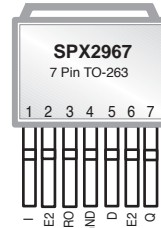


# 400mA Low Dropout Voltage Regulator

## FEATURES

- Output voltage tolerance  $\leq 2\%$
- 400mA current capability
- Low Dropout Voltage
- Very low standby current consumption
- Input voltage up to 40V
- Overvoltage protection up to 60V ( $\leq 400\text{ms}$ )
- Reset function down to 1V output voltage
- ESD protection up to 2000V
- Adjustable reset time
- On/Off logic
- Over temperature protection
- Reverse polarity protection
- Short-circuit protection
- Wide temperature range



*Now Available in Lead Free Packaging*

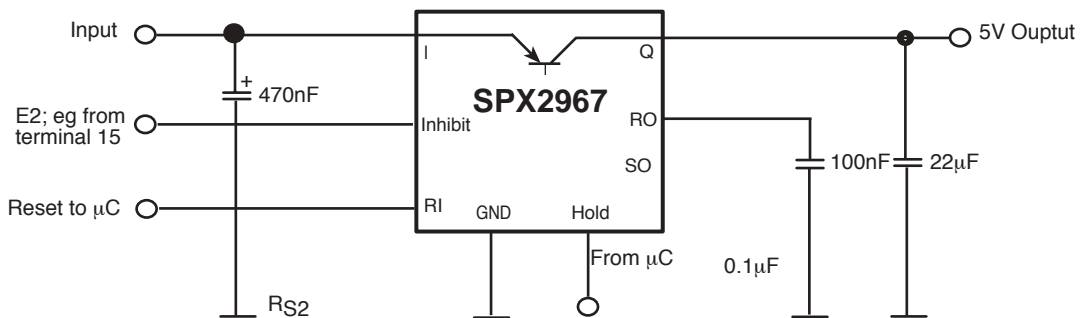
## APPLICATIONS

- Automotive
- Industrial
- Wireless Base Station

## DESCRIPTION

Sipex's SPX2967 is a 5 volt low dropout voltage regulator for automotive applications. It supplies output current at 400mA. The IC has short-circuit protection and has an overtemperature protection circuit. The part is available in 7 pin TO-220 and TO-263 packages.

## TYPICAL APPLICATION CIRCUIT



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## APPLICATIONS INFORMATION

The IC regulates an input voltage  $V_I$  in the range of  $5.5\text{ V} < V_I < 40\text{ V}$  to a nominal output voltage of  $V_O = 5.0\text{V}$ . A reset signal is generated for an output voltage of  $V_O < V_{RT}$  (typ. 4.5V). The reset delay can be set with an external capacitor. The device has two logic inputs. A voltage of  $V_{E2} > 4.0\text{V}$  given to the E2-pin (e.g. by ignition) turns the device on. Depending on the voltage on pin E6 the IC may be hold in active-state even if  $V_{E2}$  goes down to low level. This makes it simple to implement a self-holding circuit without external components. When the device is turned off, the output voltage drops to 0V and current consumption tends towards 0  $\mu\text{A}$ .

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## DESIGN NOTES FOR EXTERNAL COMPONENTS

The input capacitor  $C_I$  is necessary for compensation of line influences. The resonant circuit consisting of lead inductance and input capacitance can be damped by a resistor of approximately  $1\Omega$  in series with  $C_I$ . The output capacitor is necessary for the stability of the regulating circuit. Stability is guaranteed at values of  $\geq 22\mu\text{F}$  and an ESR of less than  $3\Omega$  within the operating temperature range.

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## CIRCUIT DESCRIPTION

The control amplifier compares a reference voltage, which is kept highly accurate by resistance adjustment, to a voltage that is proportional to the output voltage and drives the base of the series transistor via a buffer. Saturation control as a function of the load current prevents and over-saturation of the power element.

The reset output RO is in high state if the voltage on the delay capacitor  $C_D$  greater than or equal to  $V_{UD}$ . The delay capacitance  $C_D$  is charged with the current  $I_D$  for output voltages greater than the reset threshold  $V_{RT}$ . If the output voltage gets lower than  $V_{RT}$  a fast discharge of the delay capacitor  $C_D$  sets in and as soon as  $V_{CD}$  gets lower than  $V_{LD}$  the reset output RO is set to low-level. The reset delay can be set within wide range by dimensioning the capacitance of the external capacitor.

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## PIN DESCRIPTION

PIN NUMBER	PIN NAME	DESCRIPTION
1	I	<b>Input;</b> Block to GND directly at the IC with a ceramic capacitor.
2	E2	<b>Inhibit;</b> Device is turned on by High signal on this pin; internal pulldown resistor of $100\text{k}\Omega$
3	RO	<b>Reset Output;</b> The open-collector output is internally linked to Q via a $30\text{k}\Omega$ resistor. Keep it open if not needed.
4	GND	<b>Ground;</b> connected to rear of chip
5	D	<b>Reset Delay;</b> connect via capacitor to GND for setting delay
6	E6	<b>Hold;</b> see truth table for function; this input is connected to output voltage via a pull up resistor of $50\text{k}\Omega$
7	Q	<b>5V Output;</b> block to GND with $22\mu\text{F}$ capacitor, ESR $< 3\Omega$

## TRUTH TABLE FOR TURN-ON/TURN -OFF LOGIC

Pin 2, Inhibit	Pin 6, Hold	$V_Q$	Comments
L	X	OFF	Initial state, Inhibit internally pulled up
H	X	ON	Regulator switched on via Inhibit, by ignition for example
H	L	ON	Hold clamped active to ground by controller while Inhibit is still high.
X	L	ON	Previous state remains, even ignition is shut off: self-holding state
L	L	ON	Ignition shut off while regulator is in self-holding state
L	H	OFF	Regulator shut down by releasing of Hold while Inhibit remains Low, final state. No active clamping required by external self-holding circuit ( $\mu C$ ) to keep regulator in off-state

**Pin 2, Inhibit:** E2 Enable function, active High

**Pin 6, Hold:** E6 Hold and release function, active Low

## ABSOLUTE MAXIMUM RATINGS

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications below is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

Parameter	Symbol	Limit Values		Unit	Notes
		min.	max.		
<b>Input</b>					
Voltage	$V_I$	-42	42	V	-
Voltage	$V_I$	-	60	V	$T_{\leq} 400ms$
Current	$I_I$	-	-	-	Internally Limited
<b>Reset Output</b>					
Voltage	$V_{RO}$	-0.3	7	V	-
Current	$I_{RO}$	-	-	-	Internally Limited
<b>Reset Delay</b>					
Voltage	$V_D$	-0.3	42	V	-
Current	$V_D$	-	-	-	-
<b>Output</b>					
Voltage	$V_Q$	-0.3	7	V	-
Current	$I_Q$	-	-	-	Internally Limited
<b>Inhibit</b>					
Voltage	$V_{E2}$	-42	42	V	-
Current	$I_{E2}$	-5	5	mA	$t_{\leq} 400ms$

## ABSOLUTE MAXIMUM RATINGS

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications below is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

Parameter	Symbol	Limit Values		Unit	Notes
<b>Hold</b>					
Voltage	$V_{E6}$	-0.3	7	V	-
Current	$I_{E6}$	-	-	mA	Internally Limited
<b>GND</b>					
Current	$I_{GND}$	-0.5	-	A	-
<b>Temperatures</b>					
Junction Temperature	$T_J$	-40	150	°C	-
Storage Temperature	$T_{stg}$	-50	150	°C	-
<b>Operating Range</b>					
Input Voltage	$V_I$	5.5	40	V	-
<b>Thermal Resistance</b>					
Junction Ambient	$R_{thja}$	-	65	K/W	7 Pin TO220 package
Junction-case	$R_{thjc}$	-	6	K/W	7 Pin TO220 package
Junction-case	$Z_{thjc}$	-	2	K/W	7 Pin TO220 package
Junction Ambient	$R_{thja}$	-	70	K/W	7 Pin TO263 package
Junction-case	$R_{thjc}$	-	6	K/W	7 Pin TO263 package
Junction-case	$Z_{thjc}$	-	2	K/W	7 Pin TO263 package

## ELECTRICAL CHARACTERISTICS

$V_{IN} = 13.5V$ ;  $-40^{\circ}C < T_J < 125^{\circ}C$ . The ♦ denotes the specifications which apply over the full operating temperature range, unless otherwise specified.

Parameter	Sym	Min	Typ	Max	Units	Conditions
Output Volatage	$V_O$	4.9	5.0	5.1	V	$5mA \leq I_O \leq 400mA$ $6V \leq V_I \leq 26V$
Output Volatage	$V_O$	4.9	5.0	5.1	V	$5mA \leq I_O \leq 150mA$ $6V \leq V_I \leq 40V$
Output Current Limiting	$I_O$	500	-	-	mA	$T_J = 25^{\circ}C$
Current Consumption $I_q = I_I - I_O$	$I_q$	-	-	50	$\mu A$	IC turned off
Current Consumption $I_q = I_I - I_O$	$I_q$	-	1.0	10	$\mu A$	$T_J = 25^{\circ}C$ IC turned off
Current Consumption $I_q = I_I - I_O$	$I_q$	-	1.3	4	mA	$I_O = 5mA$ IC turned on
Current Consumption $I_q = I_I - I_O$	$I_q$	-	-	60	mA	$I_O = 400mA$
Current Consumption $I_q = I_I - I_O$	$I_q$	-	-	80	mA	$I_O = 400mA$ $V_r = 5V$
Drop Voltage	$V_{DR}$	-	0.3	0.6	V	$I_O = 400mA$ (note 1)
Load Regulation	$\Delta V_O$	-	-	50	mV	$5mA \leq I_O \leq 400mA$
Supply-voltage regulation	$\Delta V_O$	-	15	25	mV	$V_I = 6$ to $36V$ $I_O = 5mA$
Supply-voltage rejection	$\Delta V_O$	-	54	-	dB	$f_r = 100Hz$ $V_r = 0.5V$
Longterm stability	$\Delta V_O$	-	0	-	mV	1000 h

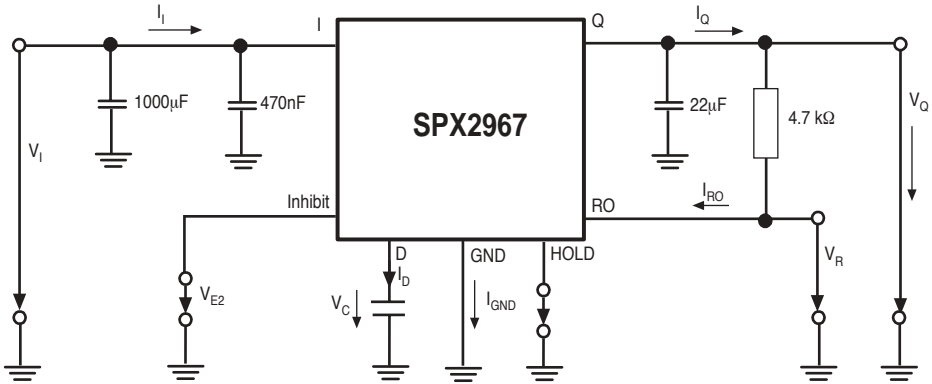
**Note 1:** Drop voltage =  $V_I - V_O$  measured when the output voltage has dropped 100mV from the nominal value obtained at 13.5V input.

## ELECTRICAL CHARACTERISTICS

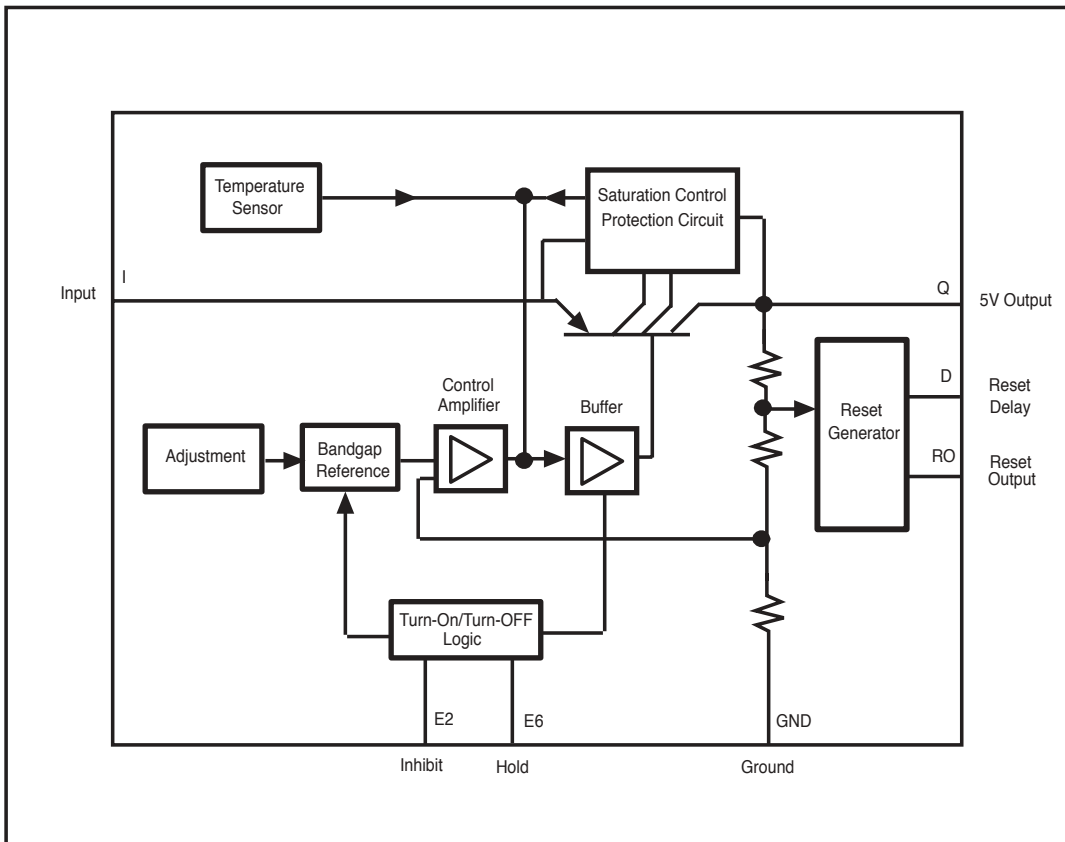
$V_{IN} = 13.5V$ ;  $-40^{\circ}C < T_J < 125^{\circ}C$ . The  $\blacklozenge$  denotes the specifications which apply over the full operating temperature range, unless otherwise specified.

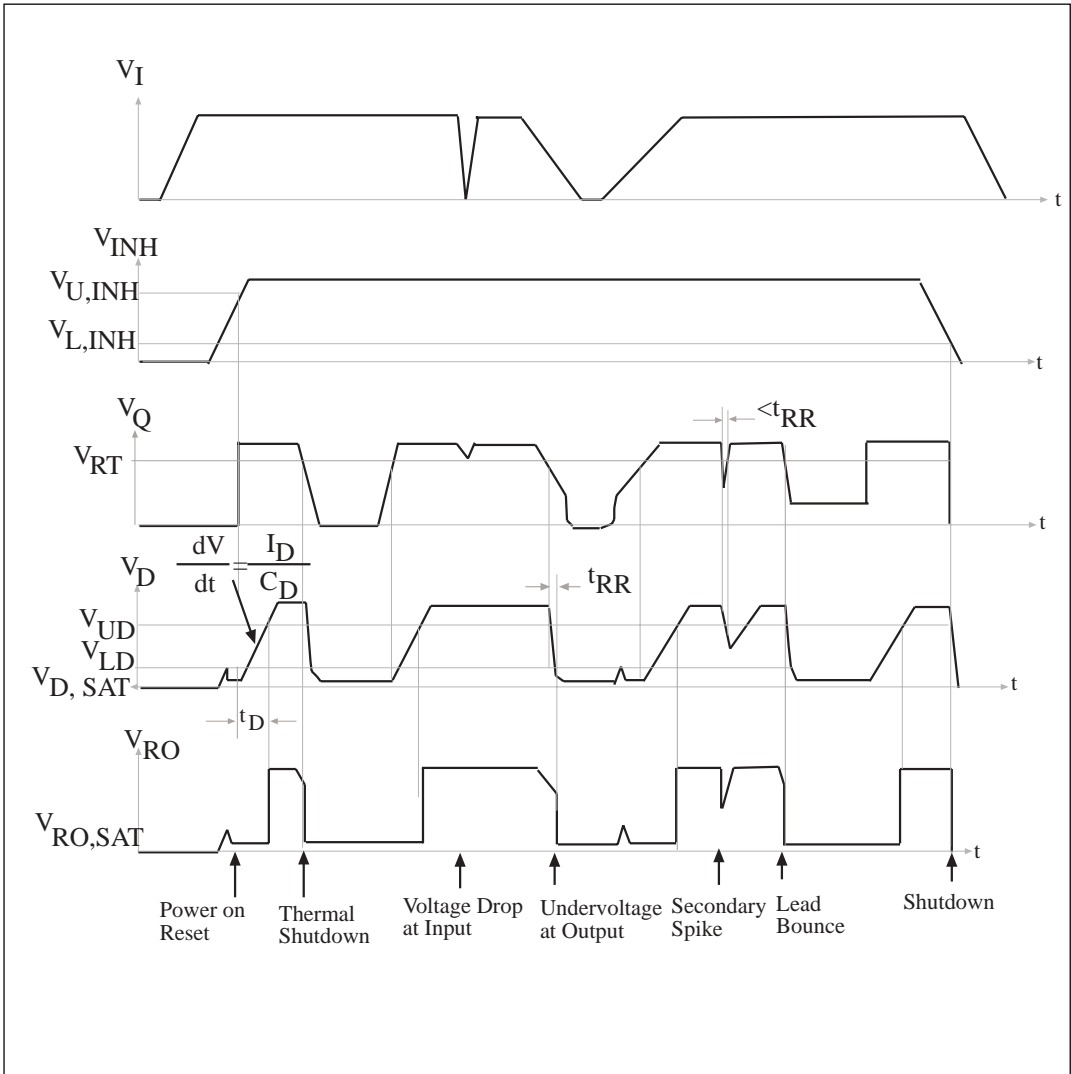
Parameter	Sym	Min	Typ	Max	Units	Conditions
<b>Reset Generator</b>						
Switching Threshold	$V_{RT}$	4.2	4.5	4.8	V	-
Reset High Level	-	4.5	-	-	V	$R_{ext} = \infty$
Saturation Voltage	$V_{RO, SAT}$	-	0.1	0.4	V	$R_R = 4.7k\Omega$ (note 2)
Internal Pull up resistor	$V_{RO}$	-	30	-	k $\Omega$	-
Saturation Voltage	$V_{D, SAT}$	-	50	100	mV	$V_Q < V_{RT}$
Charge Current	$I_D$	8	15	25	$\mu A$	$V_D = 1.5 V$
Upper delay switching threshold	$V_{UD}$	2.6	3	3.3	V	-
Delay Time	$t_D$	-	20	-	ms	$C_d = 100nF$
Lower delay switching threshold	$V_{LD}$	-	0.43	-	V	-
Reset reaction time	$t_{RR}$	-	2	-	$\mu S$	$C = 100nF$
<b>Inhibit</b>						
Turn on voltage	$V_{U, INH}$	-	3	4	V	IC turned on
Turn off voltage	$V_{L, INH}$	2	-	-	V	IC turned off
Pull down Resistor	$R_{INH}$	50	100	200	k $\Omega$	-
Hysteresis	$\Delta V_{INH}$	0.2	0.5	0.8	V	-
Input Current	$I_{INH}$	-	35	100	$\mu A$	$V_{INH} = 4V$
Hold Voltage	$V_{U, HOLD}$	30	35	40	%	Referred to $V_Q$
Turn off Voltage	$V_{L, HOLD}$	60	70	80	%	Referred to $V_Q$
Pull up Resistor	$R_{HOLD}$	20	50	100	k $\Omega$	-
<b>Overvoltage Protection</b>						
Turn off Voltage	$V_{L, OV}$	42	44	46	V	-
Turn on Hysteresis	$\Delta V_{L, OV}$	2	-	6	V	-

**Note 2:** The reset output is low for  $1V < V_Q < V_{RT}$

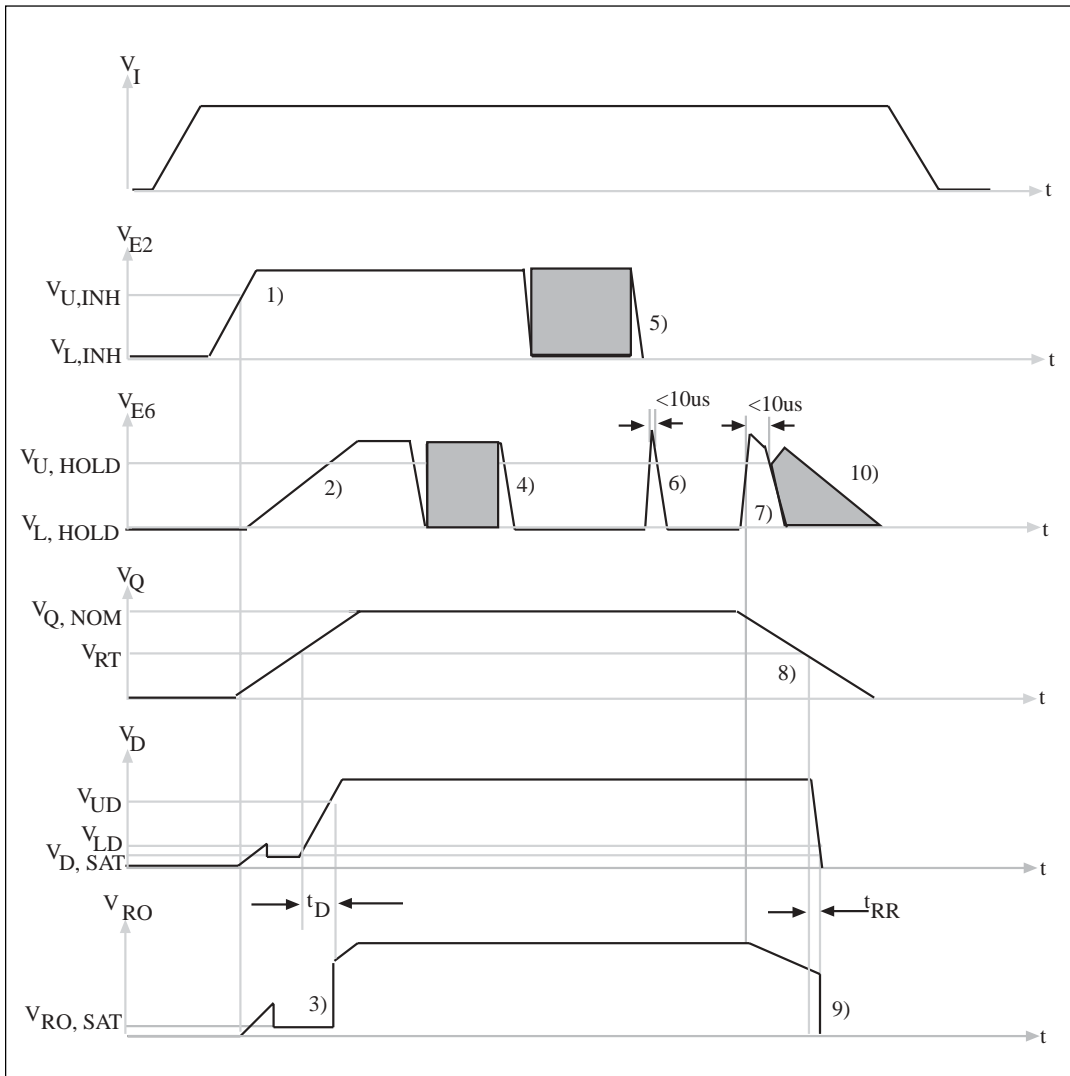


BLOCK DIAGRAM



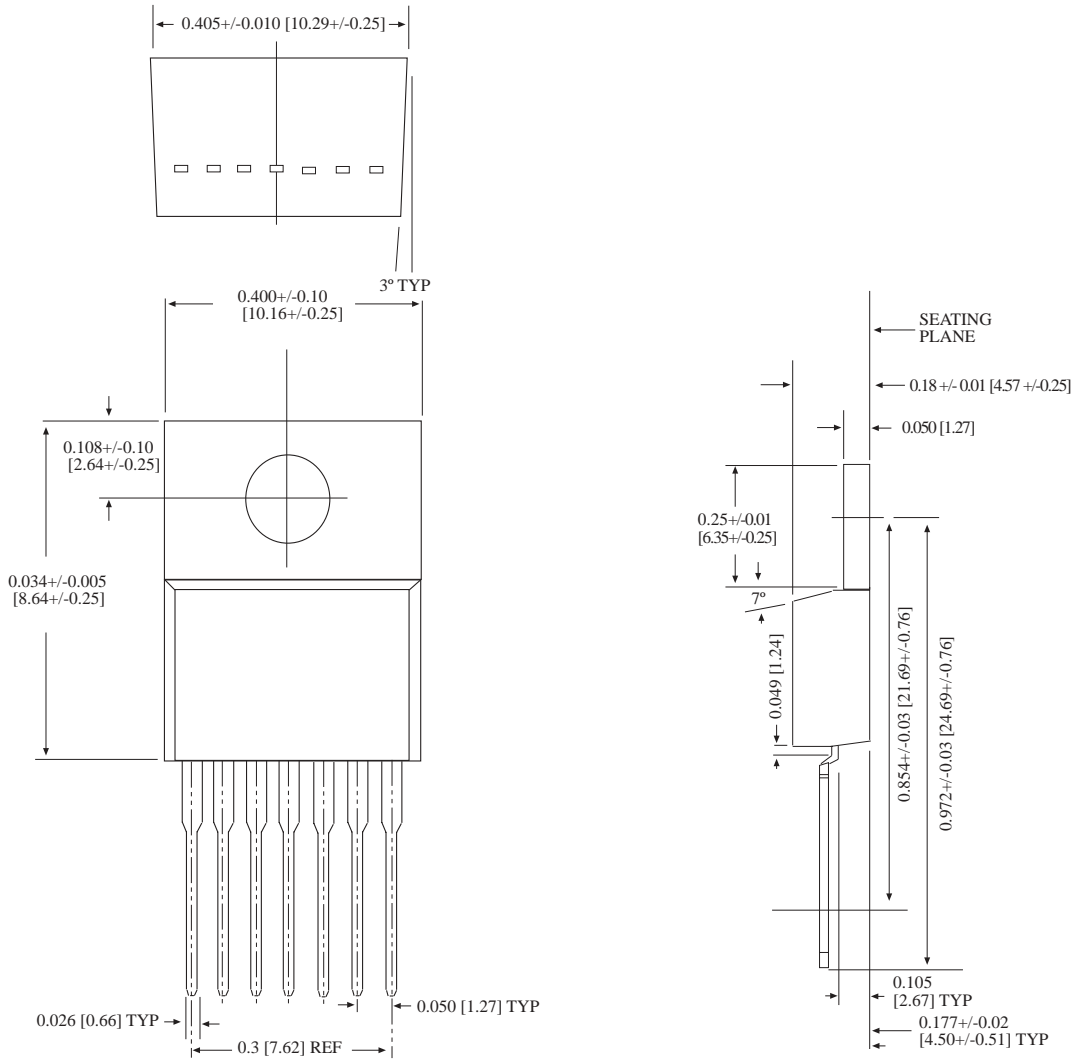


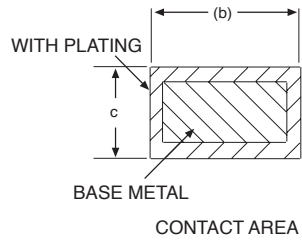
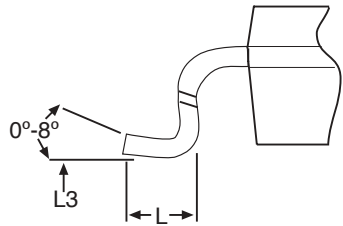
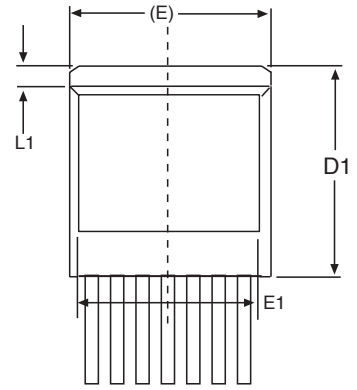
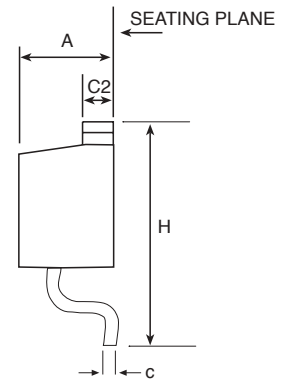
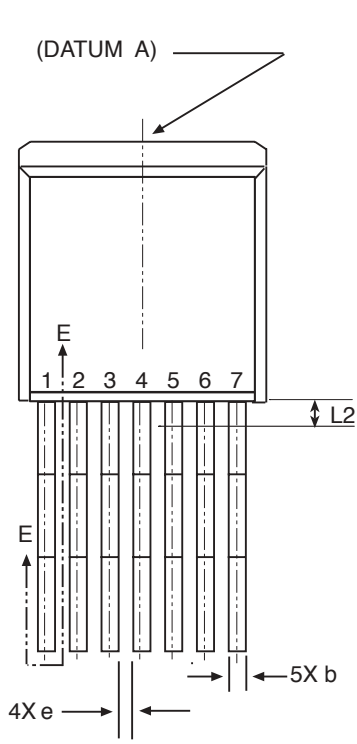




- 1) Enable Device
- 2) Hold Inactive
- 3) Power-on reset
- 4) Hold active, clamped to GND by external uC
- 5) Enable inactive, clamped by int. pull down resistor.

- 6) Pulse width smaller than 1us.
- 7) Hold inactive, released by uC.
- 8) Voltage controller shutdown.
- 9) Output-low reset
- 10) No switch via  $V_{E6}$  possible after  $E6$  was released to  $V_{E6} > V_{E6,REL}$  for more than 4 us.





7 PIN TO-263 JEDEC TO-263 (BB) Variation	Dimensions in (mm)		
	MIN	NOM	MAX
A	.160	-	.190
A1	0	-	.010
b	.020	-	.039
c	.015	-	.029
c2	.045	-	.023
D1	.270	-	-
E	.380	-	.420
E1	.245	-	-
e	.067 BSC		
H	.575	-	.625
L	.070	-	.110
L1	-	-	.066
L2	-	-	.070
L3	.010 BSC		

**7 PIN TO-263**

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**ORDERING INFORMATION**

<b>Part number</b>	<b>Output Voltage</b>	<b>Package Type</b>
SPX2967U .....	5.0V .....	7 Pin TO-220
SPX2967T .....	5.0V .....	7 Pin TO-263

Available in lead free packaging. To order add "-L" suffix to part number.

Example: SPX2967U = standard; SPX2967U-L = lead free



**ANALOG EXCELLENCE**

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