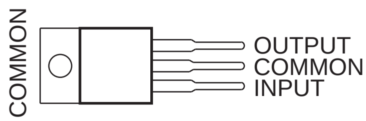
TL780 SERIES
POSITIVE-VOLTAGE REGULATORS

SLVS055M – APRIL 1981 – REVISED OCTOBER 2006

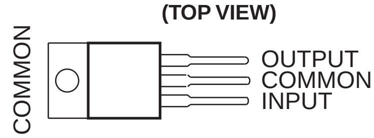
FEATURES

- ±1% Output Tolerance at 25°C
- ±2% Output Tolerance Over Full Operating Range
- Thermal Shutdown
- Internal Short-Circuit Current Limiting
- Pinout Identical to μA7800 Series
- Improved Version of μA7800 Series

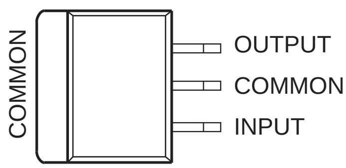
KC (TO-220) PACKAGE
(TOP VIEW)



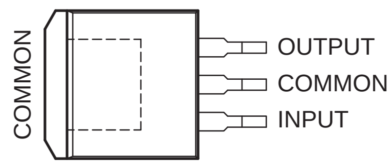
KCS (TO-220) PACKAGE
(TOP VIEW)



KTE PACKAGE
(TOP VIEW)



KTT (TO-263) PACKAGE
(TOP VIEW)



DESCRIPTION/ORDERING INFORMATION

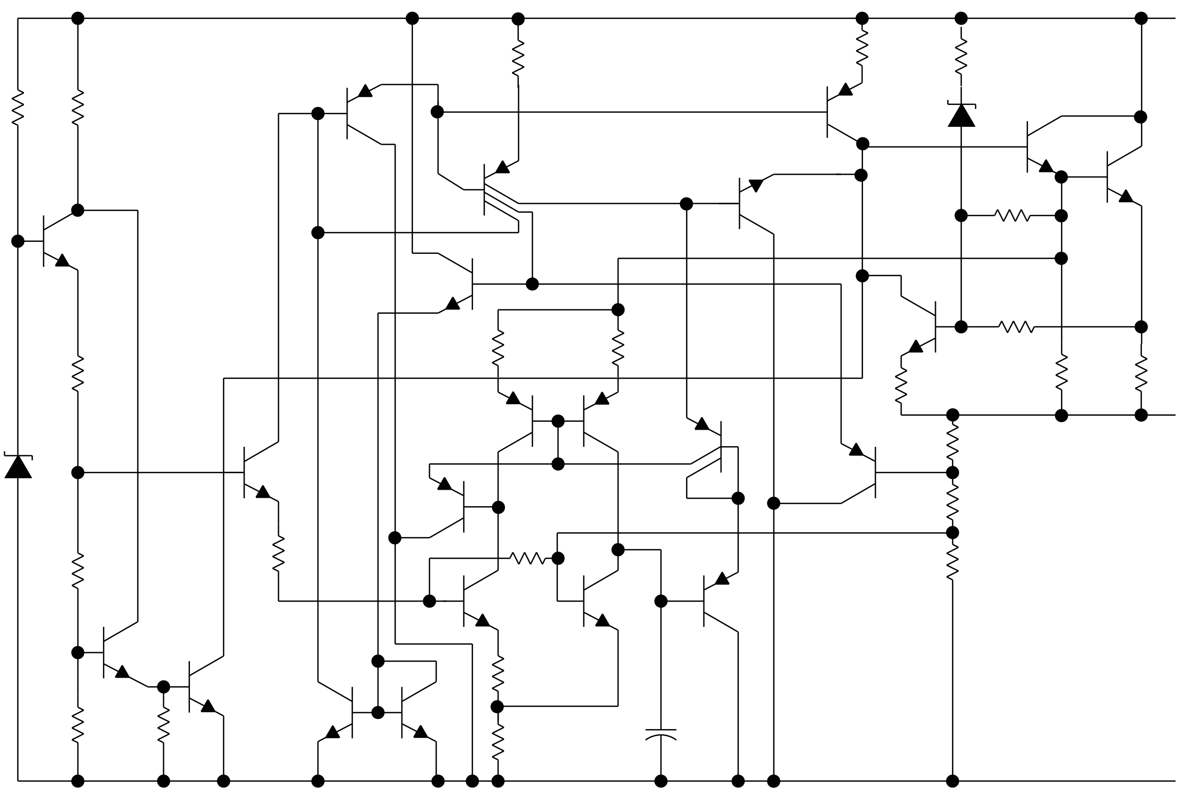
Each fixed-voltage precision regulator in the TL780 series is capable of supplying 1.5 A of load current. A unique temperature-compensation technique, coupled with an internally trimmed band-gap reference, has resulted in improved accuracy when compared to other three-terminal regulators. Advanced layout techniques provide excellent line, load, and thermal regulation. The internal current-limiting and thermal-shutdown features essentially make the devices immune to overload.

ORDERING INFORMATION

T_J	V_O TYP (V)	PACKAGE(1)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 125°C	5	PowerFLEX™ – KTE	Reel of 2000	TL780-05CKTER	TL780-05C
		TO-220 – KC	Tube of 50	TL780-05CKC	TL780-05C
		TO-220, short shoulder – KCS	Tube of 20	TL780-05KCS	TL780-05
		TO-263 – KTT	Reel of 500	TL780-05CKTTR	TL780-05C
	12	TO-220 – KC	Tube of 50	TL780-12CKC	TL780-12C
		TO-220, short shoulder – KCS	Tube of 20	TL780-12KCS	TL780-12
	15	TO-220 – KC	Tube of 50	TL780-15CKC	TL780-15C
		TO-220, short shoulder – KCS	Tube of 20	TL780-15KCS	TL780-15

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

SCHEMATIC



Absolute Maximum Ratings(1)

over operating temperature ranges (unless otherwise noted)

		MIN	MAX	UNIT
V_I	Input voltage		35	V
T_J	Operating virtual junction temperature		150	°C
	Lead temperature 1,6 mm (1/16 in) from case for 10 s		260	°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.

Package Thermal Data(1)

PACKAGE	BOARD	θ_{JP} (2)	θ_{JC}	θ_{JA}
PowerFLEX (KTE)	High K, JESD 51-5	2.7°C/W	11.6°C/W	23.3°C/W
TO-220 (KC/KCS)	High K, JESD 51-5	3°C/W	17°C/W	19°C/W
TO-263 (KTT)	High K, JESD 51-5	1.91°C/W	18°C/W	25.3°C/W

(1) Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) – T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activated at power levels slightly above or below the rated dissipation.
(2) For packages with exposed thermal pads, such as QFN, PowerPAD™, or PowerFLEX, θ_{JP} is defined as the thermal resistance between the die junction and the bottom of the exposed pad.

Recommended Operating Conditions

			MIN	MAX	UNIT
V_I	Input voltage	TL780-05C	7	25	V
		TL780-12C	14.5	30	
		TL780-15C	17.5	30	
I_O	Output current			1.5	A
T_J	Operating virtual junction temperature		0	125	°C

Electrical Characteristics

at specified virtual junction temperature, V_I = 10 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_J(1)	TL780-05C MIN	TYP	MAX	UNIT
Output voltage	I_O = 5 mA to 1 A, P ≤ 15 W, V_I = 7 V to 20 V	25°C	4.95	5	5.05	V
		0°C to 125°C	4.9		5.1	
Input voltage regulation	V_I = 7 V to 25 V	25°C		0.5	5	mV
	V_I = 8 V to 12 V			0.5	5	
Ripple rejection	V_I = 8 V to 18 V, f = 120 Hz	0°C to 125°C	70	85		dB
Output voltage regulation	I_O = 5 mA to 1.5 A	25°C		4	25	mV
	I_O = 250 mA to 750 mA			1.5	15	
Output resistance	f = 1 kHz	0°C to 125°C		0.0035		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		0.25		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		75		µV
Dropout voltage	I_O = 1 A	25°C		2		V
Input bias current		25°C		5	8	mA
Input bias-current change	V_I = 7 V to 25 V	0°C to 125°C		0.7	1.3	mA
	I_O = 5 mA to 1 A			0.003	0.5	
Short-circuit output current		25°C		750		mA
Peak output current		25°C		2.2		A

(1) Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-µF capacitor across the input and a 0.22-µF capacitor across the output.

Electrical Characteristics

at specified virtual junction temperature, V_I = 19 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_J(1)	TL780-12C			UNIT
			MIN	TYP	MAX	
Output voltage	I_O = 5 mA to 1 A, P ≤ 15 W, V_I = 14.5 V to 27 V	25°C	11.88	12	12.12	V
		0°C to 125°C	11.76		12.24	
Input voltage regulation	V_I = 14.5 V to 30 V	25°C		1.2	12	mV
	V_I = 16 V to 22 V			1.2	12	
Ripple rejection	V_I = 15 V to 25 V, f = 120 Hz	0°C to 125°C	65	80		dB
Output voltage regulation	I_O = 5 mA to 1.5 A	25°C		6.5	60	mV
	I_O = 250 mA to 750 mA			2.5	36	
Output resistance	f = 1 kHz	0°C to 125°C		0.0035		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		0.6		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		180		µV
Dropout voltage	I_O = 1 A	25°C		2		V
Input bias current		25°C		5.5	8	mA
Input bias-current change	V_I = 14.5 V to 30 V	0°C to 125°C		0.4	1.3	mA
	I_O = 5 mA to 1 A			0.03	0.5	
Short-circuit output current		25°C		350		mA
Peak output current		25°C		2.2		A

(1) Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-µF capacitor across the input and a 0.22-µF capacitor across the output.

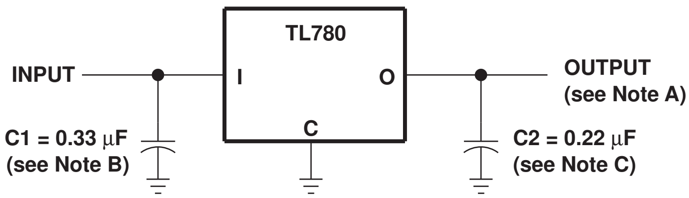
Electrical Characteristics

at specified virtual junction temperature, V_I = 23 V, I_O = 500 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_J(1)	TL780-15C			UNIT
			MIN	TYP	MAX	
Output voltage	I_O = 5 mA to 1 A, P ≤ 15 W, V_I = 17.5 V to 30 V	25°C	14.85	15	15.15	V
		0°C to 125°C	14.7		15.3	
Input voltage regulation	V_I = 17.5 V to 30 V	25°C		1.5	15	mV
	V_I = 20 V to 26 V			1.5	15	
Ripple rejection	V_I = 18.5 V to 28.5 V, f = 120 Hz	0°C to 125°C	60	75		dB
Output voltage regulation	I_O = 5 mA to 1.5 A	25°C		7	75	mV
	I_O = 250 mA to 750 mA			2.5	45	
Output resistance	f = 1 kHz	0°C to 125°C		0.0035		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		0.62		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		225		µV
Dropout voltage	I_O = 1 A	25°C		2		V
Input bias current		25°C		5.5	8	mA
Input bias-current change	V_I = 17.5 V to 30 V	0°C to 125°C		0.4	1.3	mA
	I_O = 5 mA to 1 A			0.02	0.5	
Short-circuit output current		25°C		230		mA
Peak output current		25°C		2.2		A

(1) Pulse-testing techniques maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-µF capacitor across the input and a 0.22-µF capacitor across the output.

PARAMETER MEASUREMENT INFORMATION



A. Permanent damage can occur when OUTPUT is pulled below ground.

B. C1 is required when the regulator is far from the power-supply filter.

C. C2 is not required for stability; however, transient response is improved.

Figure 1. Test Circuit

APPLICATION INFORMATION

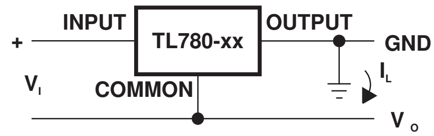


Figure 2. Positive Regulator in Negative Configuration (V_I Must Float)

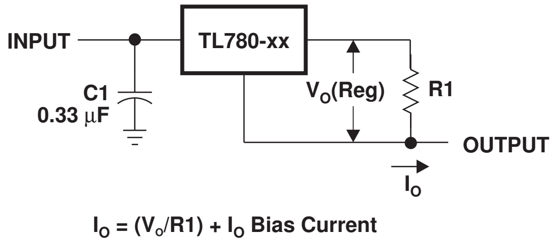


Figure 3. Current Regulator

Operation With a Load Common to a Voltage of Opposite Polarity

In many cases, a regulator powers a load that is not connected to ground, but instead, is connected to a voltage source of opposite polarity (e.g., operational amplifiers, level-shifting circuits, etc.). In these cases, a clamp diode should be connected to the regulator output as shown in Figure 4. This protects the regulator from output polarity reversals during startup and short-circuit operation.

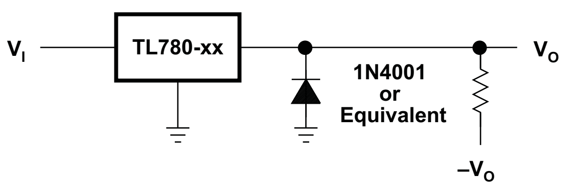


Figure 4. Output Polarity-Reversal-Protection Circuit

Reverse-Bias Protection

Occasionally, the input voltage to the regulator can collapse faster than the output voltage. This, for example, could occur when the input supply is crowbarred during an output overvoltage condition. If the output voltage is greater than approximately 7 V, the emitter-base junction of the series pass element (internal or external) could break down and be damaged. To prevent this, a diode shunt can be employed, as shown in Figure 5.

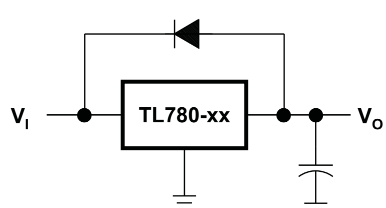


Figure 5. Reverse-Bias-Protection Circuit

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
TL780-05CKC	NRND	TO-220	KC	3	50	Pb-Free (RoHS)	CU SN	N / A for Pkg Type
TL780-05CKTER	NRND	PFM	KTE	3	2000	TBD	CU SNPB	Level-1-220C-UNLIM
TL780-05CKTTR	ACTIVE	DDPAK/ TO-263	KTT	3	500	Green (RoHS & no Sb/Br)	CU SN	Level-3-245C-168 HR
TL780-05CKTTRG3	ACTIVE	DDPAK/ TO-263	KTT	3	500	Green (RoHS & no Sb/Br)	CU SN	Level-3-245C-168 HR
TL780-05KCS	ACTIVE	TO-220	KCS	3	50	Pb-Free (RoHS)	CU SN	N / A for Pkg Type
TL780-05KCSE3	ACTIVE	TO-220	KCS	3	50	Pb-Free (RoHS)	CU SN	N / A for Pkg Type
TL780-12CKC	NRND	TO-220	KC	3	50	Pb-Free (RoHS)	CU SN	N / A for Pkg Type
TL780-12CKCE3	NRND	TO-220	KC	3	50	Pb-Free (RoHS)	CU SN	N / A for Pkg Type
TL780-12CKTER	OBSOLETE	PFM	KTE	3		TBD	Call TI	Call TI
TL780-12KCS	ACTIVE	TO-220	KCS	3	50	Pb-Free (RoHS)	CU SN	N / A for Pkg Type
TL780-15CKC	NRND	TO-220	KC	3	50	Pb-Free (RoHS)	CU SN	N / A for Pkg Type
TL780-15CKTER	OBSOLETE	PFM	KTE	3		TBD	Call TI	Call TI
TL780-15KCS	ACTIVE	TO-220	KCS	3	50	Pb-Free (RoHS)	CU SN	N / A for Pkg Type

[1] The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

[2] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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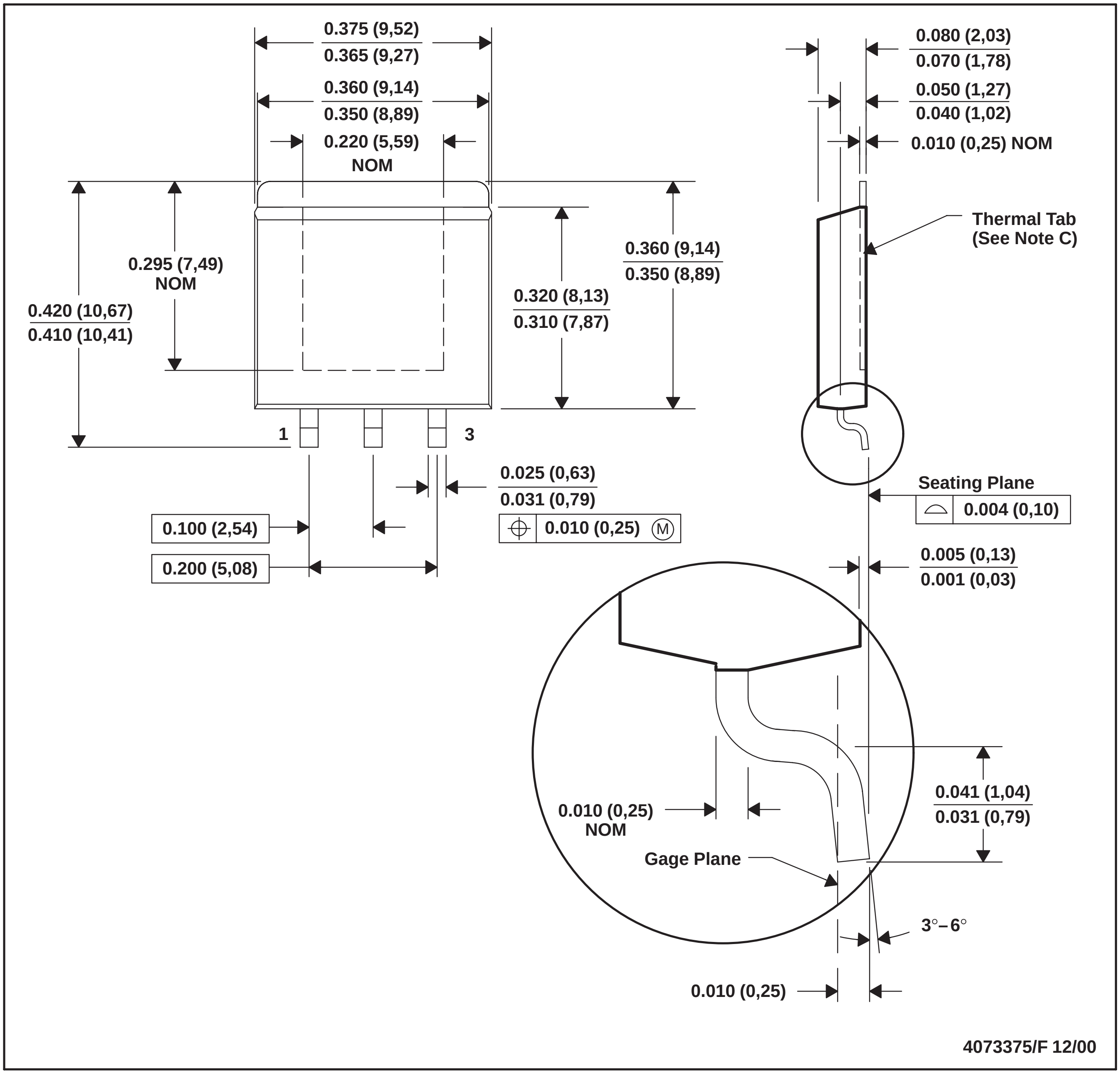
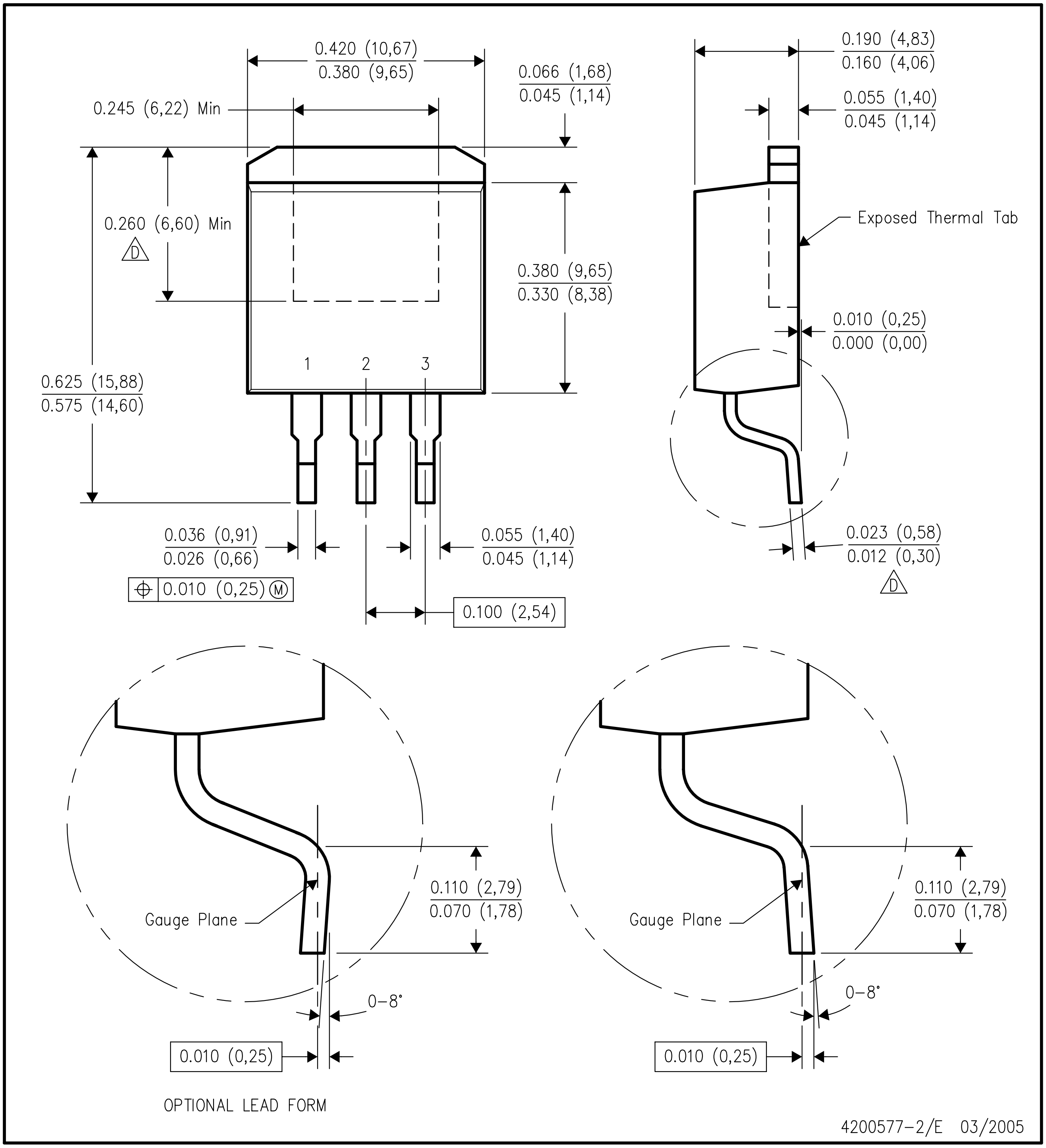
KTE (R-PSFM-G3) **PowerFLEX™ PLASTIC FLANGE-MOUNT**



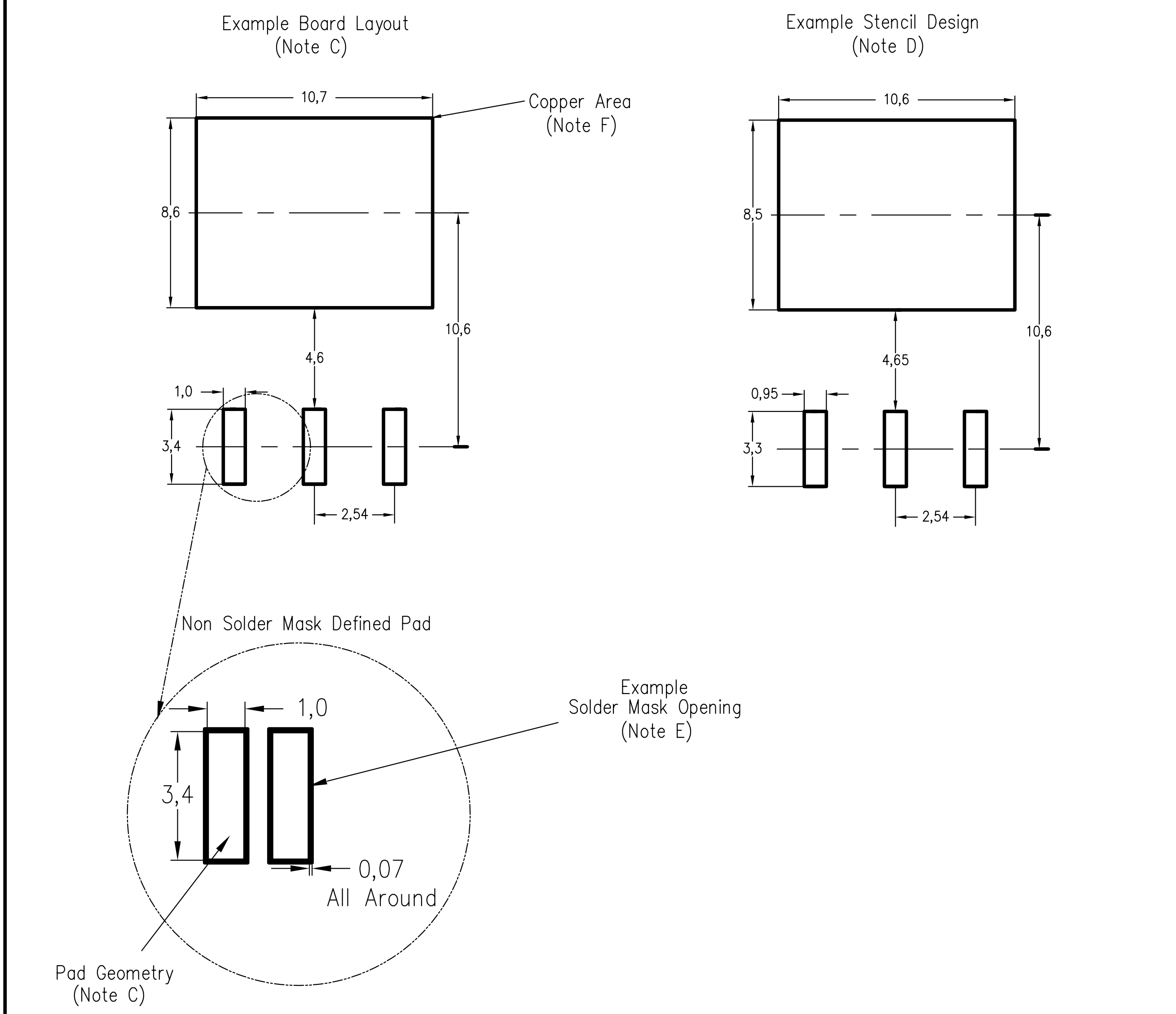
NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. The center lead is in electrical contact with the thermal tab.
D. Dimensions do not include mold protrusions, not to exceed 0.006 (0,15).
E. Falls within JEDEC MO-169

KTT (R–PSFM–G3) PLASTIC FLANGE–MOUNT PACKAGE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion. Mold flash or protrusion not to exceed 0.005 (0,13) per side.
D. Falls within JEDEC TO–263 variation AA, except minimum lead thickness and minimum exposed pad length.

KTT (R–PSFM–G3)



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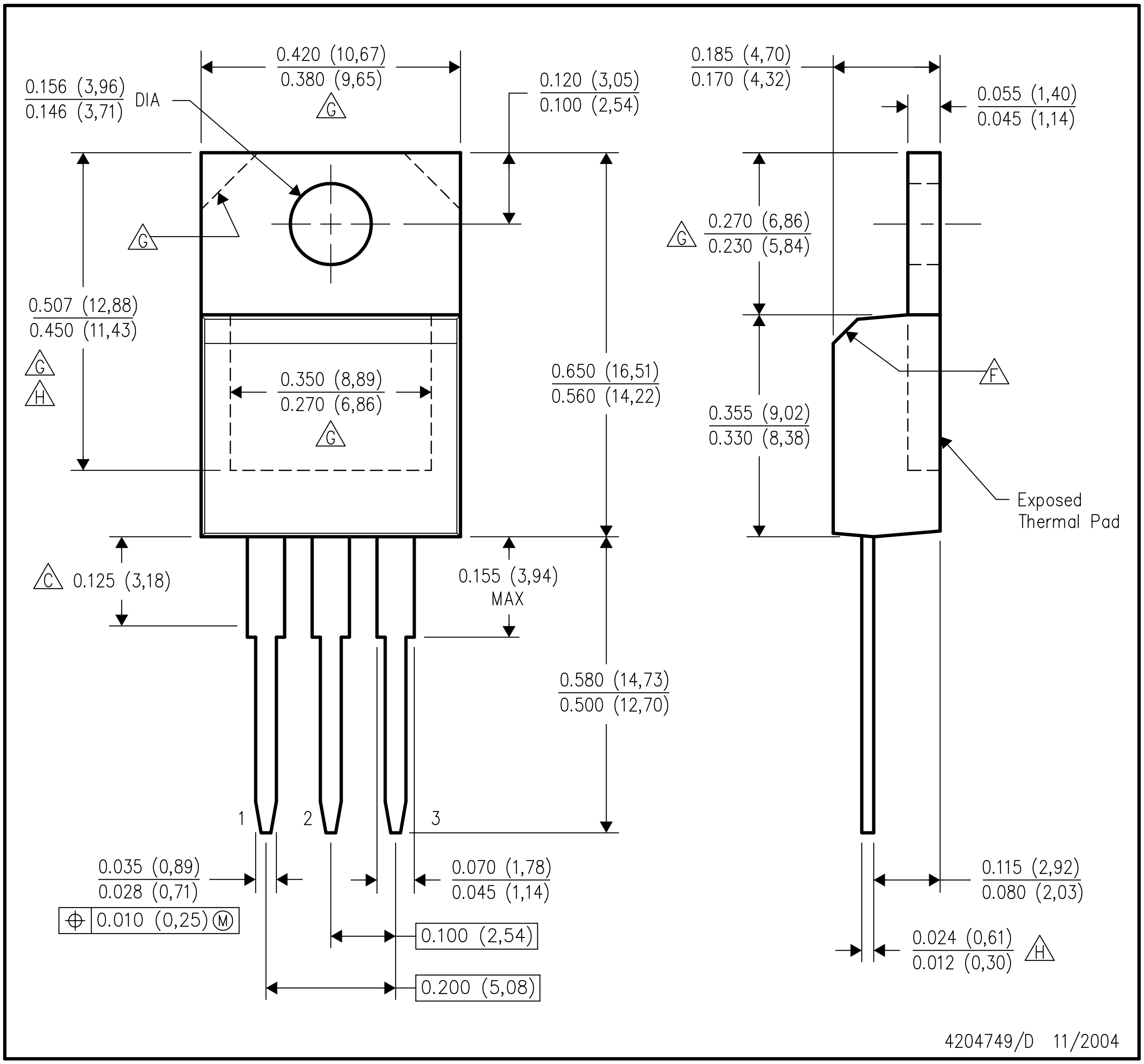
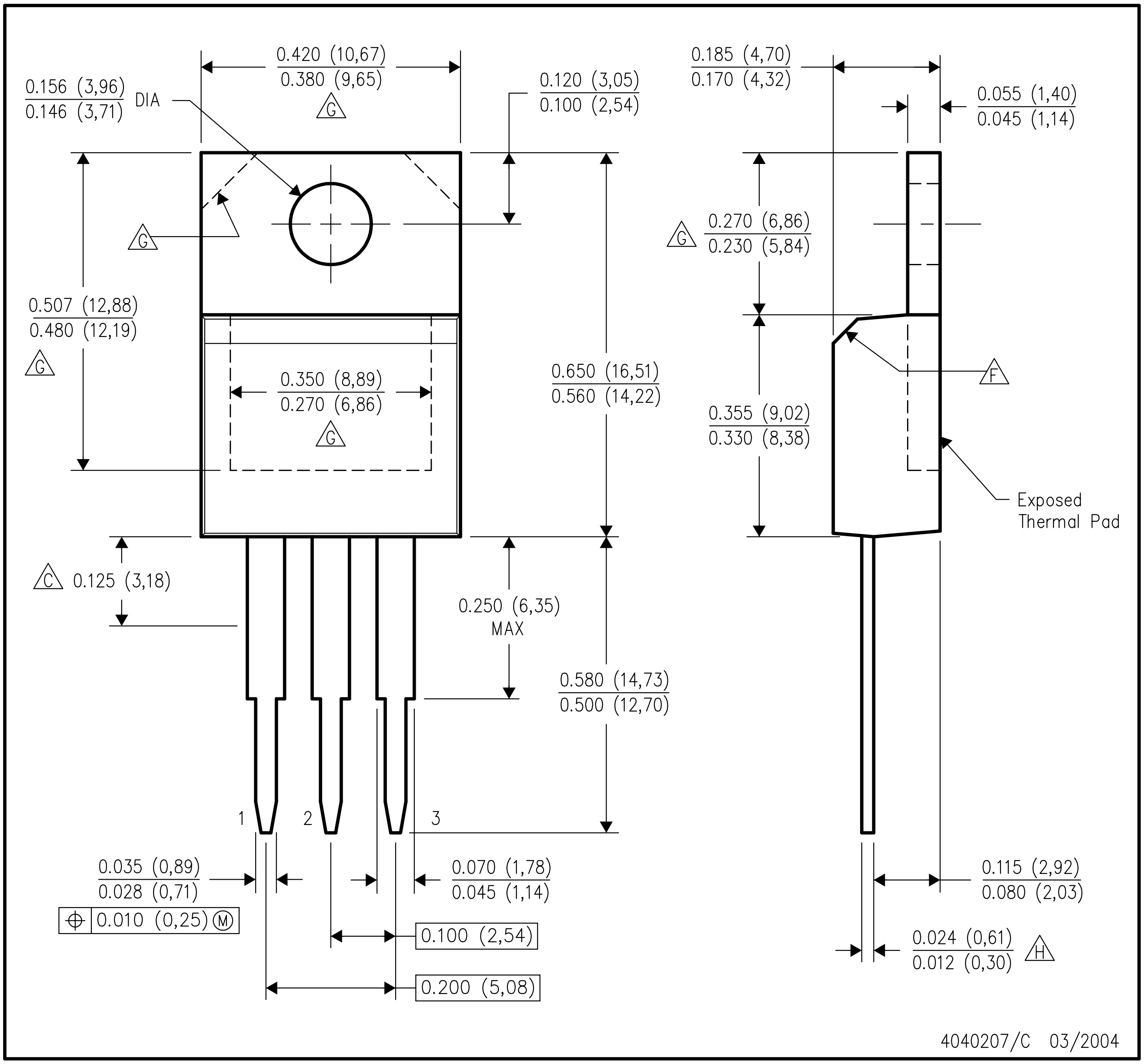
NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–SM–782 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.
F. This package is designed to be soldered to a thermal pad on the board. Refer to the Product Datasheet for specific thermal information, via requirements, and recommended thermal pad size. For thermal pad sizes larger than shown a solder mask defined pad is recommended in order to maintain the solderable pad geometry while increasing copper area.

KCS (R–PSFM–T3) PLASTIC FLANGE–MOUNT PACKAGE



NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Lead dimensions are not controlled within this area.
- D. All lead dimensions apply before solder dip.
- E. The center lead is in electrical contact with the mounting tab.
- F. The chamfer is optional.
- G. Thermal pad contour optional within these dimensions.
- H. Falls within JEDEC TO–220 variation AB, except minimum lead thickness and minimum exposed pad length.

KC (R–PSFM–T3) PLASTIC FLANGE–MOUNT PACKAGE



NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Lead dimensions are not controlled within this area.
- D. All lead dimensions apply before solder dip.
- E. The center lead is in electrical contact with the mounting tab.
- F. The chamfer is optional.
- G. Thermal pad contour optional within these dimensions.
- H. Falls within JEDEC TO–220 variation AB, except minimum lead thickness.

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Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265