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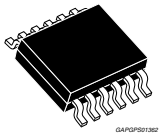
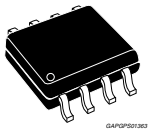
L5150CJ
L5150CS

5 V low dropout voltage regulator

Datasheet - production data



PowerSSO-12



SO-8

Features

Max DC supply voltage	V_S	40 V
Max output voltage tolerance	ΔV_o	±2%
Max dropout voltage	V_{dp}	500 mV
Output current	I_o	150 mA
Quiescent current	I_{qn}	55 µA(1)

1. Typical value

- Operating DC supply voltage range 5.6 V to 40 V
- Low dropout voltage
- Low quiescent current consumption
- Precision output voltage 5 V ±2%
- Reset circuit sensing the output voltage
- Programmable reset pulse delay with external capacitor
- Adjustable reset threshold
- Early warning
- Very wide stability range with low value output capacitor
- Thermal shutdown and short-circuit protection
- Wide temperature range (T_j = -40 °C to 150 °C)

Description

L5150CJ and L5150CS are low dropout linear regulators with microprocessor control functions such as power on reset, low voltage reset, early warning.

Typical quiescent current is 55 µA at very low output current.

On chip trimming results in high output voltage accuracy (2%). Accuracy is kept over wide temperature range, line and load variation. Early warning circuit monitors the input voltage and compares it with an internal voltage reference.

Output voltage reset threshold can be adjusted down to 3.5 V by means of an external voltage divider.

The maximum input voltage is 40 V. The max output current is internally limited. Internal temperature protection disables the voltage regulator output. In addition, only low-value ceramic capacitor on output is required for stability.

Table 1. Device summary

Package	Order codes	
	Tube	Tape & reel
PowerSSO-12	L5150CJ	L5150CJTR
SO-8	L5150CS	L5150CSTR

Contents

List of tables

List of figures

1 Block diagram and pins description

Figure 1. Block diagram

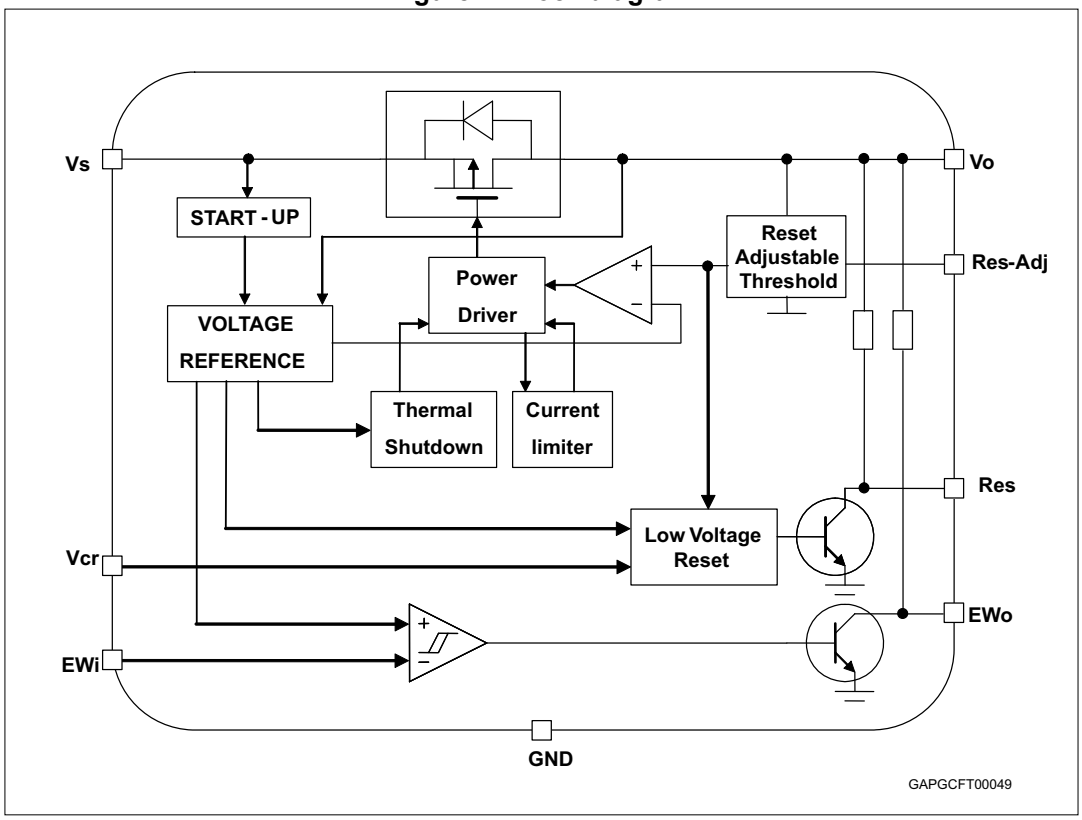


Figure 2. Configuration diagram (top view)

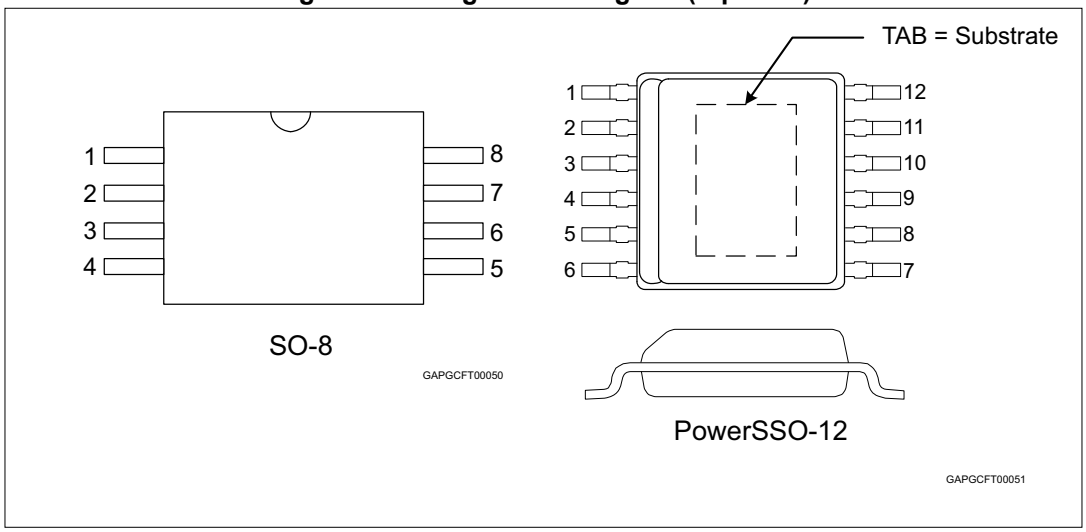


Table 2. Pins description

Pin name	PowerSSO-12 pin #	SO-8 pin #	Function
R_{es_Adj}	1	8	Reset adjustable threshold. Connected to an appropriate external voltage divider, it allows to properly set the reset threshold down to 3.5 V. Connect to GND if not needed.
R_{es}	2	1	Reset output. Internally connected to V_o through a 20 KΩ pull up resistor. This pin is pulled low when $V_o < V_{o\_th}$. Keep open if not needed.
V_{cr}	3	2	Reset delay. Connect an external capacitor between V_{cr} pin and ground to adjust the reset delay time. Keep open if not needed.
GND	4	3	Ground reference.
NC	5, 11, 8, 9	-	Not connected.
V_o	6	4	5 V regulated output. Block to GND with a ceramic capacitor ($C_o \geq 220$ nF for regulator stability).
V_S	7	5	Supply voltage, block directly to GND on the IC with a capacitor.
EW_i	10	6	Early warning input. This pin monitors the V_S voltage level through a resistor divider. Connect to V_S if not needed.
EW_o	12	7	Early warning output. Internally connected to V_o through 20 KΩ pull up resistor. This pin is pulled low when EW_i is below bandgap reference voltage. Keep open if not needed.
TAB	-	-	TAB is connected to the substrate of the chip: connect toGND or leave open (see *Figure 2* for PowerSSO-12 only).

2 Electrical specifications

2.1 Absolute maximum ratings

Stressing the device above the rating listed in the *Table 3: Absolute maximum ratings* may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the operating sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
Vsdc	DC supply voltage	-0.3 to 40	V
Isdc	Input current	internally limited	
V_{odc}	DC output voltage	-0.3 to 6	V
I_{odc}	DC output current	internally limited	
$V_{od\ Res}$	Open drain output voltage R_{es}	-0.3 to Vodc + 0.3	V
$I_{od\ Res}$	Open drain output current R_{es}	internally limited	
V_{Res_adj}	V_{Res_adj} voltage	-0.3 to Vodc + 0.3	V
$V_{od\ EWo}$	Open drain output voltage EW_o	-0.3 to Vodc + 0.3	V
$I_{od\ EWo}$	Open drain output current EW_o	internally limited	
V_{cr}	V_{cr} voltage	-0.3 to Vo + 0.3	V
V_{EWi}	Early warning input voltage	-0.3 to 40	V
T_j	Junction temperature	-40 to 150	°C
$V_{ESD\ HBM}$	ESD HBM voltage level (HBM-MIL STD 883C)	± 2	kV
VESD CDM	ESD CDM voltage level (CDM-)	± 750	V

2.2 Thermal data

Table 4. Thermal data

Symbol	Parameter	Value		Unit
		PowerSSO-12	SO-8	
$R_{thj\text{-}case}$	Thermal resistance junction to case:	8		°K/W
$R_{thj\text{-}lead}$	Thermal resistance junction to lead:		40	°K/W
$R_{thj\text{-}amb}$ (1)	Thermal resistance junction to ambient:	52	112	°K/W

1. **PowerSSO-12**: The values quoted are for PCB 77 mm x 86 mm x 1.6 mm, FR4, double copper layer with single heatsink layer, copper thickness 70 µm, thermal vias, copper area 2 cm^2.
SO-8: The values quoted are for PCB 48 mm x 48 mm x 2 mm, FR4, double copper layer with single heatsink layer, copper thickness 35 µm, copper area 2 cm^2.

2.3 Electrical characteristics

Values specified in this section are for V_S = 5.6 V to 31 V, T_j = -40 °C to +150 °C unless otherwise stated.

Table 5. General

Pin	Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V_o	V_{o_ref}	Output voltage	V_S = 8 V to 18 V I_o = 8 mA to 150 mA	4.9	5.0	5.1	V
Vo	V_{o_ref}	Output voltage	V_S = 5.6 V to 31 V I_o = 8 mA to 150 mA	4.85	5.0	5.15	V
Vo	V_{o_ref}	Output voltage	V_S = 5.6 V to 31 V I_o = 0.1 mA to 8 mA	4.75	5.0	5.25	V
Vo	I_{short}	Short-circuit current	V_S = 13.5 V	0.65	0.95	1.25	A
Vo	I_{lim}	Output current capability (1)	V_S = 13.5 V	280	470	660	mA
V_S, Vo	V_{line}	Line regulation voltage	V_S = 6 V to 28 V I_o = 30 mA	–	–	40	mV
V_o	V_{load}	Load regulation voltage	V_S = 8 V to 18 V, I_o = 8 mA to 150 mA	–	–	55	mV
			V_S = 13.5 V, T_j = 25 °C I_o = 8 mA to 150 mA	–	–	40	
V_S, V_o	V_{dp}	Drop voltage (2)	I_o = 150 mA	–	–	500	mV
V_S, V_o	SVR	Ripple rejection	f_r = 100 Hz(3)	–	48	–	dB
V_o	Io_{th_H}	Normal consumption mode output current	V_S = 8 V to 18 V	8	–	–	mA
V_o	Io_{th_L}	Very low consumption mode output current	V_S = 8 V to 18 V	–	–	1.1	mA
V_o	Io_{th_Hyst}	Output current switching threshold hysteresis	V_S = 13.5 V T_j = 25 °C	–	0.8	–	mA

Table 5. General (continued)

Pin	Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V_S, V_o	I_{qn_1}	Current consumption $I_{qn\_1} = I_{Vs} - Io$	V_S = 13.5 V, I_o = 0.1 mA to 1 mA, T_j = 25 °C	–	55	80	µA
			V_S = 13.5 V, I_o = 0.1 mA to 1 mA,	–		95	
V_S, V_o	I_{qn_150}	Current consumption $I_{qn\_150} = I_{Vs} - I_o$	V_S = 13.5 V I_o = 150 mA	–	3	4.2	mA
–	T_w	Thermal protection temperature	–	150	–	190	°C
–	T_{w_hy}	Thermal protection temperature hysteresis	–	–	10	–	°C

1. Measured Output Current when the output voltage has dropped 100 mV from its nominal Value obtained at 13.5 V and I_o =75 mA.
2. Vs - V_o Measured Dropout when the output voltage has dropped 100 mV from its nominal Value obtained at 13.5 V and I_o =75 mA.
3. Guaranteed by design.

Table 6. Reset

Pin	Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
R_{es}	V_{res_l}	Reset output low voltage	R_{ext} = 5 kΩ V_o > 1 V	–	–	0.4	V
R_{es}	I_{Res_lkg}	Reset output high leakage current	VRes = 5 V	–	–	1	µA
R_{es}	R_{Res}	Pull up internal resistance	Versus V_o	10	20	40	kΩ
R_{es}	V_{o_th}	V_o out of regulation threshold	Vres_adj < 0.2 V, V_o decreasing	6	8	10	% Below V_{o_ref}
R_{es_adj}	V_{res_adj}	Reset adjustable switching threshold	–	2.35	2.5	2.65	V
R_{es_adj}	V_{Res_adjl}	Reset adjustable low voltage	–	0.4	0.9	1.3	V
R_{es_adj}	IRes_adj_lkg	Reset adjustable leakage current	Vres_adj = 2.5 V	-1	–	1	µA
V_{cr}	V_{Rlth}	Reset timing low threshold	V_S = 13.5 V	15	18	22	% V_{o_ref}
V_{cr}	V_{Rhth}	Reset timing high threshold	V_S =13.5 V	47	50	53	% V_{o_ref}
V_{cr}	I_{cr}	Charge current	V_S = 13.5 V	10	20	30	µA
V_{cr}	I_{dr}	Discharge current	V_S = 13.5 V	10	20	30	µA

Table 6. Reset (continued)

Pin	Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
R_{es}	T_{rr}	Reset reaction time	–	–	–	2	µs
R_{es}	T_{rd}	Reset delay time	V_S = 13.5 V; C_{tr} = 1000 pF	2	4	11	ms

Table 7. Early warning

Pin	Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
EW_i	V_{EWi_thl}	EW input low threshold voltage	–	2.35	2.50	2.65	V
EW_i	V_{EWi_thh}	EW input high threshold voltage	–	2.42	2.57	2.72	V
EW_i	V_{EWi_thhyst}	EW input threshold hysteresis	–	–	70	–	mV
EW_i	I_{EWi_lkg}	EW input leakage current	V_{EWi} = 2.5 V, V_S > 4 V	-1	–	1	µA
EW_o	R_{EWo}	Pull up internal resistance	Versus V_o	10	20	40	kΩ
EW_o	V_{EWo_lv}	EW output low voltage (with external pull up)	V_{EWi} < 2.35 V; V_S > 4 V; R_{ext} = 5 kΩ	–	–	0.4	V
EW_o	I_{EWo_lkg}	EW output leakage current	V_{EWo} = 5 V	–	–	1	µA

2.4 Electrical characteristics curves

Figure 3. Output voltage vs. T_j

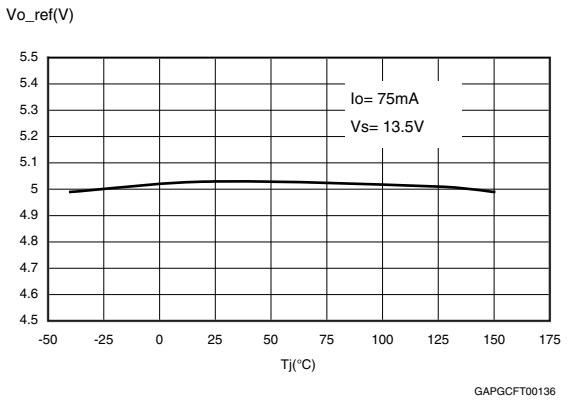


Figure 4. Output voltage vs. V_S

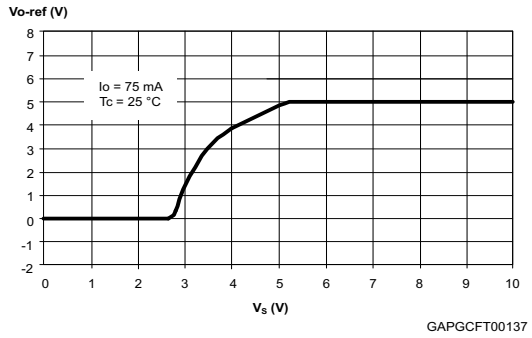


Figure 5. Drop voltage vs. output current

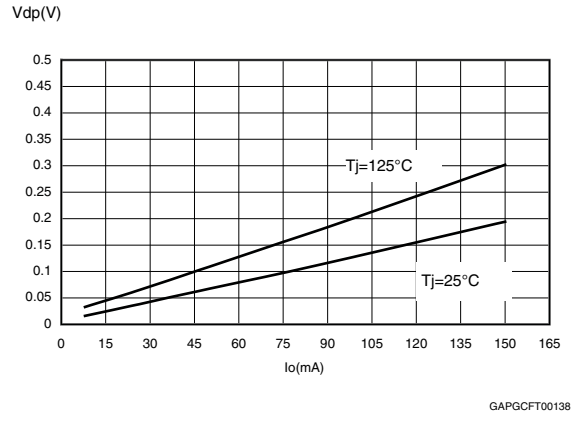


Figure 6. Current consumption vs. output current

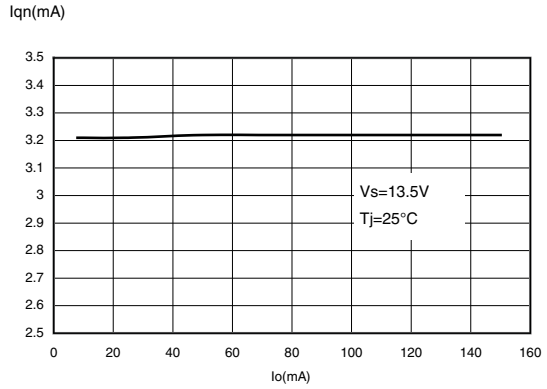


Figure 7. Current consumption vs. output current (at light load condition)

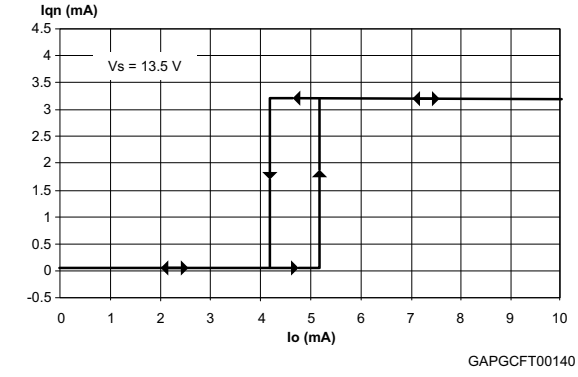


Figure 8. Current consumption vs. input voltage (Io = 0.1 mA)

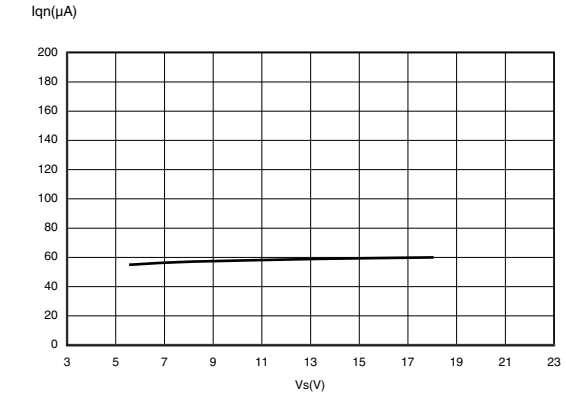


Figure 9. Current consumption vs. input voltage (Io = 75 mA)

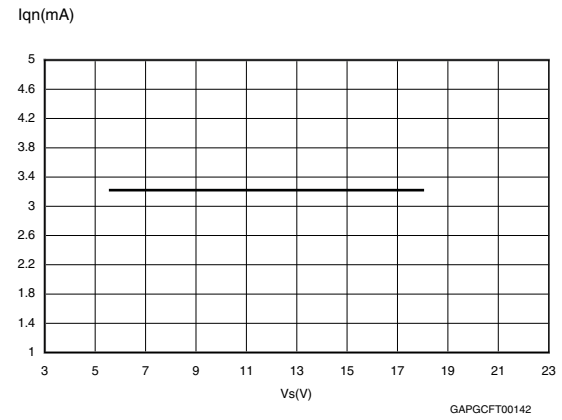


Figure 10. Current limitation vs. T_j

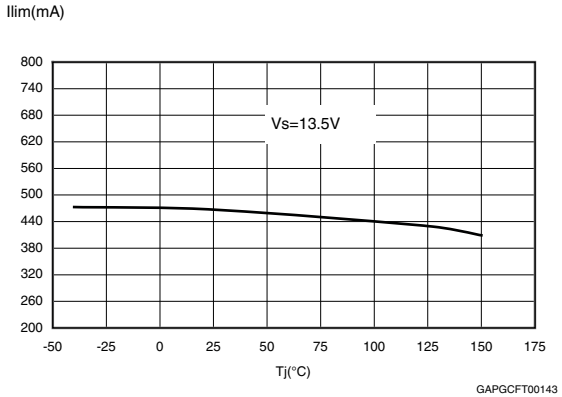


Figure 11. Current limitation vs. input voltage

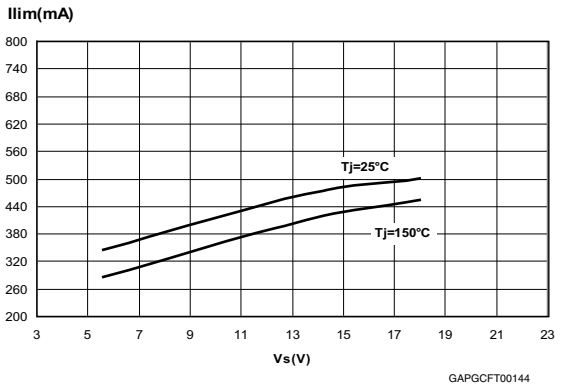


Figure 12. Short-circuit current vs. T_j

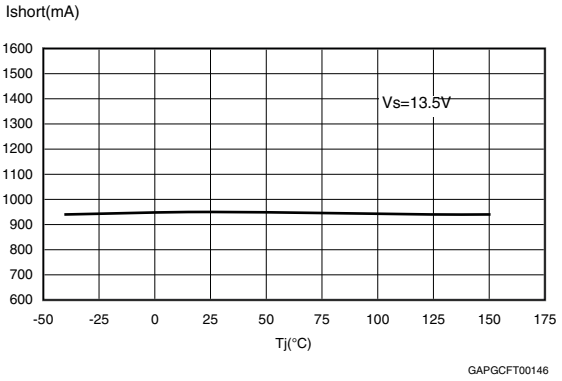


Figure 13. Short-circuit current vs. input voltage

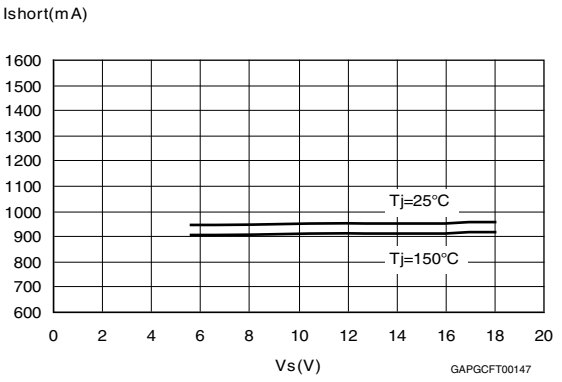


Figure 14. V_{Rhth} vs. T_j

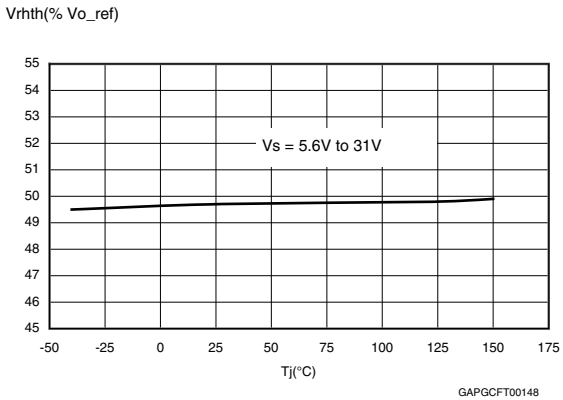


Figure 15. V_{RIth} vs. T_j

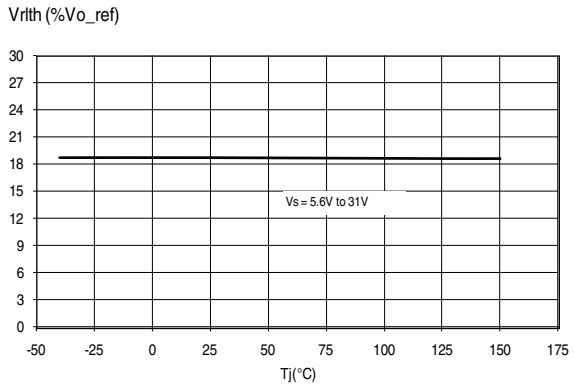


Figure 16. V_{EWi_thh} vs. T_j

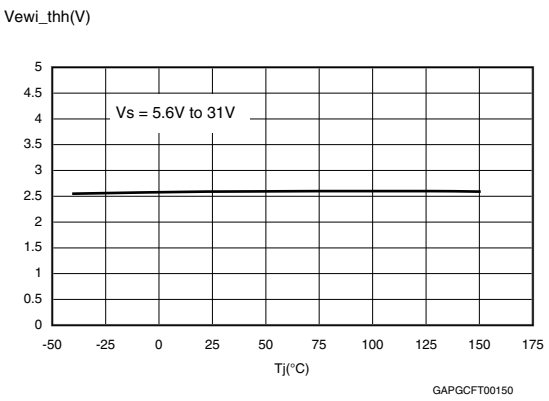


Figure 17. V_{EWi_thl} vs. T_j

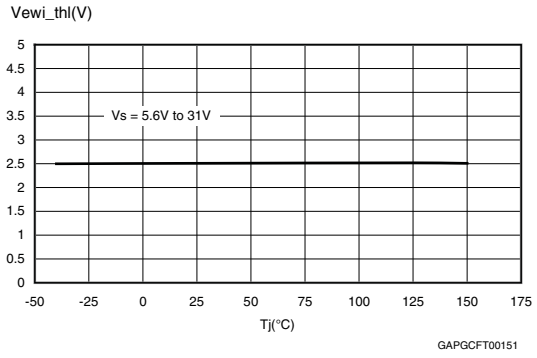


Figure 18. I_{cr} vs. T_j

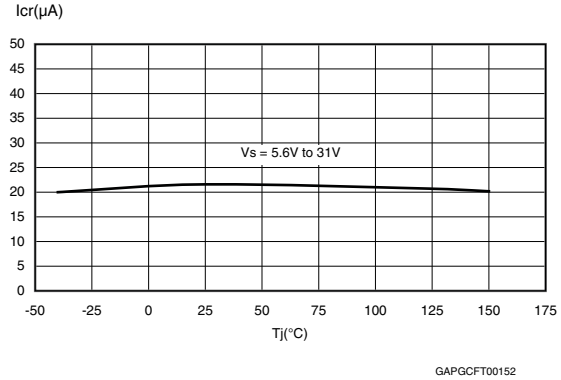


Figure 19. I_{dr} vs. T_j

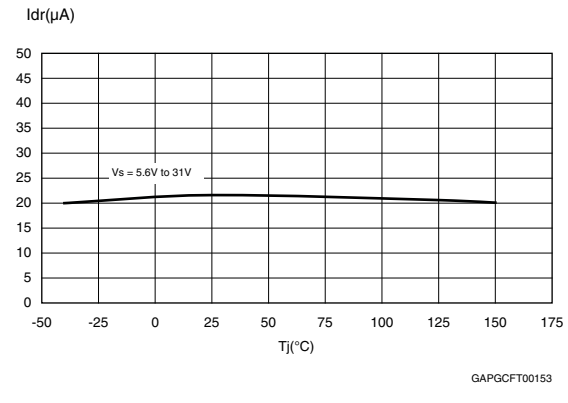
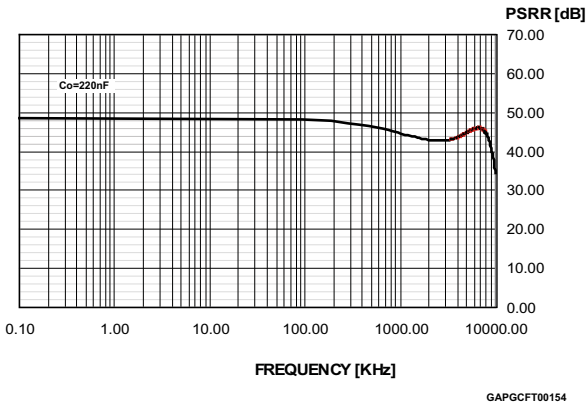


Figure 20. PSRR

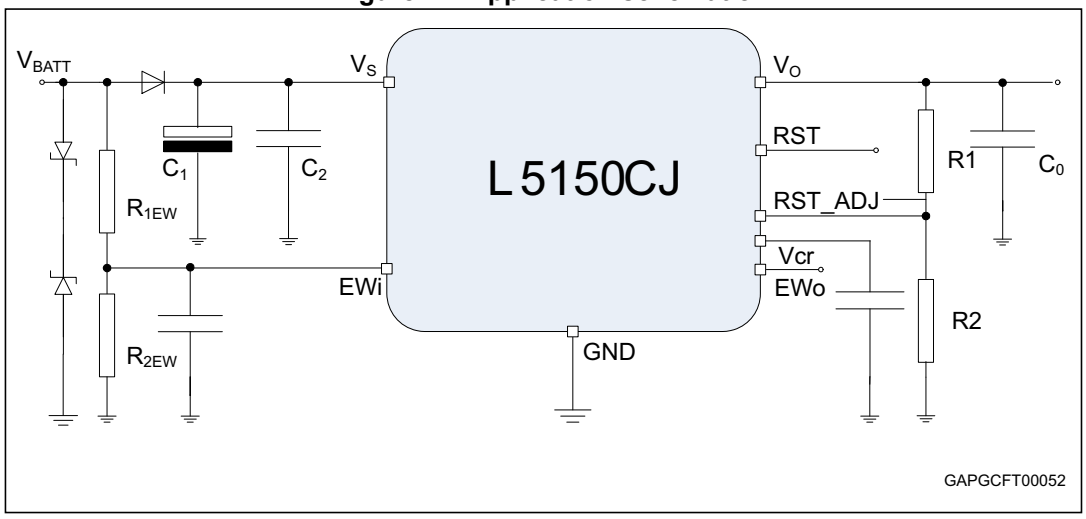


3 Application information

3.1 Voltage regulator

The voltage regulator uses a p-channel mos transistor as a regulating element. With this structure a very low dropout voltage at current up to 150 mA is obtained. The output voltage is regulated up to input supply voltage of 40 V. The high-precision of the output voltage (2%) is obtained with a pre-trimmed reference voltage. The voltage regulator automatically adapts its own quiescent current to the output current level. In light load conditions the quiescent current goes to 55 µA only (low consumption mode). This procedure features a certain hysteresis on the output current (see *Figure 7*). Short-circuit protection to GND and a thermal shutdown are provided.

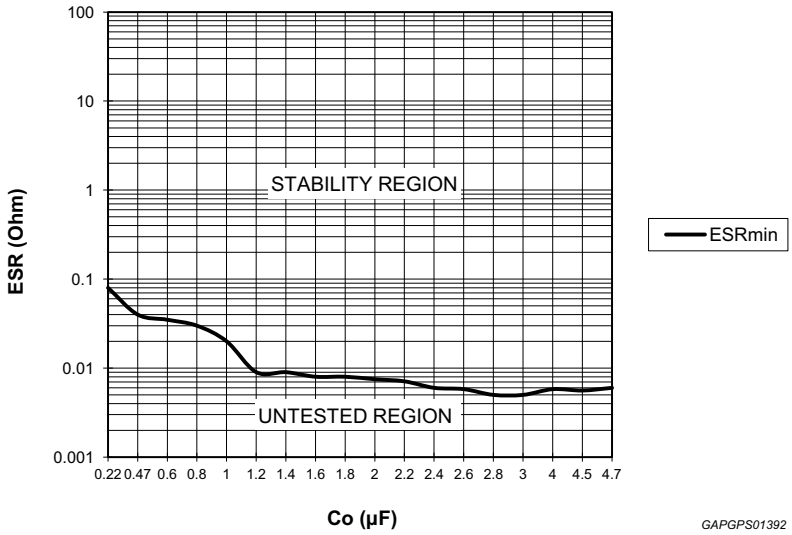
Figure 21. Application schematic



The input capacitor $C_1 \geq 100$ µF is necessary as backup supply for negative pulses which may occur on the line. The second input capacitor $C_2 \geq 220$ nF is needed when the C_1 is too distant from the V_S pin and it compensates smooth line disturbances. The C_0 ceramic capacitor, connected to the output pin, is for bypassing to GND the high-frequency noise and it guarantees stability even during sudden line and load variations. Suggested value is $C_0 = 220$ nF with ESR ≥ 100 mΩ.

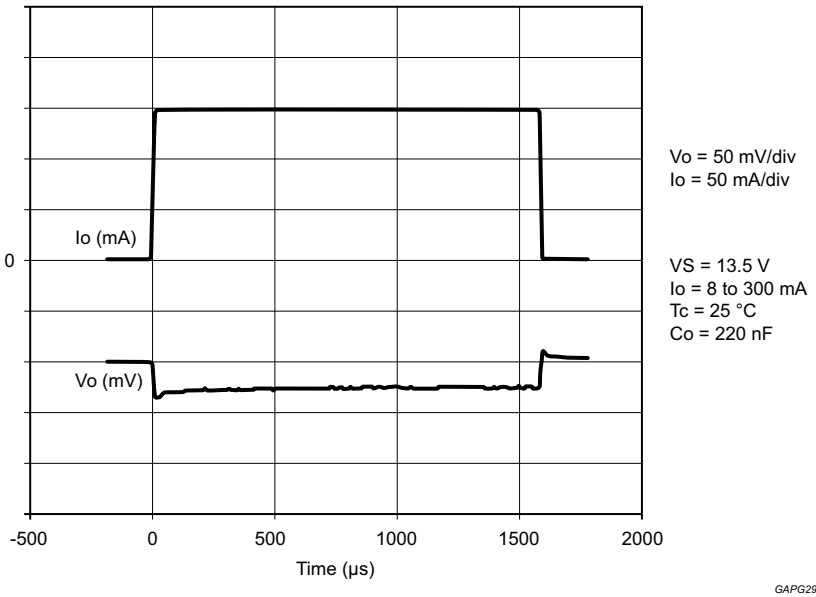
Stability region is reported in *Figure 22*.

Figure 22. Stability region



Note: The curve which describes the minimum ESR is derived from characterization data on the regulator with connected ceramic capacitors which feature low ESR values (at 100 kHz). Any capacitor with further lower ESR than the given plot value must be evaluated in each and every case.

Figure 23. Maximum load variation response



3.2 Reset

The reset circuit monitors the output voltage V_o. If the output voltage becomes lower than V_{o_th} then R_{es} goes low with a delay time (t_{rr}). When the output voltage becomes higher than V_{o_th} then R_{es} goes high with a delay time t_{rd}. This delay is obtained by 32 periods of oscillator. The oscillator period is given by:

Equation 1

$$T_{osc} = [(V_{Rhth} - V_{Rlth}) \times C_{tr}] / I_{cr} + [(V_{Rhth} - V_{Rlth}) \times C_{tr}] / I_{dr}$$

where:

I_{cr} = 20 µA is an internally generated charge current,

I_{dr} = 20 µA is an internally generated discharge current,

V_{Rhth} = 2.5 V (typ) and **V_{Rlth}** = 0.9 V (typ) are two voltage thresholds,

C_{tr} is an external capacitor put between V_{cr} pin and GND.

Reset pulse delay T_{rd} is given by:

Equation 2

$$t_{rd} = 32 \times T_{osc}$$

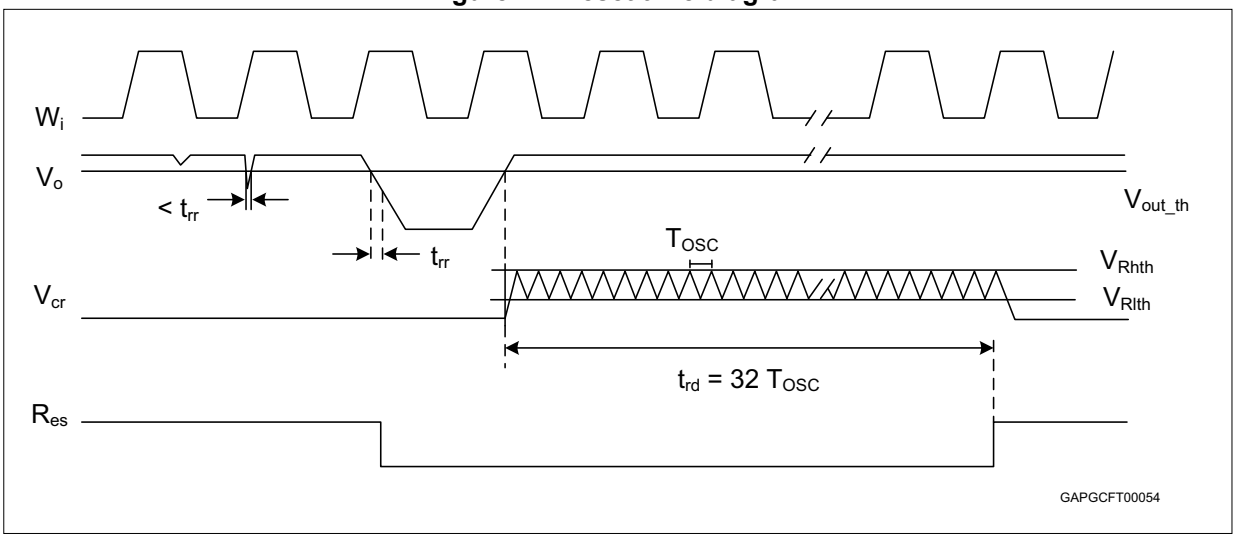
The Output Voltage Reset threshold can be adjusted via an external voltage divider $R_1 + R_2$ (R_1 connected between R_{es_Adj} and V_0, R_2 connected between R_{es_Adj} and GND) according to the following formula:

Equation 3

$$V_{thre} = [(R_1 + R_2) / R_2] * V_{Res\_adj}$$

The Output Voltage Reset threshold can be decreased down to 3.5 V. If it is needed to maintain it to its default value (8% below V_{0_ref} typical), it is enough to connect the R_{es_Adj} pin directly to GND.

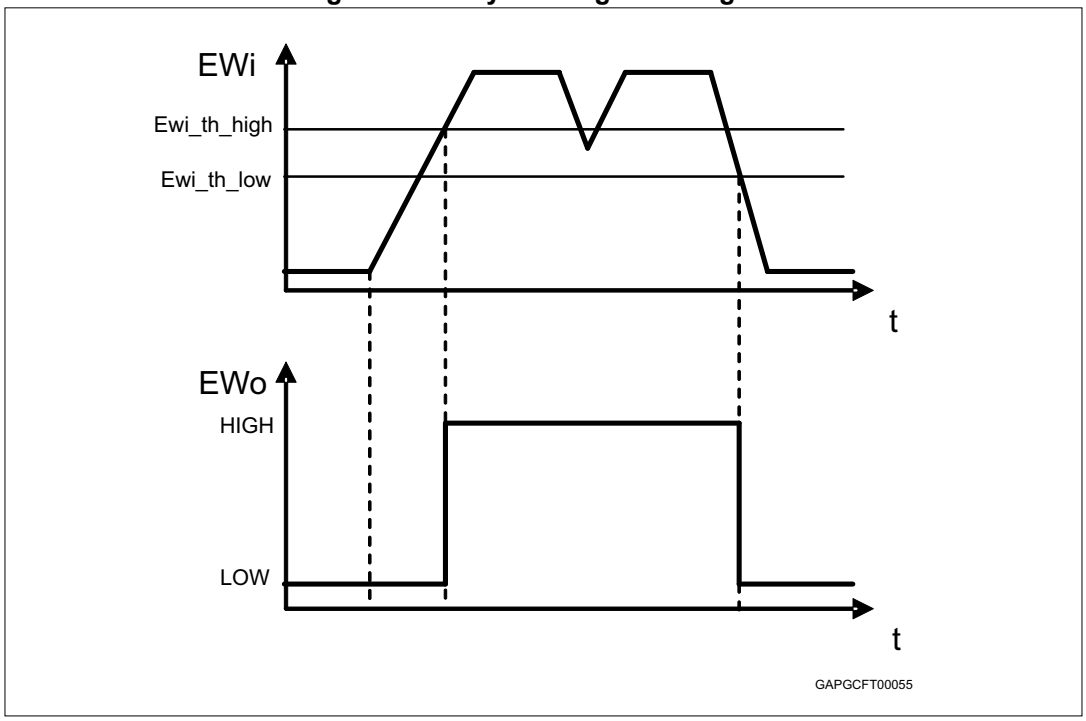
Figure 24. Reset time diagram



3.3 Early warning

This circuit compares the EW_i input signal with the internal voltage reference (typically 2.5 V). The use of an external voltage divider makes the comparator very flexible in the application. This function can be used to supervise the supply input voltage either before or after the protection diode and to give additional information to the microprocessor such as low voltage warnings.

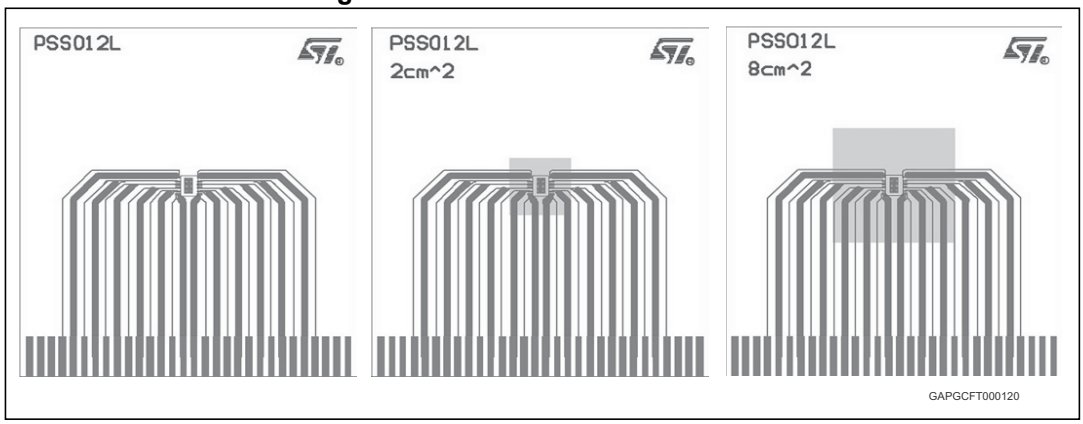
Figure 25. Early warning time diagram



4 Package and PCB thermal data

4.1 PowerSSO-12 thermal data

Figure 26. PowerSSO-12 PC board(1)



1. Layout condition of R_{th} and Z_{th} measurements (PCB: double layer, thermal vias, FR4 area = 77 mm x 86 mm, PCB thickness = 1.6 mm, Cu thickness = 70 µm (front and back side), thermal vias separation 1.2 mm, thermal via diameter 0.3 mm +/- 0.08 mm, Cu thickness on vias 25 µm, footprint dimension 4.1 mm x 6.5 mm).

Figure 27. $R_{thj\text{-}amb}$ vs PCB copper area in open box free air condition

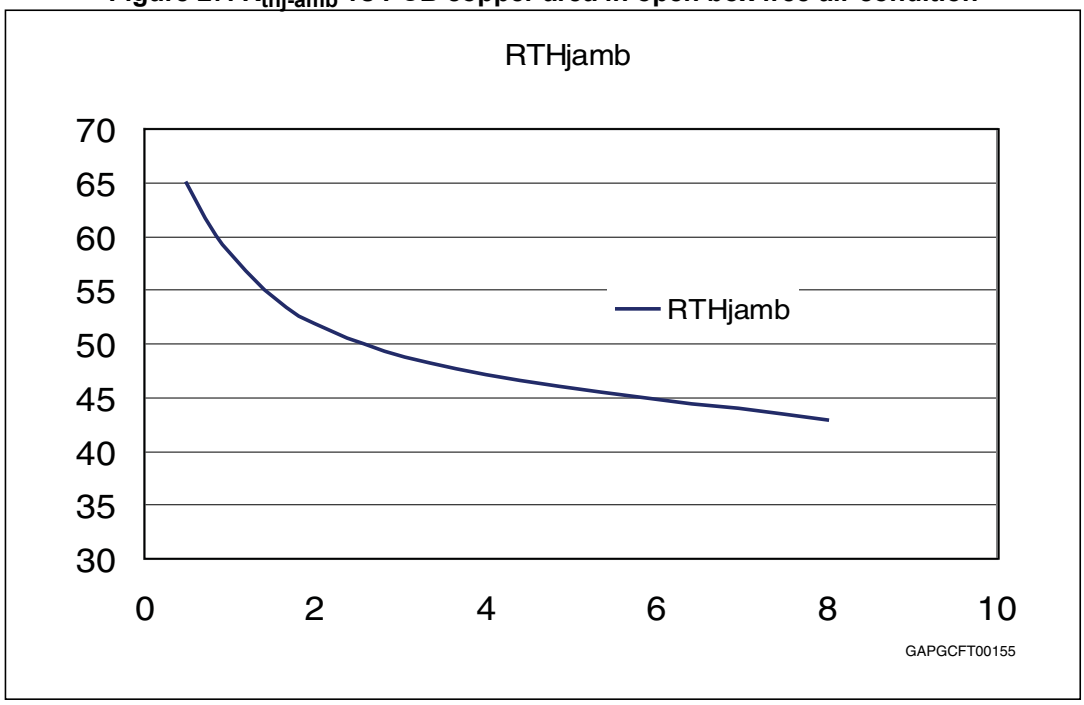
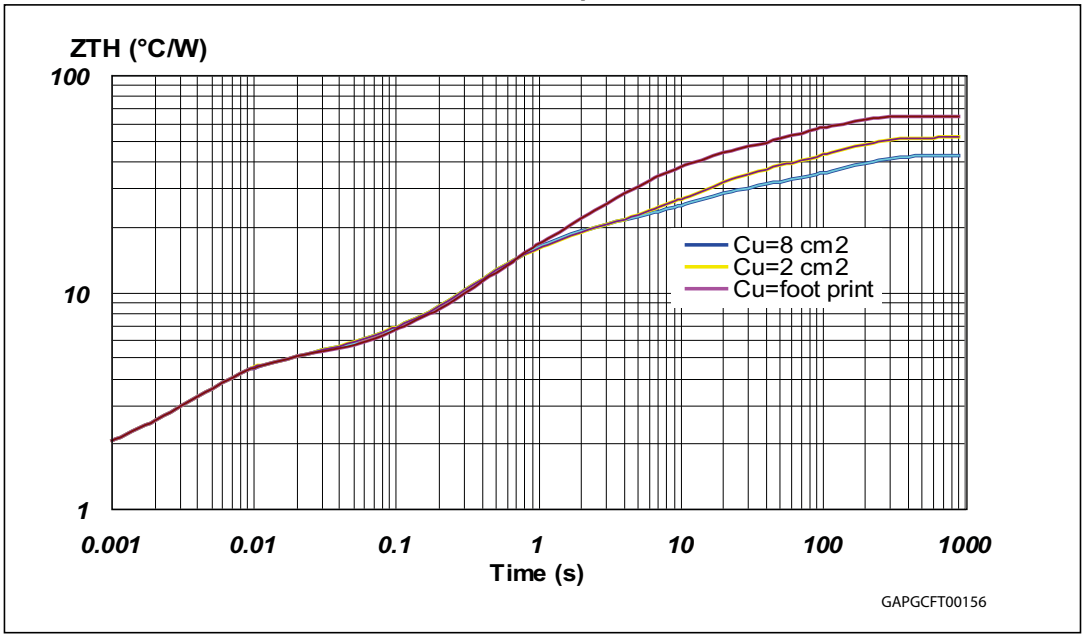


Figure 28. PowerSSO-12 thermal impedance junction ambient single pulse



Equation 4: pulse calculation formula

$$Z_{TH\delta} = R_{TH} \cdot \delta + Z_{THtp}(1 - \delta)$$

where $\delta = t_P/T$

Figure 29. Thermal fitting model of Vreg in PowerSSO-12

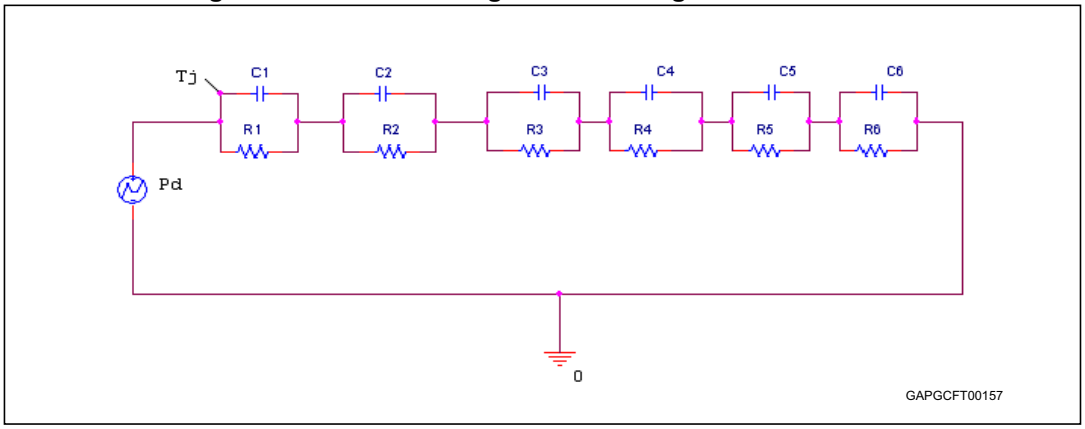
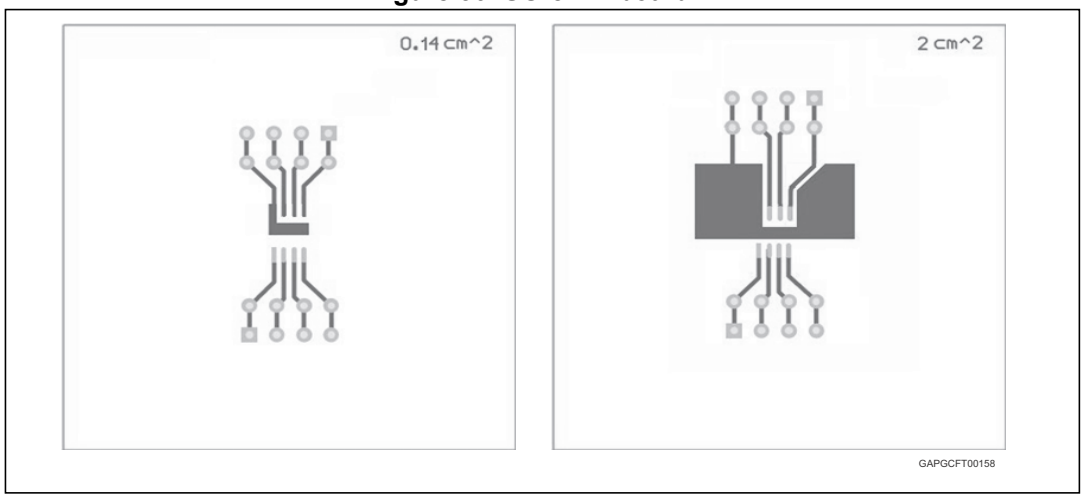


Table 8. PowerSSO-12 thermal parameter

Area (cm^2)	Footprint	2	8
R1 (°K/W)	1.53		
R2 (°K/W)	3.21		
R3 (°K/W)	5.2		
R4 (°K/W)	7	7	8
R5 (°K/W)	22	15	10
R6 (°K/W)	26	20	15
C1 (W.s/°K)	0.00004		
C2 (W.s/°K)	0.0016		
C3 (W.s/°K)	0.08		
C4 (W.s/°K)	0.2	0.1	0.1
C5 (W.s/°K)	0.27	0.8	1
C6 (W.s/°K)	3	6	9

4.2 SO-8 thermal data

Figure 30. SO-8 PC board(1)



1. Layout condition of R_{th} and Z_{th} measurements (PCB: double layer, thermal vias, FR4 area = 48 mm x 48 mm, PCB thickness = 2 mm, Cu thickness = 35 µm (front and back side), Cu thickness on vias 25 µm, Footprint dimension 4.1 mm x 6.5 mm).

Figure 31. $R_{thj\text{-}amb}$ vs. PCB copper area in open box free air condition

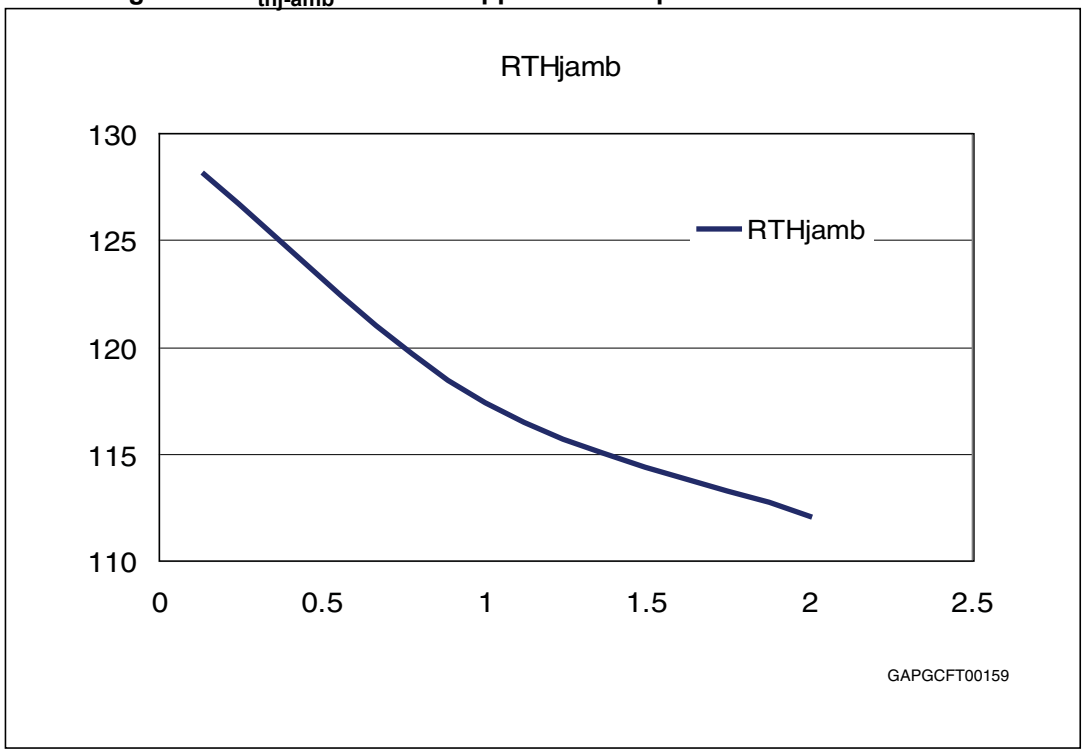
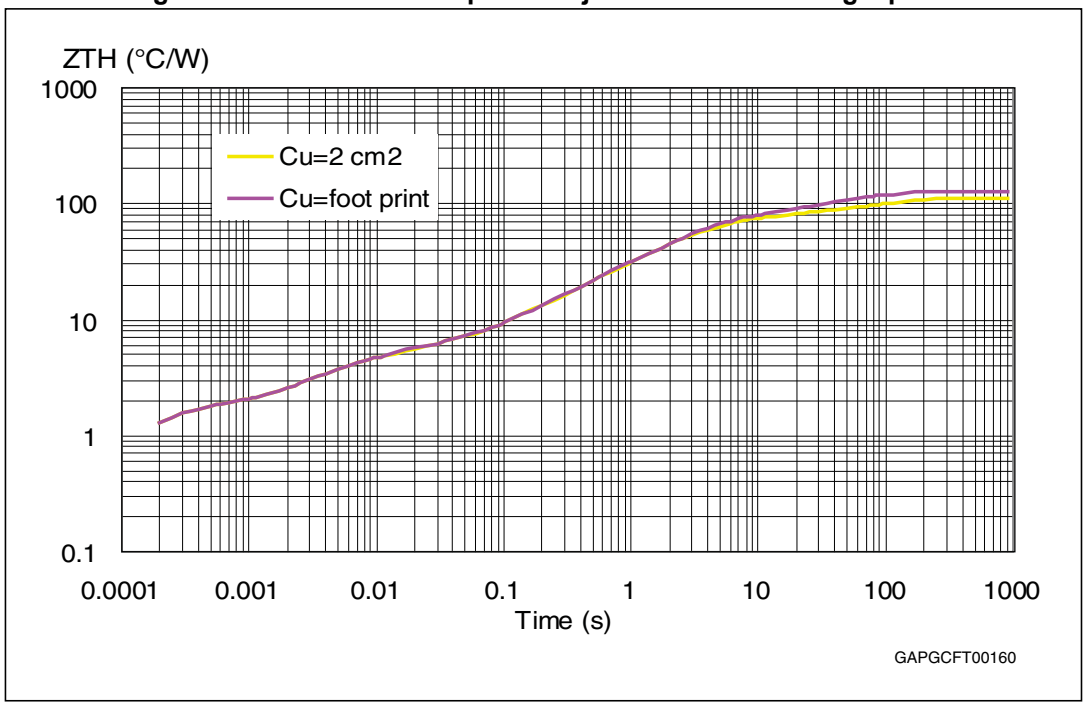


Figure 32. SO-8 thermal impedance junction ambient single pulse



Equation 5: pulse calculation formula

$$Z_{TH\delta} = R_{TH} \cdot \delta + Z_{THtp}(1 - \delta)$$

where $\delta = t_P/T$

Figure 33. Thermal fitting model of V_{reg} in in SO-8

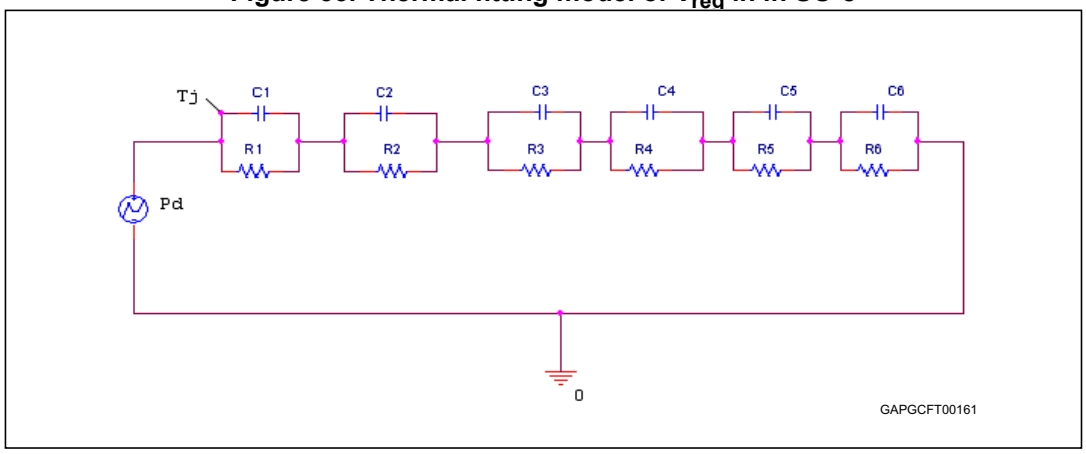


Table 9. SO-8 thermal parameter

Area (cm^2)	Footprint	2
R1 (°K/W)	1.53	
R2 (°K/W)	3.21	
R3 (°K/W)	5.4	
R4 (°K/W)	32	
R5 (°K/W)	34	
R6 (°K/W)	52	36
C1 (W.s/°K)	0.00004	
C2 (W.s/°K)	0.0016	
C3 (W.s/°K)	0.04	
C4 (W.s/°K)	0.05	
C5 (W.s/°K)	0.15	
C6 (W.s/°K)	1	2.5

5 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: *www.st.com*. ECOPACK® is an ST trademark.

5.1 PowerSSO-12 package information

Figure 34. PowerSSO-12 package outline