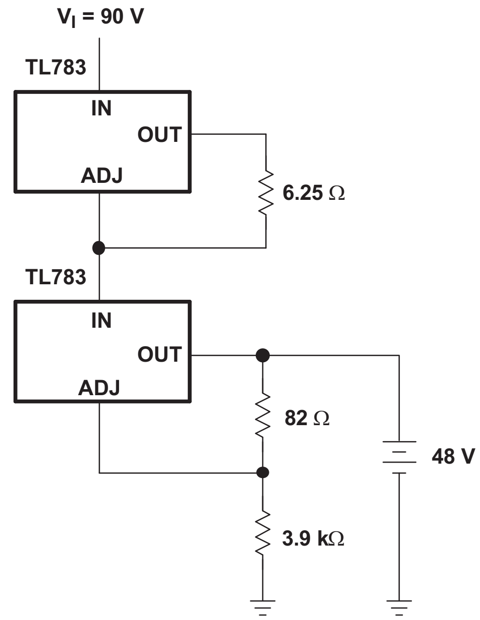
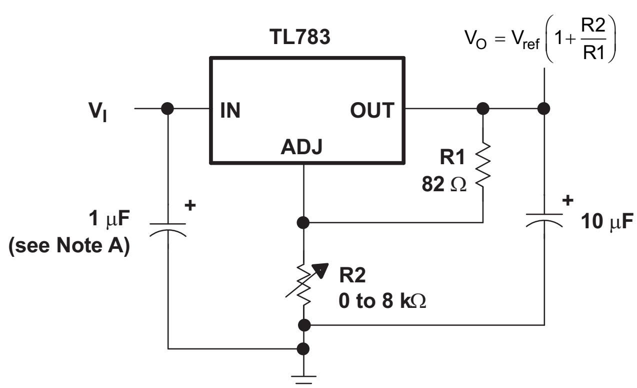


Figure 19. 48-V 200-mA Float Charger

9.2 Typical Application

The TL783 is typically used as an adjustable regulator.



A. Needed if device is more than 4 inches from filter capacitor

Figure 20. 1.25-V to 115-V Adjustable Regulator

9.2.1 Design Requirements

- Input and output decoupling capacitors for noise filtering.
- Resistor divider consisting of R1 and R2 to set the output voltage.

Typical Application (continued)

9.2.2 Detailed Design Procedure

The internal reference (see *Simplified Schematic*) generates 1.25 V nominal (V_{ref}) between OUT and ADJ. This voltage is developed across R1 and causes a constant current to flow through R1 and the programming resistor R2, giving an output voltage of:

$$V_O = V_{ref} (1 + R2 / R1) + I_{I(ADJ)} (R2)$$

or

$$V_O \approx V_{ref} (1 + R2 / R1)$$

The TL783 was designed to minimize the input current at ADJ and maintain consistency over line and load variations, thereby minimizing the associated (R2) error term.

To maintain $I_{I(ADJ)}$ at a low level, all quiescent operating current is returned to the output terminal. This quiescent current must be sunk by the external load and is the minimum load current necessary to prevent the output from rising. The recommended R1 value of 82 Ω provides a minimum load current of 15 mA. Larger values can be used when the input-to-output differential voltage is less than 125 V (see the output-current curve in Figure 12) or when the load sinks some portion of the minimum current.

9.2.2.1 Bypass Capacitors

The TL783 regulator is stable without bypass capacitors; however, any regulator becomes unstable with certain values of output capacitance if an input capacitor is not used. Therefore, the use of input bypassing is recommended whenever the regulator is located more than four inches from the power-supply filter capacitor. A 1-μF tantalum or aluminum electrolytic capacitor usually is sufficient.

Adjustment-terminal capacitors are not recommended for use on the TL783 because they can seriously degrade load transient response, as well as create a need for extra protection circuitry. Excellent ripple rejection presently is achieved without this added capacitor.

Due to the relatively low gain of the MOS output stage, output voltage dropout may occur under large-load transient conditions. The addition of an output bypass capacitor greatly enhances load transient response and prevents dropout. For most applications, it is recommended that an output bypass capacitor be used, with a minimum value of:

$$C_o (\mu F) = 15 / V_O$$

Larger values provide proportionally better transient-response characteristics.

Typical Application (continued)

9.2.2.2 Protection Circuitry

The TL783 regulator includes built-in protection circuits capable of guarding the device against most overload conditions encountered in normal operation. These protective features are current limiting, safe-operating-area protection, and thermal shutdown. These circuits protect the device under occasional fault conditions only. Continuous operation in the current limit or thermal shutdown mode is not recommended.

The internal protection circuits of the TL783 protect the device up to maximum-rated V_I as long as certain precautions are taken. If V_I is switched on instantaneously, transients exceeding maximum input ratings may occur, which can destroy the regulator. Usually, these are caused by lead inductance and bypass capacitors causing a ringing voltage on the input. In addition, when rise times in excess of 10 V/ns are applied to the input, a parasitic npn transistor in parallel with the DMOS output can be turned on, causing the device to fail. If the device is operated over 50 V and the input is switched on, rather than ramped on, a low-Q capacitor, such as tantalum or aluminum electrolytic, should be used, rather than ceramic, paper, or plastic bypass capacitors. A Q factor of 0.015, or greater, usually provides adequate damping to suppress ringing. Normally, no problems occur if the input voltage is allowed to ramp upward through the action of an ac line rectifier and filter network.

Similarly, when an instantaneous short circuit is applied to the output, both ringing and excessive fall times can result. A tantalum or aluminum electrolytic bypass capacitor is recommended to eliminate this problem. However, if a large output capacitor is used, and the input is shorted, addition of a protection diode may be necessary to prevent capacitor discharge through the regulator. The amount of discharge current delivered is dependent on output voltage, size of capacitor, and fall time of V_I. A protective diode (see Figure 21) is required only for capacitance values greater than:

$$C_o\ (\mu F) = 3 \times 10^4 / (V_O)^2$$

Care always should be taken to prevent insertion of regulators into a socket with power on. Power should be turned off before removing or inserting regulators.

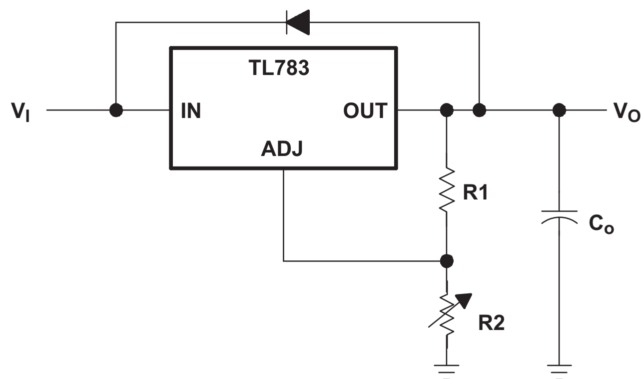


Figure 21. Regulator With Protective Diode

Typical Application (continued)

9.2.2.3 Load Regulation

The current-set resistor (R1) should be located close to the regulator output terminal, rather than near the load. This eliminates long line drops from being amplified, through the action of R1 and R2, to degrade load regulation. To provide remote ground sensing, R2 should be near the load ground.

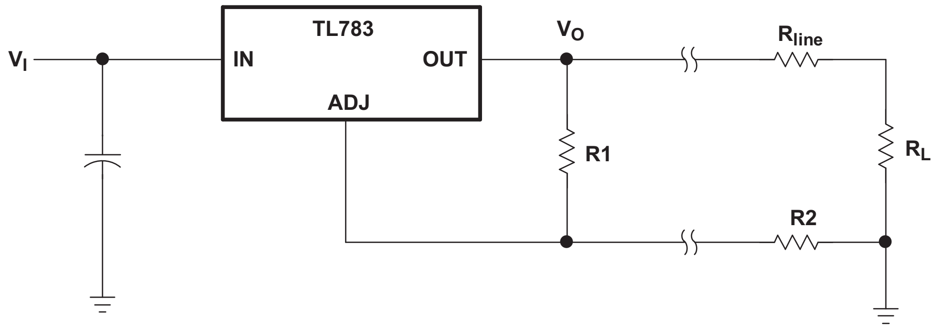


Figure 22. Regulator With Current-Set Resistor

9.2.3 Application Curves

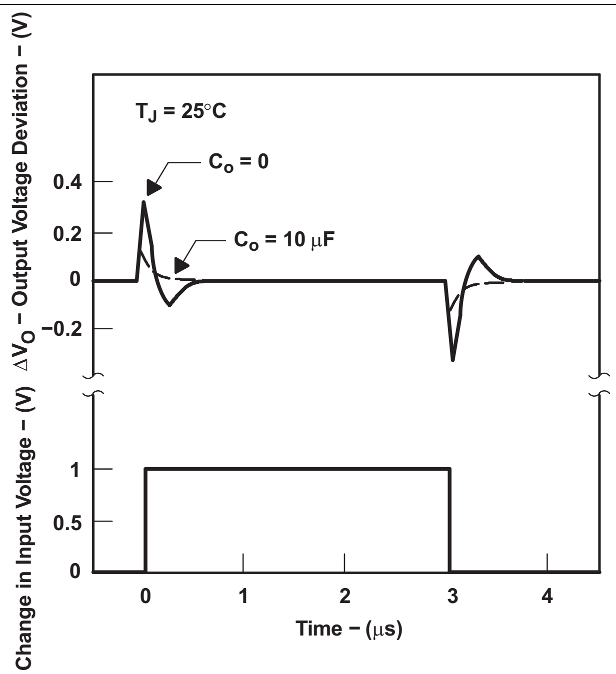


Figure 23. Line Transient Response

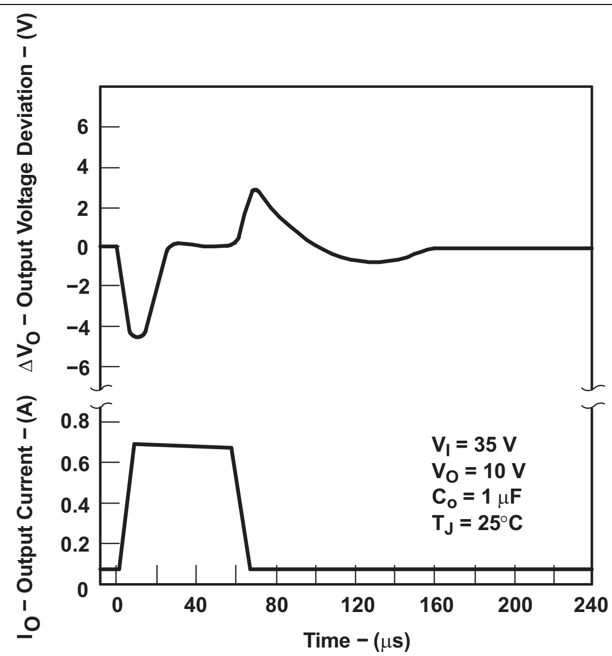


Figure 24. Load Transient Response

10 Power Supply Recommendations

A decoupling capacitor is needed on the IN pin of the TL783 if the TL783 is more than 4 inches from its power supply's filter capacitor. The differential input and output voltage levels are detailed in *Recommended Operating Conditions*.

11 Layout

11.1 Layout Guidelines

Input and output traces should be thick enough to handle desired currents, which can reach up to 700 mA on the output. ADJ pin traces can be smaller because the adjustment current is negligible.

11.2 Layout Example

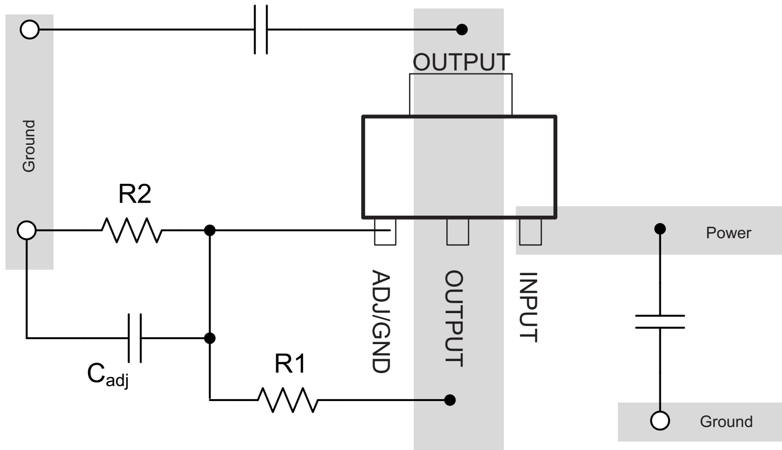


Figure 25. Layout Example

12 Device and Documentation Support

12.1 Trademarks

All trademarks are the property of their respective owners.

12.2 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

12.3 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TL783CKCSE3	Active	Production	TO-220 (KCS) | 3	50 | TUBE	Yes	SN	N/A for Pkg Type	0 to 125	TL783C
TL783CKCSE3.A	Active	Production	TO-220 (KCS) | 3	50 | TUBE	Yes	SN	N/A for Pkg Type	0 to 125	TL783C

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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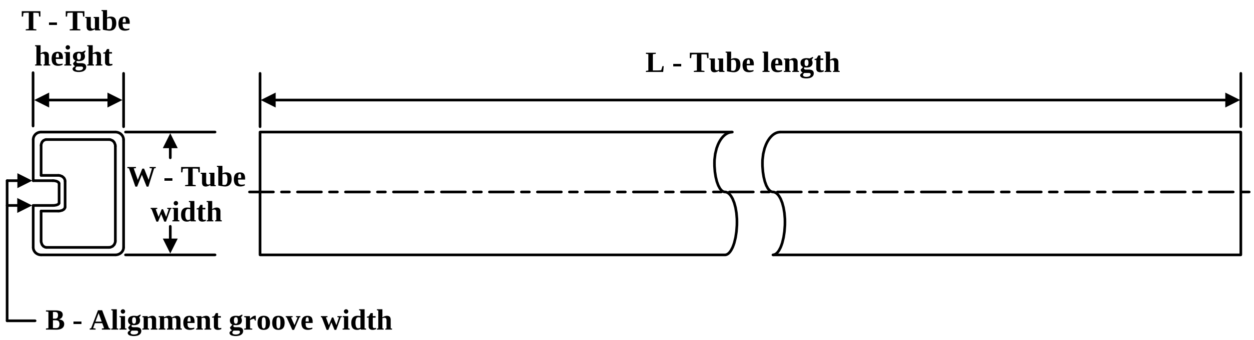
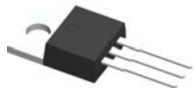
TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
TL783CKCSE3	KCS	TO-220	3	50	532	34.1	700	9.6
TL783CKCSE3.A	KCS	TO-220	3	50	532	34.1	700	9.6

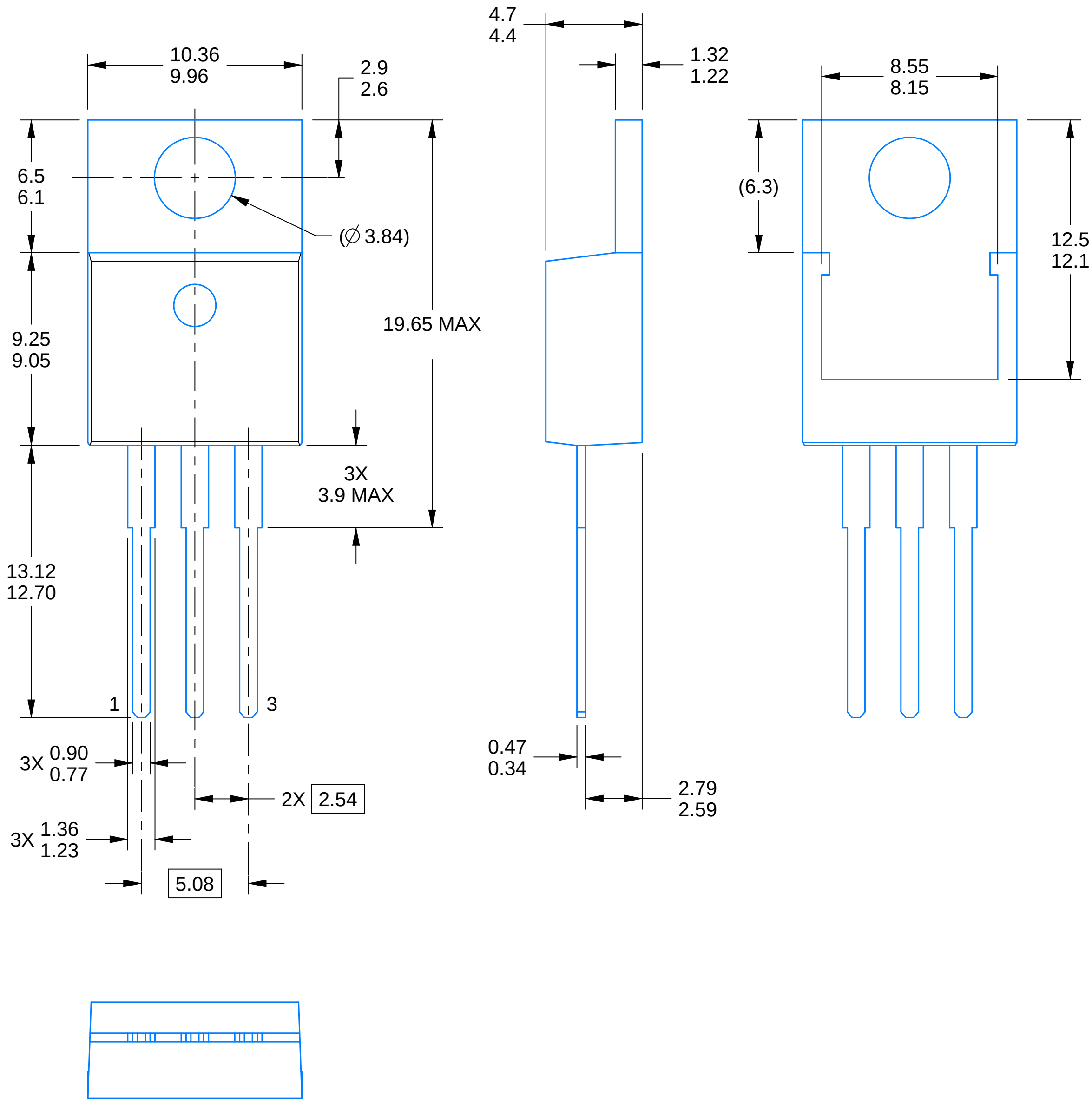


PACKAGE OUTLINE

KCS0003B

TO-220 - 19.65 mm max height

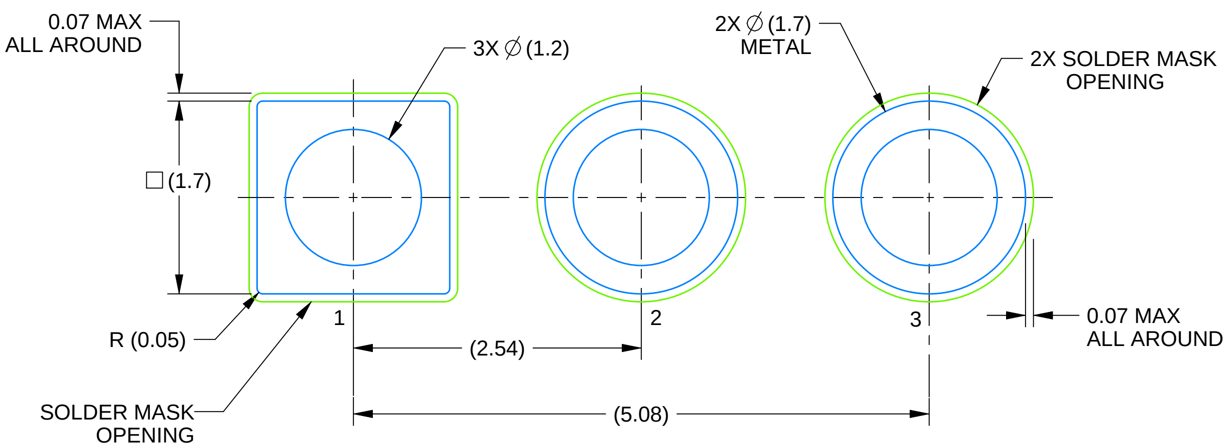
TO-220



4222214/B 08/2018

NOTES:

1. Dimensions are in millimeters. Any dimension in brackets or parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration TO-220.



LAND PATTERN EXAMPLE
NON-SOLDER MASK DEFINED
SCALE:15X