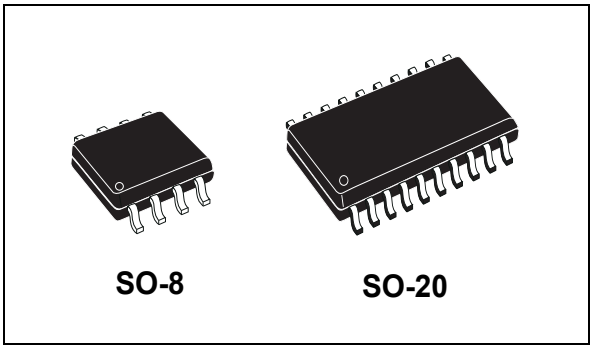
L4989D, L4989MD

Automotive low power voltage regulator

Datasheet - production data



Features

- AEC-Q100 qualified
- Operating DC supply voltage range 5.6 V to 31 V
- Very low quiescent current with watchdog disabled
- Precision output voltage (±3%)
- Low drop voltage (180 mV typ at I_o = 150 mA)
- Reset circuit sensing the output voltage down to 1 V
- Programmable reset delay with external capacitor
- Watchdog disable input
- Programmable watchdog timer with external capacitor
- Thermal shutdown and short circuit protection
- Wide temperature range (T_j = -40°C to 150°C)

Description

The L4989M and L4989MD are monolithic integrated 5 V voltage regulators with a low drop voltage at currents up to 150 mA.

The output voltage regulating element consists in a p-channel MOS and the regulation is performed regardless of input voltage transients up to 40 V. The high precision of the output voltage is obtained with a pre-trimmed reference voltage.

The devices are protected against short circuit and an overtemperature protection switches off the devices in case of extremely high power dissipation.

The L4989M and L4989MD watchdogs are active when the Enable pin is high. Features like reset and watchdog make this devices particularly suitable to supply microprocessor systems in automotive applications.

Table 1. Device summary

Package	Order codes	
	Tube	Tape & reel
SO-8	L4989D	L4989D013TR
SO-20	L4989MD	L4989MD013TR

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1 Block diagram and pin configuration

Figure 1. Block diagram

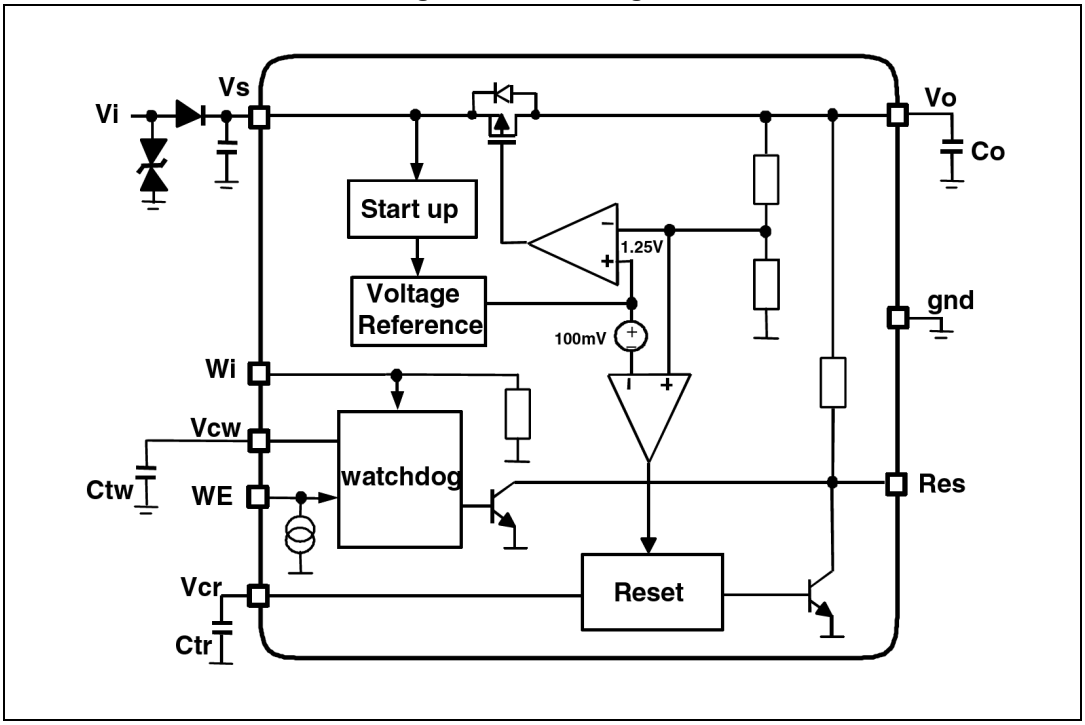


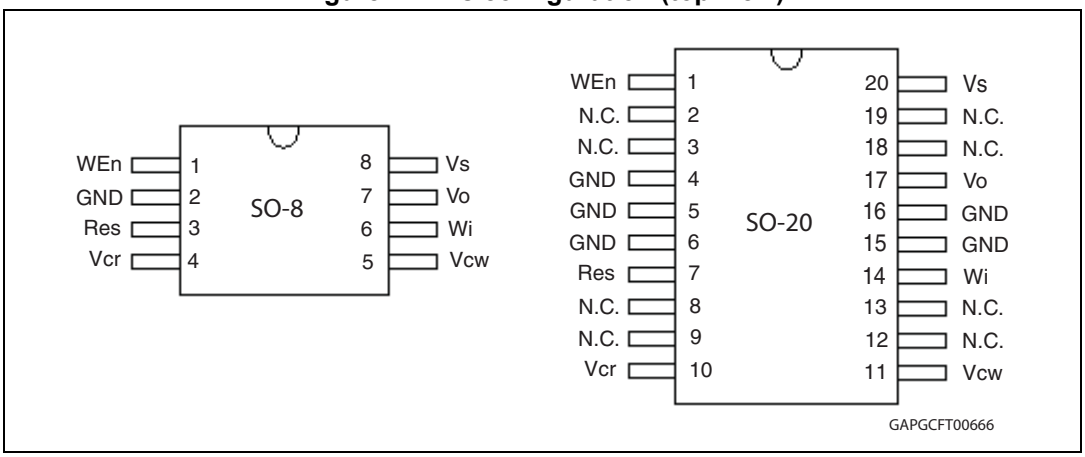
Table 2. Pins description

Pin name	SO-8(D)	S0-20(MD)	Function
WE_n	1	1	Watchdog Enable input If high watchdog functionality is active.
Gnd	2	4	Ground reference
Gnd		5, 6, 15, 16	Ground. Connected these pins to a heat spreader ground
Res	3	7	Reset output. It is pulled down when output voltage goes below V_{o_th} or frequency at Wi is too low.
Vcr	4	10	Reset timing adjust. A capacitor between Vcr pin and gnd, sets the reset delay time (t_{rd})
Vcw	5	11	Watchdog timer adjust A capacitor between Vcw pin and gnd, sets the time response of the watchdog monitor.
Wi	6	14	Watchdog input. If the frequency at this input pin is too low, the Reset output is activated.

Table 2. Pins description (continued)

Pin name	SO-8(D)	S0-20(MD)	Function
V_o	7	17	Voltage regulator output Block to ground with a capacitor >100 nF (needed for regulator stability)
V_S	8	20	Supply voltage Block to ground directly at IC pin with a capacitor
N.C.		2, 3, 8, 9, 12, 13, 18, 19	Not connected

Figure 2. Pins configuration (top view)



2 Electrical specifications

2.1 Absolute maximum ratings

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{Vsdc}	DC supply voltage	-0.3 to 40	V
I_{Vsdc}	Input current	Internally limited	
V_{Vo}	DC output voltage	-0.3 to 6	V
I_{Vo}	DC output current	Internally limited	
V_{Wi}	Watchdog input voltage	-0.3 to V_{Vo} + 0.3	V
V_{od}	Open Drain output voltage	-0.3 to V_{Vo} + 0.3	V
I_{od}	Open Drain output current	Internally limited	
V_{cr}	Reset delay voltage	-0.3 to V_{Vo} + 0.3	V
V_{cw}	Watchdog delay voltage	-0.3 to V_{Vo} + 0.3	V
V_{WEn}	Watchdog Enable input voltage	-0.3 to 40	V
T_j	Junction temperature	-40 to 150	°C
V_{ESD}	ESD voltage level (HBM-MIL STD 883C)	±2	kV

Note: Maximum ratings are absolute ratings; exceeding any one of these values may cause permanent damage to the integrated circuit.

2.2 Thermal data

Table 4. Thermal data

Symbol	Parameter	S0-8	S0-12+4+4	Unit
$R_{th\text{-}jamb}$	Thermal resistance junction to ambient	130 to 180	50(1)	°C/W

1. With 6 sq. cm on board heat sink.

2.3 Electrical characteristics

V_S = 5.6 V to 31 V, T_j = -40°C to +150°C unless otherwise specified.

Table 5. General

Pin	Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
V_o	V_{o_ref}	Output voltage	V_S = 5.6 to 31 V; I_o = 1 to 150 mA	4.85	5.0	5.15	V
V_o	I_{short_13}	Short circuit current	V_S = 13.5 V(1)	160	210	250	mA
V_o	I_{lim}	Output current limitation	V_S = 13.5 V(1)	170	250	290	mA
V_S, V_o	V_{line}	Line regulation voltage	V_S = 5.6 to 31 V; I_o = 1 to 150 mA			25	mV
V_o	V_{load}	Load regulation voltage	I_o = 1 to 150 mA			25	mV
V_S, V_o	V_{dp}	Drop voltage	I_o = 150 mA		180	400	mV
V_S, V_o	SVR	Ripple rejection	fr = 100 Hz	55			dB
V_S, V_o	I_{qs_1}	Current consumption with watchdog not active $I_{qs\_1} = I_{VS}$-I_o	V_S = 13.5 V; I_o < 1 mA; WE_n = low		69	115	µA
V_S, V_o	I_{qs_10}	Current consumption with watchdog not active $I_{qs\_10} = I_{VS}$-I_o	V_S = 13.5 V; I_o = 10 mA; WE_n = low		127	300	µA
V_S, V_o	I_{qs_50}	Current consumption with watchdog not active $I_{qs\_50} = I_{VS}$-I_o	V_S = 13.5 V; I_o = 50 mA; WE_n = low		498	900	µA
V_S, V_o	I_{qs_150}	Current consumption with watchdog not active $I_{qs\_150} = I_{VS}$-I_o	V_S = 13.5 V; I_o = 150 mA; WE_n = low		1.40	2	mA
V_S, V_o	I_{qn_1}	Current consumption with watchdog active $I_{qn\_1} = I_{VS}$-I_o	V_S = 13.5 V; I_o < 1 mA; WE_n = high		110	170	µA
V_S, V_o	I_{qn_10}	Current consumption with watchdog active $I_{qn\_10} = I_{VS}$-I_o	V_S = 13.5 V; I_o = 10 mA; WE_n = high		168	350	µA
V_S, V_o	I_{qn_50}	Current consumption with watchdog active $I_{qn\_50} = I_{VS}$-I_o	V_S = 13.5 V; I_o = 50 mA; WE_n = high		538	1000	µA
V_S, V_o	I_{qn_150}	Current consumption with watchdog active $I_{qn\_150} = I_{VS}$-I_o	V_S = 13.5 V; I_o = 150 mA; WE_n = high		1.45	2	mA
	Tw	Thermal protection temperature		150		190	°C
	Tw_hy	Thermal protection temperature hysteresis			10		°C

1. See *Figure 3*.

Table 6. Reset

Pin	Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
Res	Vres_l	Reset output low voltage	R_{ext} = 5 kΩ to V_o; V_o > 1 V			0.4	V
Res	I_{Res_lkg}	Reset output high leakage current	V_{Res} = 5 V			1	µA
Res	R_{Res}	Pull up internal resistance	Versus V_o	10	20	50	kΩ
Res	V_{o_th}	Reset threshold voltage	V_S = 5.6 to 31 V; I_o = 1 to 150 mA	6%	8%	10%	Below V_{o_ref}
Vcr	V_{rlth}	Reset timing low threshold	V_S = 13.5 V	10%	13%	16%	V_{o_ref}
Vcr	V_{rhth}	Reset timing high threshold	V_S = 13.5 V	44%	47%	50%	V_{o_ref}
Vcr	I_{cr}	Charge current	V_S = 13.5 V	8	15	30	µA
Vcr	I_{dr}	Discharge current	V_S = 13.5 V	8	15	30	µA
Res	T_{rr_2}	Reset reaction time(1)	V_o = V_{o_th} -100 mV	100	250	700	µs
Res	T_{rd}	Reset delay time	V_S = 13.5 V; Ctr = 1 nF	65	115	165	ms

1. When V_o becomes lower than 4 V, the reset reaction time decreases down to 2 µs assuring a faster reset condition in this particular case.

Table 7. Watchdog

Pin	Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
Wi	Vih	Input high voltage	V_S = 13.5 V	3.5			V
Wi	Vil	Input low voltage	V_S = 13.5 V			1.5	V
Wi	Vih	Input hysteresis	V_S = 13.5 V		500		mV
Wi	Rwi	Pull down resistor	V_S = 13.5 V	30	100	250	KΩ
Vcw	Vwhth	High threshold	V_S = 13.5 V	44%	47%	50%	V_{o_ref}
Vcw	Vwlth	Low threshold	V_S = 13.5 V	10%	13%	16%	V_{o_ref}
Vcw	Icwc	Charge current	V_S = 13.5 V; Vcw = 0.1 V	5	10	20	µA
Vcw	Icwd	Discharge current	V_S = 13.5 V; Vcw = 2.5 V	1.25	2.5	5	µA
Vcw	Twop	Watchdog period	V_S = 13.5 V; Ctw = 47 nF	20	40	80	ms
Res	twol	Watchdog output low time	V_S = 13.5 V; Ctw = 47 nF	4	8	16	ms

Table 8. Watchdog Enable

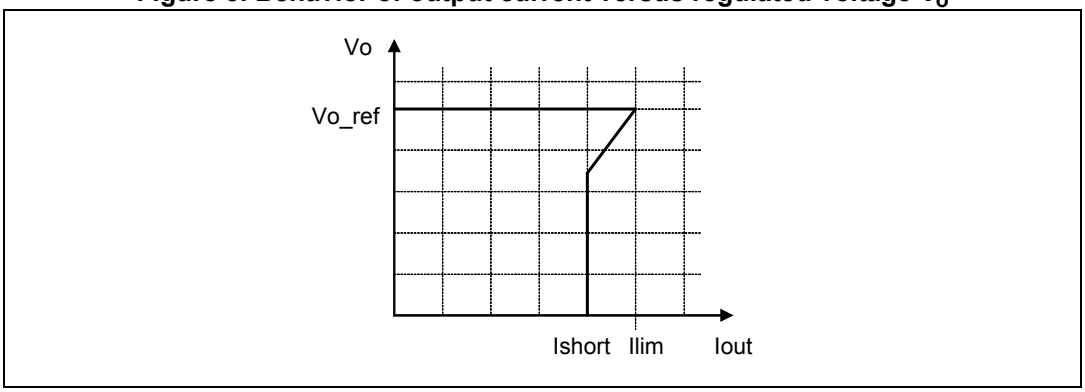
Pin	Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
WE_n	V_{WEn_l}	Enable input low voltage				1	V
WE_n	V_{WEn_h}	Enable input high voltage		3			V
WE_n	V_{WEn_hy}	Enable input hysteresis		600	920	1300	mV
WE_n	I_leak	Pull down current	V_S = 13.5 V	1	2.5	5	µA

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 transient input supply voltage of 40 V. No functional interruption due to over-voltage pulses is generated.The voltage Regulator is always active and not depending on the state of WE_n input pin. A short circuit protection to GND is provided.

Figure 3. Behavior of output current versus regulated voltage V_o



3.2 Reset

The reset circuit supervises the output voltage V_o. The V_{o_th} reset threshold is defined with the internal reference voltage and a resistor output divider. If the output voltage becomes lower than V_{o_th} then Res goes low with a reaction time trr. The reset low signal is guaranteed for an output voltage V_o greater than 1 V.

When the output voltage becomes higher than V_{o_th} then Res goes high with a delay t_{rd}. This delay is obtained by an internal oscillator.

The oscillator period is given by:

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

where:

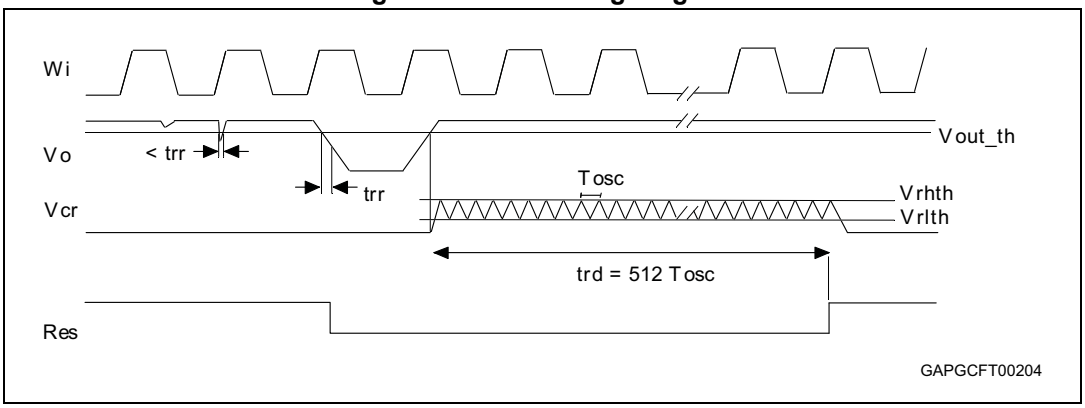
- I_{cr}: is an internally generated charge current
- I_{dr}: is an internally generated discharge current
- V_{rhth}, V_{rlth}: are two voltages defined with the output voltage and a resistor output divider
- C_{tr}: is an external capacitance.

t_{rd} is given by:

$$t_{rd} = 512 \times T_{osc}$$

The Reset is always active and not depending on the state of WE_n input pin.

Figure 4. Reset timing diagram



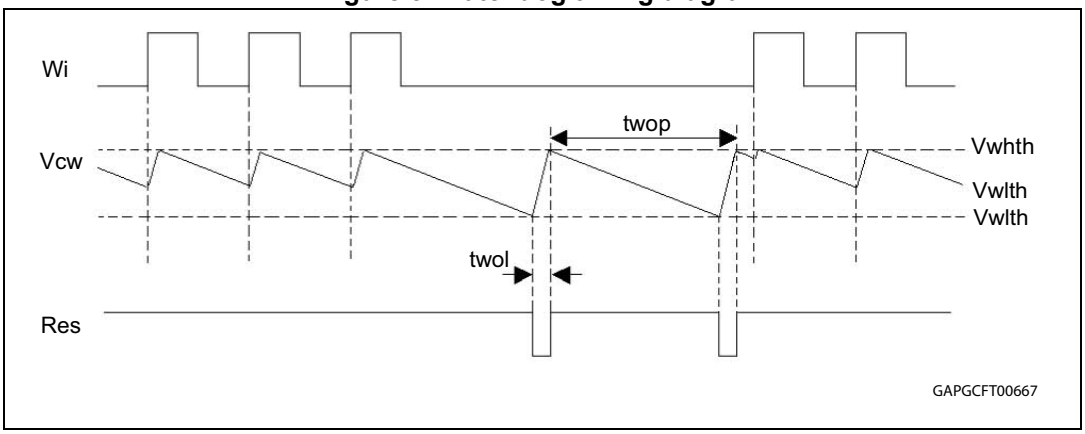
3.3 Watchdog

A connected microcontroller is monitored by the watchdog input W_i. If pulses are missing, the Reset output pin is set to low. The pulse sequence time can be set within a wide range with the external capacitor, C_{tw}. The watchdog circuit discharges the capacitor C_{tw}, with the constant current I_{cwd}. If the lower threshold V_{wlth} is reached, a watchdog reset is generated. To prevent this the microcontroller must generate a positive edge during the discharge of the capacitor before the voltage has reached the threshold V_{wlth}. In order to calculate the minimum time t, during which the micro-controller must output the positive edge, the following equation can be used:

$$(V_{whth} - V_{wlth}) \times C_{tw} = I_{cwd} \times t$$

Every W_i positive edge switches the current source from discharging to charging. The same happens when the lower threshold is reached. When the voltage reaches the upper threshold, V_{whth}, the current switches from charging to discharging. The result is a saw-tooth voltage at the watchdog timer capacitor C_{tw}.

Figure 5. Watchdog timing diagram



4 Package and packing information

4.1 ECOPACK® packages

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.

4.2 SO-8 package information

Figure 6. SO-8 package dimensions

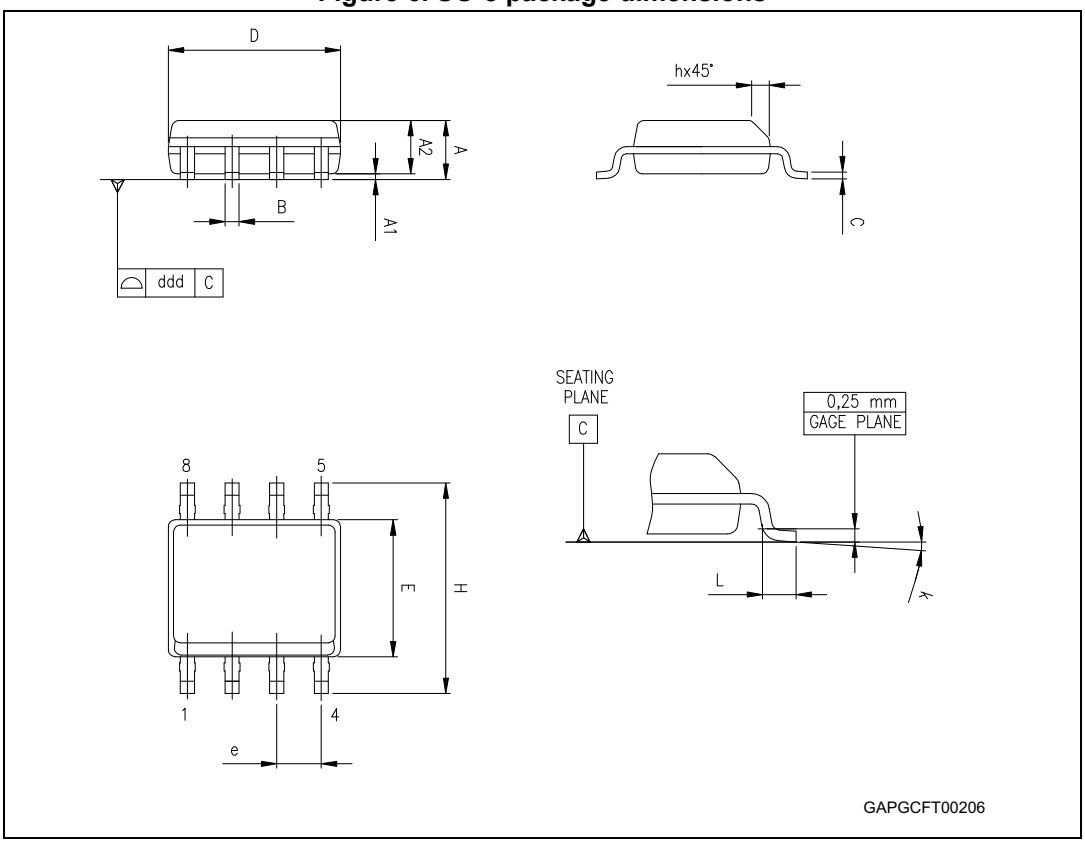


Table 9. SO-8 mechanical data

Symbol	Millimeters		
	Min.	Typ.	Max.
A			1.75
A1	0.10		0.25
A2	1.25		
b	0.28		0.48
c	0.17		0.23
D(1)	4.80	4.90	5.00
E	5.80	6.00	6.20
E1(2)	3.80	3.90	4.00
e		1.27	
h	0.25		0.50
L	0.40		1.27
L1		1.04	
k	0°		8°
ccc			0.10

1. Dimensions D does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15 mm in total (both side).
2. Dimension “E1” does not include interlead flash or protrusions. Interlead flash or protrusions shall not exceed 0.25 mm per side.

4.3 SO-20 package information

Figure 7. SO-20 package dimensions

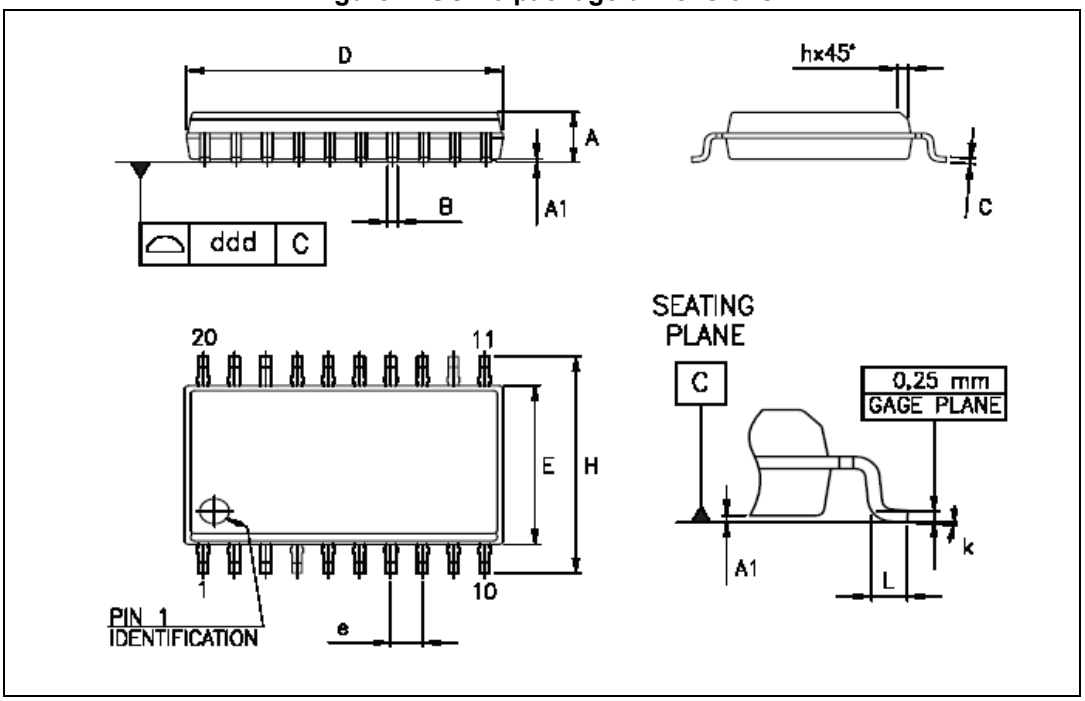


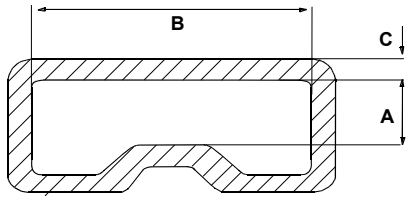
Table 10. SO-20 mechanical data

Symbol	Millimeters		
	Min.	Typ.	Max.
A	2.35		2.65
A1	0.10		0.30
B	0.33		0.51
C	0.23		0.32
D(1)	12.60		13.00
E	7.40		7.60
e		1.27	
H	10.0		10.65
h	0.25		0.75
L	0.40		1.27
k	0°		8°
ddd			0.10

1. “D” dimension does not include mold flash, protusions or gate burrs. Mold flash, protusions or gate burrs shall not exceed 0.15 mm per side.

4.4 SO-8 packing information

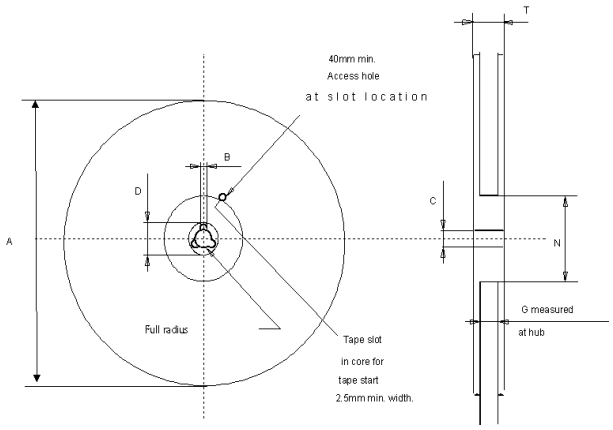
Figure 8. SO-8 tube shipment (no suffix)



Base Q.ty	100
Bulk Q.ty	2000
Tube length (± 0.5)	532
A	3.2
B	6
C (± 0.1)	0.6

All dimensions are in mm.

Figure 9. SO-8 tape and reel shipment (suffix "TR")



Reel dimensions

Base Q.ty	2500
Bulk Q.ty	2500
A (max)	330
B (min)	1.5
C (± 0.2)	13
F	20.2
G (+ 2 / -0)	12.4
N (min)	60
T (max)	18.4

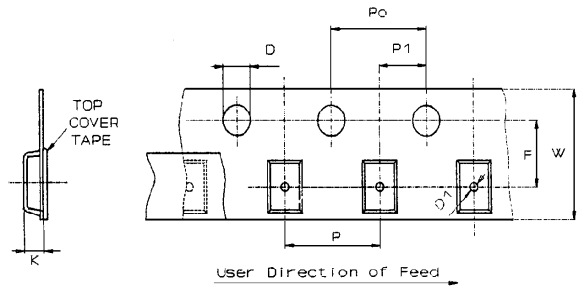
All dimensions are in mm.

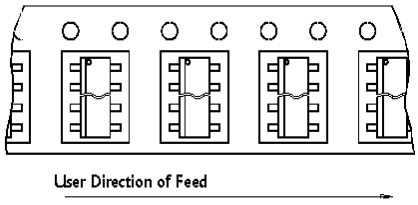
Tape dimensions

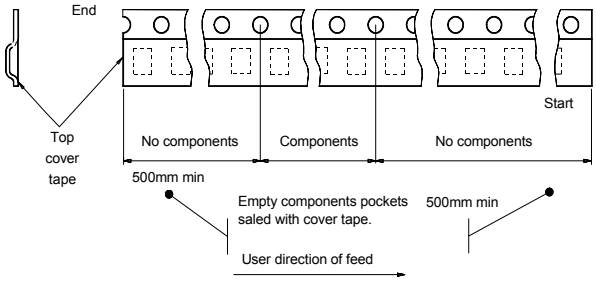
According to Electronic Industries Association (EIA) Standard 481 rev. A, Feb. 1986

Tape width	**W**	12
Tape Hole Spacing	**P0 (± 0.1)**	4
Component Spacing	**P**	8
Hole Diameter	**D (+0.1/-0)**	1.5
Hole Diameter	**D1 (min)**	1.5
Hole Position	**F (± 0.05)**	5.5
Compartment Depth	**K (max)**	4.5
Hole Spacing	**P1 (± 0.1)**	2

All dimensions are in mm.

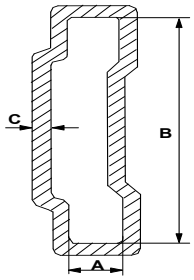






4.5 SO-20 packing information

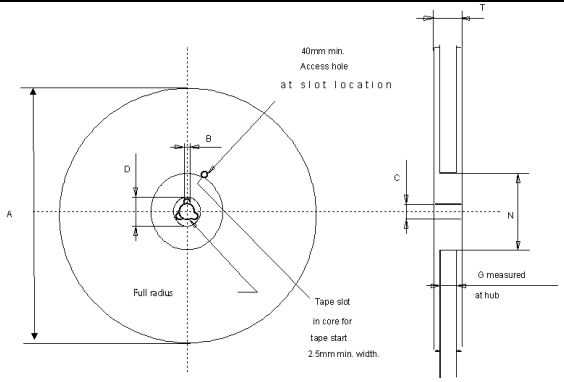
Figure 10. SO-20 tube shipment (no suffix)



Base Q.ty	40
Bulk Q.ty	800
Tube length (± 0.5)	532
A	3.5
B	13.8
C (± 0.1)	0.6

All dimensions are in mm.

Figure 11. SO-20 tape and reel shipment (suffix "TR")



Reel dimensions

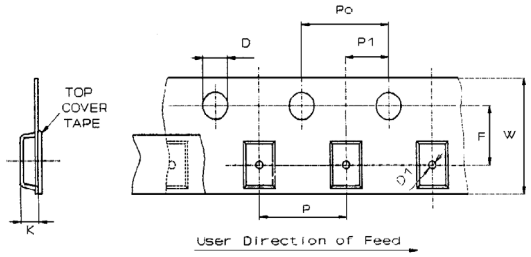
Base Q.ty	1000
Bulk Q.ty	1000
A (max)	330
B (min)	1.5
C (± 0.2)	13
D	20.2
G (+ 2 / -0)	24.4
N (min)	60
T (max)	30.4

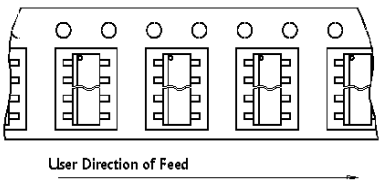
Tape dimensions

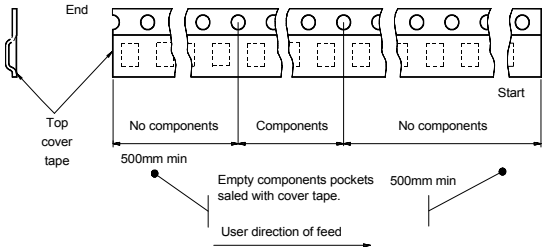
According to Electronic Industries Association (EIA) Standard 481 rev. A, Feb. 1986

Tape width	**W**	24
Tape Hole Spacing	**P0 (± 0.1)**	4
Component Spacing	**P**	12
Hole Diameter	**D (+0.1/-0)**	1.5
Hole Diameter	**D1 (min)**	1.5
Hole Position	**F (± 0.05)**	11.5
Compartment Depth	**K (max)**	6.5
Hole Spacing	**P1 (± 0.1)**	2

All dimensions are in mm.







5 Revision history

Table 11. Document revision history

Date	Revision	Changes
16-Apr-2012	1	Initial release. This document replace the L4989 datasheet.
19-Sep-2013	2	Updated Disclaimer.
01-Oct-2018	3	Updated title and added the feature “AEC-Q100 qualified” in cover page with automotive logo.

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