LPQ3988

Automotive Ultra-Low Noise and High PSRR

Features

- Qualified for automotive applications
- AEC-Q100 qualified with the following results:
  - Device temperature grade1
  - Device HBM ESD classification level H3A
  - Device CDM ESD classification level C3
- Input voltage range: 2.0V to 5.5V
- High output voltage accuracy: ±1.5%(typ)
- Ultra-high PSRR: 92dB @ 1kHz($V_{OUT(NOM)}$ = 3.3V)
- Ultra-low noise: 10μV_{RMS}
- Low current consumption: 24μA (typ)
- Output current: up to 600mA
- Low dropout voltage:
  - 150mV @300mA ($V_{OUT(NOM)}$ = 3.3V)
  - 315mV @600mA ($V_{OUT(NOM)}$ = 3.3V)
- Integrated over-current protection
- Line regulation: 0.002%/V (typ)
- Load regulation: 0.0015%/mA (typ)
- Thermal shutdown
- Active-high enable
- Package: SOT23-5, DFN2x2-6
- RoHS compliant and 100% lead (Pb)-free

Applications

- Automotive camera modules
- ADAS cameras and radar
- Image sensor power
- Automotive infotainment head units
- Microprocessor power rail

Description

The LPQ3988 family are high performance low-dropout (LDO) voltage regulators with ultra-low output noise, high PSRR and fast transient response. The devices operate normally with junction temperture from -40℃ to 125℃ for automotive applications. The devices can deliver up to 600mA load current. The devices include fixed output voltage of 1.8V, 2.5V, 2.8V, 3.0V, and 3.3V.

The LPQ3988 family integrated over current protection and thermal shutdown in order to protect the system from abnormal situation.

The input and output capacitors can be as low as 1μF for LPQ3988.

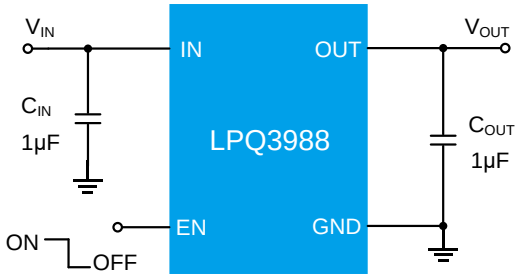
The LPQ3988 is available in normal SOT23-5 and DFN2x2mm-6 package.

Order Information

LPQ3988 - □□ □□ □

- F: Pb-Free
- Package Type:
  B5 : SOT23-5
  QV : DFN2x2-6
- Output Voltage:
  33: 3.3V
  30: 3.0V
  28: 2.8V
  25: 2.5V
  18: 1.8V

Typical Application Circuit



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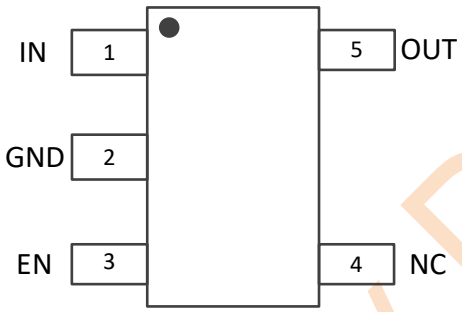
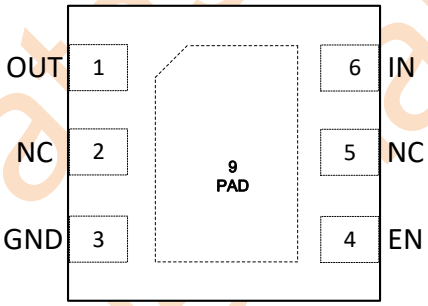
Device Information

Device	Marking	Moisture Sensitivity Level	Package	Shipping
LPQ3988-33B5F	LPS QEYWX	MSL1	SOT23-5	3K/REEL
LPQ3988-33QVF	LPS QEYWX	MSL1	DFN2x2-6	4K/REEL
Marking indication: Y: Production year, W: Production week, X: Production batch				

Pin Diagram



SOT23-5(top view)



DFN2x2mm-6(top view)

Pin Description

Pin #		Name	Description
SOT23-5	DFN2x2-6		
1	6	IN	Input and power source. A small capacitor is recommended from this pin to ground.
2	3	GND	Ground.
3	4	EN	Active-high enable pin. high: enable the device. low or floating: disable the device.
4	2, 5	NC	No connection.
5	1	OUT	Regulated output. A minimum 0.1μF ceramic capacitor is needed from it to ground.

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Absolute Maximum Ratings (Note 1)

IN to GND ---------- -0.3V to 6V
OUT to GND ---------- -0.3V to (V_{IN} + 0.3V) or 6V
EN to GND ---------- -0.3V to 6V
Maximum Output Current ---------- Internally Limited (Note 2)
Maximum Junction Temperature (T_J) ---------- 150°C
Maximum Soldering Temperature (At leads, 10 sec) ---------- 260°C

Notes:

(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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
(2) Maximum continuous output current capability is limited by the chip power dissipation and ambient temperature and internally current limit.

Thermal Information

Thermal Resistance (θ_{JA}, SOT23-5) (Note) ---------- 200 °C/W
Thermal Resistance (θ_{JA}, DFN2x2-6) (Note) ---------- 95 °C/W

Note: Measured using 2S2P JEDEC standard PCB with ambient temperature < 25°C

Electro-Static Discharge

HBM (Human Body Model, AEC-Q100-002) ---------- 4000V
CDM (Charged Device Model, AEC-Q100-011) ---------- 1000V

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Recommended Operating Conditions

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
V_{IN}	Input Voltage	2.0		5.5	V
I_{OUT}	Output Current		(Note 1)		mA
T_J	Operating Junction Temperature Range (T_J)	-40		125	℃
T_A	Ambient Temperature Range	-40		125	℃
C_{IN}	Input Capacitance (Note 2)	1			μF
C_{OUT}	Output Capacitance (Note 2)	1			μF

Notes:

(1) Recommend continuous output current is under the limit line as below according to the IN-OUT voltage difference and ambient temperature(T_A) while using 2S2P JEDEC standard PCB.

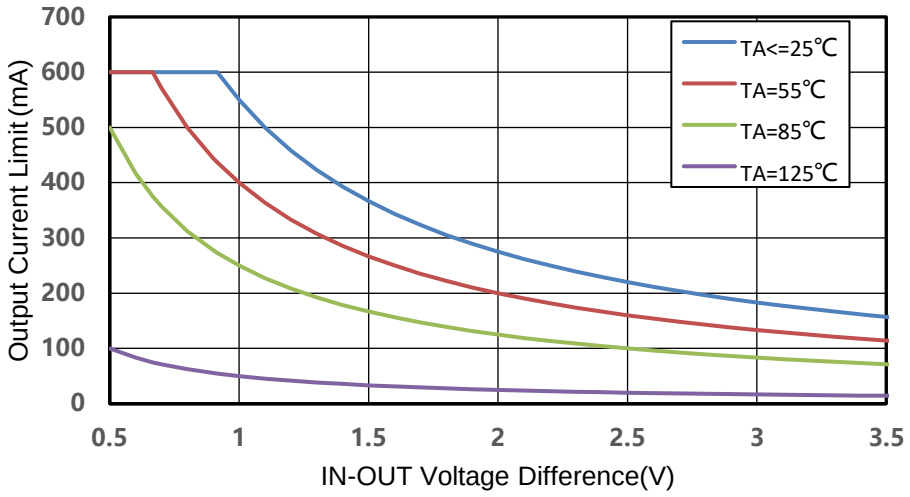

Figure 1 Output current limit vs IN-OUT voltage difference in SOT23-5 package

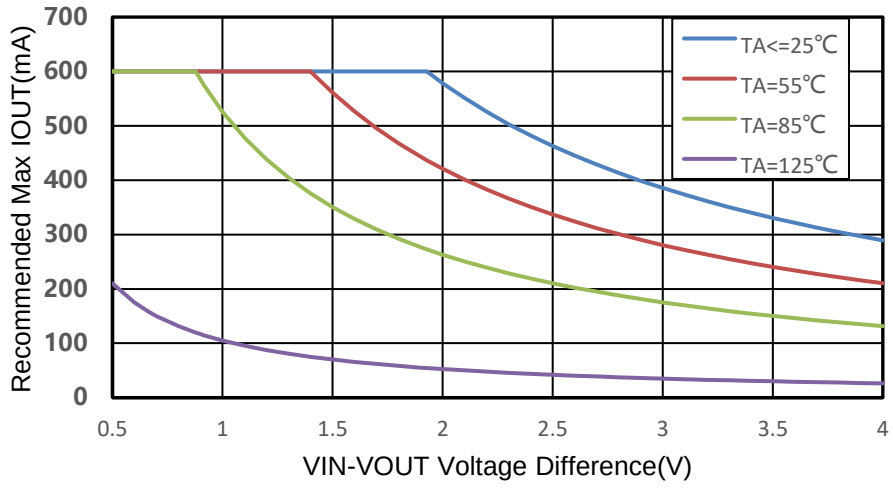

Figure 2 Output current limit vs IN-OUT voltage difference in DFN2x2-6 package

(2) X7R and 16V or higher voltage rating are recommended.

Electrical Characteristics

(The parameters are specified under conditions: V_{IN} is equal to the greater value between $V_{OUT(NOM)}$ + 0.5V and 2.0V, $V_{OUT(NOM)}$=3.3V , I_{OUT} = 1mA, C_{IN} = C_{OUT} = 1μF, -40°C ≤ T_A ≤ 125°C, , unless otherwise noted. Typical values are at T_a = 25°C.)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP.	MAX	UNIT
	Output voltage accuracy	$V_{OUT(NOM)}$ = 3.3V, T_J = 25°C	-1.5		1.5	%
	Output voltage accuracy over temperature	$V_{OUT(NOM)}$ = 3.3V, -40°C ≤ T_A ≤ 125°C	-2.5		2.5	%
I_Q	Input quiescent current	V_{IN} = 2V to 5.5V, V_{EN} = V_{IN}, no load		24		μA
I_{SHDN}	Input shutdown current	V_{IN} = $V_{OUT(NOM)}$ + 0.5V to 5.5V, V_{EN} = 0V, no load		0.01		μA
$\frac{\Delta V_{OUT}}{\Delta V_{IN} \times V_{OUT}}$	Line regulation	I_{OUT} = 1mA, V_{IN} = ($V_{OUT(NOM)}$ + 0.5V) to 5.5V, T_A = 25°C		0.002		%/V
ΔV_{LOAD}	Load regulation	I_{OUT} = 1mA to 600mA, V_{IN} = $V_{OUT(NOM)}$ + 1V, T_A = 25°C		30		mV
V_{DROP}	Dropout voltage	$V_{OUT(NOM)}$ = 3.3V, I_{OUT} = 100mA,		50		mV
		$V_{OUT(NOM)}$ = 3.3V, I_{OUT} = 300mA,		150		mV
		$V_{OUT(NOM)}$ = 3.3V, I_{OUT} = 600mA,		315		mV
I_{LIM}	Output current limit	$V_{OUT(NOM)}$ = 3.3V, V_{IN} = $V_{OUT(NOM)}$ + 1V, V_{OUT} = 0.9 × $V_{OUT(NOM)}$	700	960		mA
V_{NOISE}	Output voltage noise	BW = 10Hz to 100kHz, I_{OUT} = 20mA		10		μV_{RMS}
PSRR	Power supply rejection ratio	V_{IN} = $V_{OUT(NOM)}$ + 1V, I_{OUT} = 20mA, f = 1kHz, ΔV_{RIPPLE} = 0.2 × V_{PP}		92		dB
V_{IH}	EN logic high voltage level		1.1		V_{IN}	V
V_{IL}	EN logic low voltage level		0		0.4	V
I_{EN_PU}	EN pull-up current	V_{IN}=V_{EN}=5.5V		200		nA
T_{SD}	Thermal shutdown threshold			155		℃
T_{SD_H}	Thermal shutdown hysteresis			25		℃
R_{DIS}	Output discharge resistance	V_{EN} = 0V		300		Ω

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Typical Characteristics

(T_J = 25℃, V_{IN} = $V_{OUT(NOM)}$ + 1V, $V_{OUT(NOM)}$=3.3V, V_{EN} = V_{IN}, C_{IN} = C_{OUT} = 1.0μF, unless otherwise noted.)

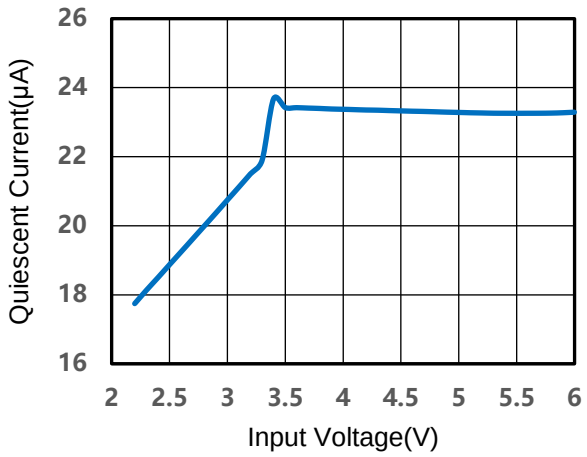

Figure 3 Quiescent Current vs Input Voltage

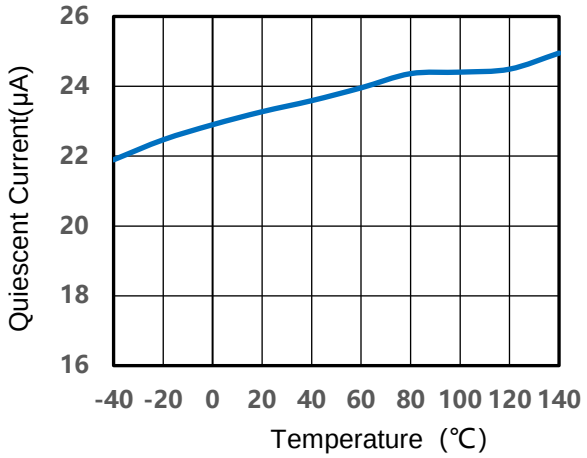

Figure 4 Quiescent Current vs Temperature

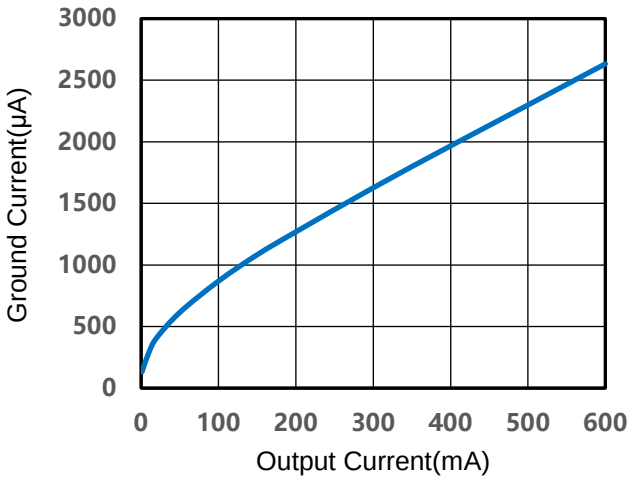

Figure 5 Ground Current vs Output Current

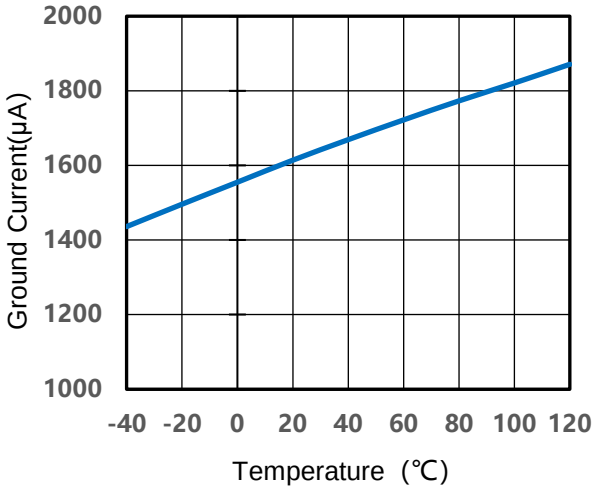

Figure 6 Ground Current vs Temperature at 300mA Output Current

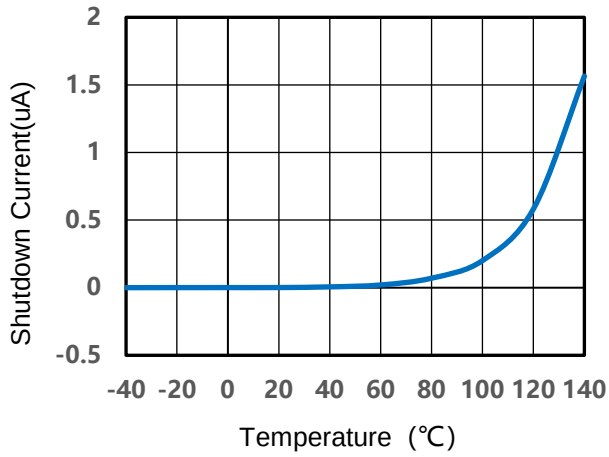

Figure 7 Shutdown Current vs Temperature

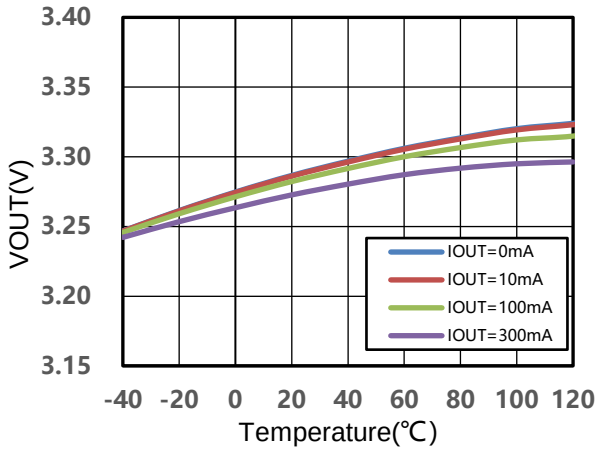

Figure 8 V_{OUT} vs Temperature

Typical Characteristics(continued)

(T_J = 25℃, V_{IN} = $V_{OUT(NOM)}$ + 1V, $V_{OUT(NOM)}$=3.3V, V_{EN} = V_{IN}, C_{IN} = C_{OUT} = 1.0μF, unless otherwise noted.)

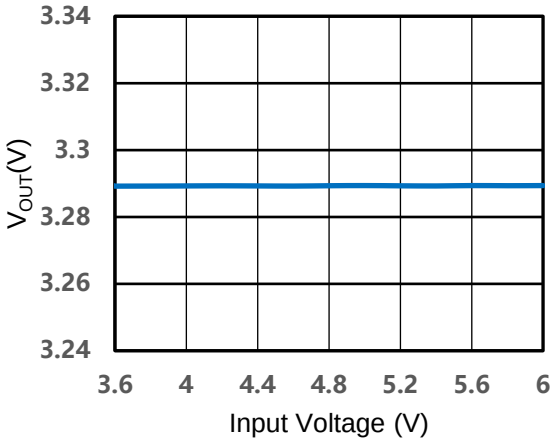

Figure 9 V_{OUT} vs Input Voltage at 1mA Output Current

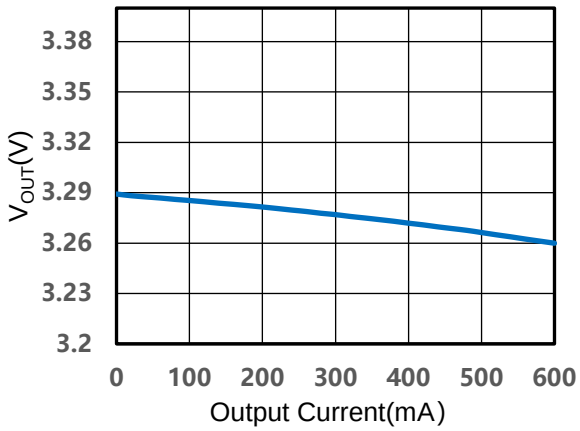

Figure 10 V_{OUT} vs Output Current

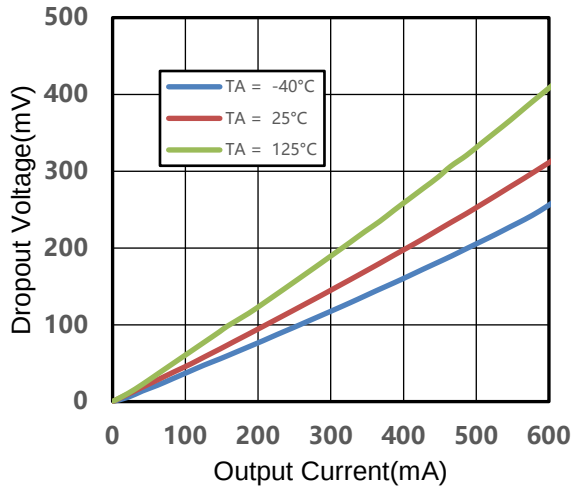

Figure 11 Dropout Voltage vs Output Current

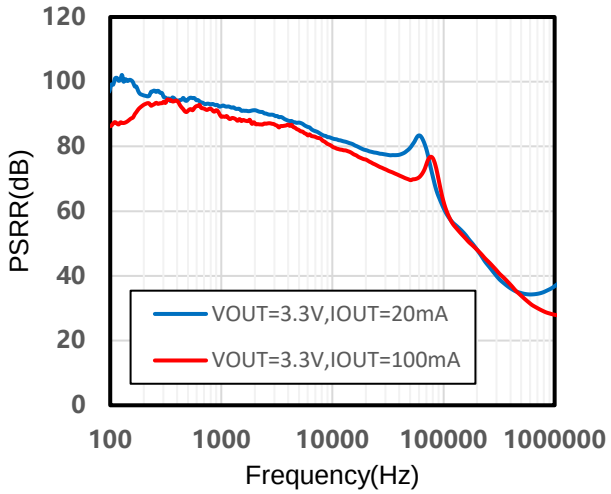

Figure 2 PSRR vs Frequency while V_{OUT}=3.3V

Typical Characteristics(continued)

(T_J = 25℃, V_{IN} = $V_{OUT(NOM)}$ + 1V, $V_{OUT(NOM)}$=3.3V, V_{EN} = V_{IN}, C_{IN} = C_{OUT} = 1.0μF, unless otherwise noted.)

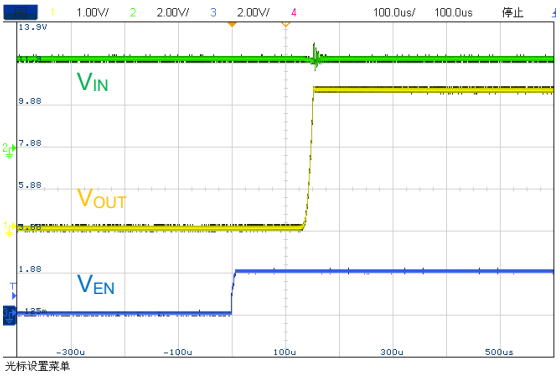

Figure 33 Strat up waveform with EN on

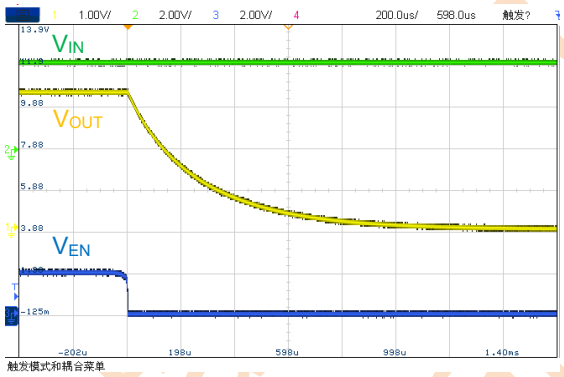

Figure 4 Turn off with EN off

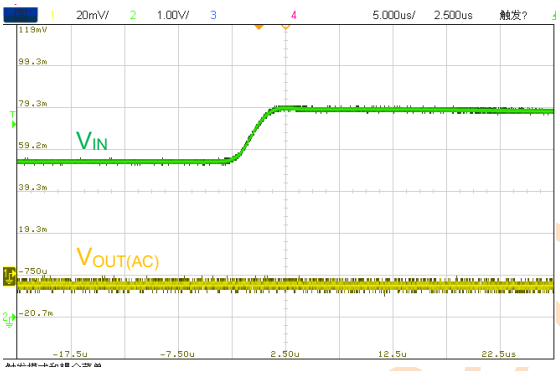

Figure 55 Line transient waveform:
VIN=3.8V->5V in 5μs

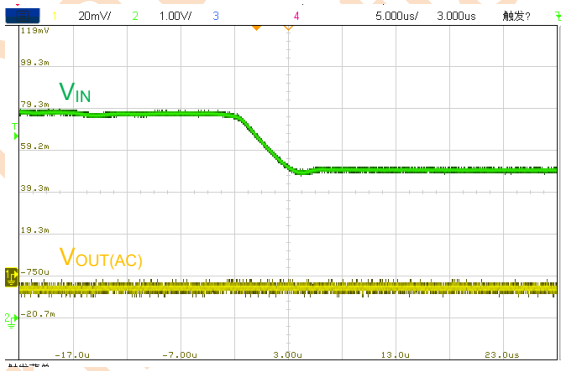

Figure 66 Line transient waveform:
VIN=5V->3.8V in 5μs

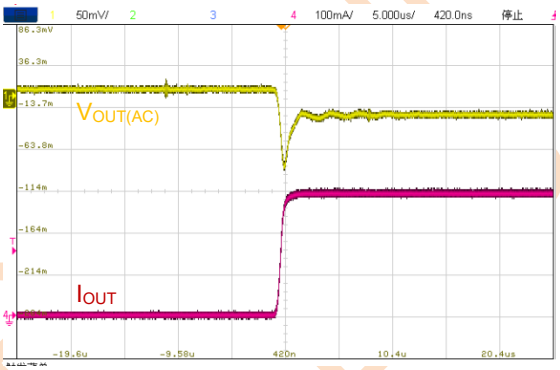

Figure 77 Load transient wavefrom:
I_{OUT}=1mA->300mA in 1μs

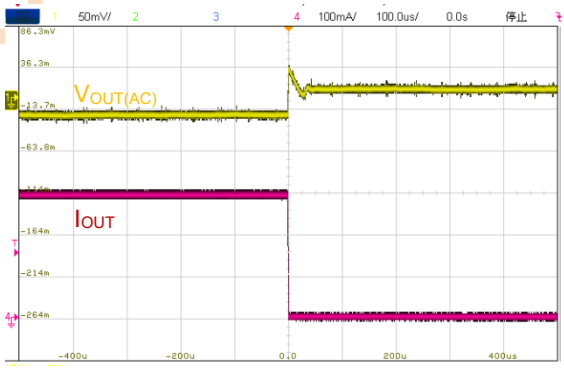

Figure 88 Load transient waveform:
I_{OUT}=300mA->1mA in 1μs

Functional Block Diagram

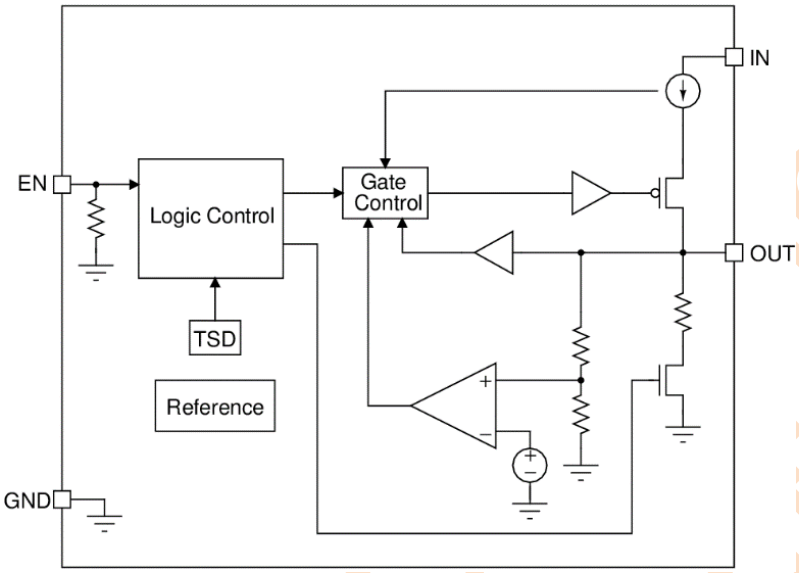

Figure 99 Functional block diagram

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Detailed Description

Overview

The LPQ3988 family are low dropout voltage regulator with ultra-low noise and ultra-high PSRR. It has fixed output voltage of 1.8V, 2.5V, 2.8V, 3.0V, and 3.3V, with good transient performance and no external setting resistors needed. The product is available in a traditional SOT23-5 and DFN2x2-6 package.

Enable function

The EN pin is an active high Logic input pin that is compatible with 1.8V control logic. The internal power element is turned off when EN pin is tied low or left floating.

When the EN pin is pulled high, the LPQ3988 will be activated and output voltage according to the internal setting.

Auto discharge

The LPQ3988 has a quick discharge function. When the device is disabled by pulling down the EN pin, a discharge resistor is connected between OUT and GND. The resistance is 300Ω (typical).

Power supply rejection ratio

The LPQ3988 is working with ultra-high Power Supply Rejection Ratio (PSRR). By selecting proper output capacitor and PCB layout, the PSRR could even be tuned to a higher value.

Over current protection

The device features a current limit function with a limit of 960mA (typical). The output current will be clamped and output voltage will drop accordingly, as given in the *Electrical Characteristics Table.*

Application Information

Capacitor consideration

External capacitors on IN and OUT are recommended in application, 1μF each for C_{OUT} and C_{IN} at least. Closer placement of the capacitors to the device, both IN and OUT, will result in better stability.

Power dissipation

The internal power dissipation from the power MOSFET, when it is turned on, is the main source of junction temperature rising. In this case, the power dissipation and the junction temperature in conducting mode can be calculated as following:

$$P_D = (V_{IN} - V_{OUT}) \times I_{OUT}$$

P_D: Power Dissipation (W)

V_{IN}: Input voltage (V)

V_{OUT}: Output voltage (V)

I_{OUT}: Output current (A)

$$T_J = P_D \times \theta_{JA} + T_A$$

T_J: Junction temperature (°C)

θ_{JA}: Package thermal resistance (°C /W) (Note 4)

T_A: Ambient temperature (°C)

Note: The calculation based on the thermal resistance is only valid in Lab condition. The value of θ_{JA} can change in customer's PCB environment.

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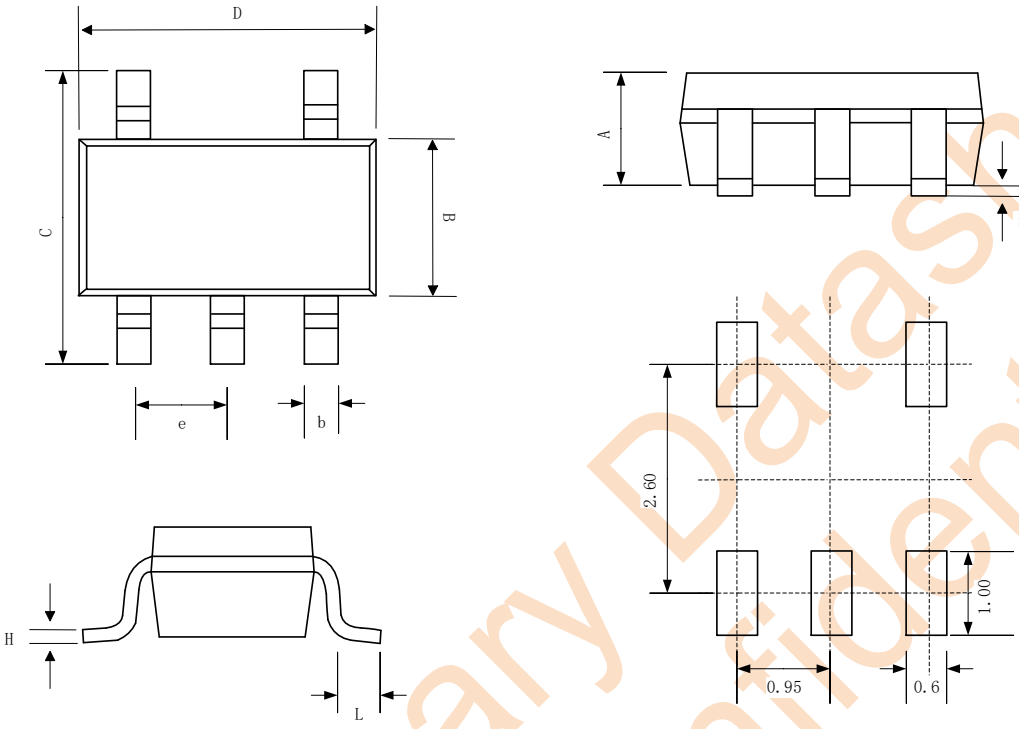
Package Information

SOT23-5



Recommended Land Pattern

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.889	1.100	1.295
A1	0.000	0.050	0.152
B	1.397	1.600	1.803
b	0.28	0.35	0.559
C	2.591	2.800	3.000
D	2.692	2.920	3.120
e	0.95BSC		
H	0.080	0.152	0.254
L	0.300	0.450	0.610

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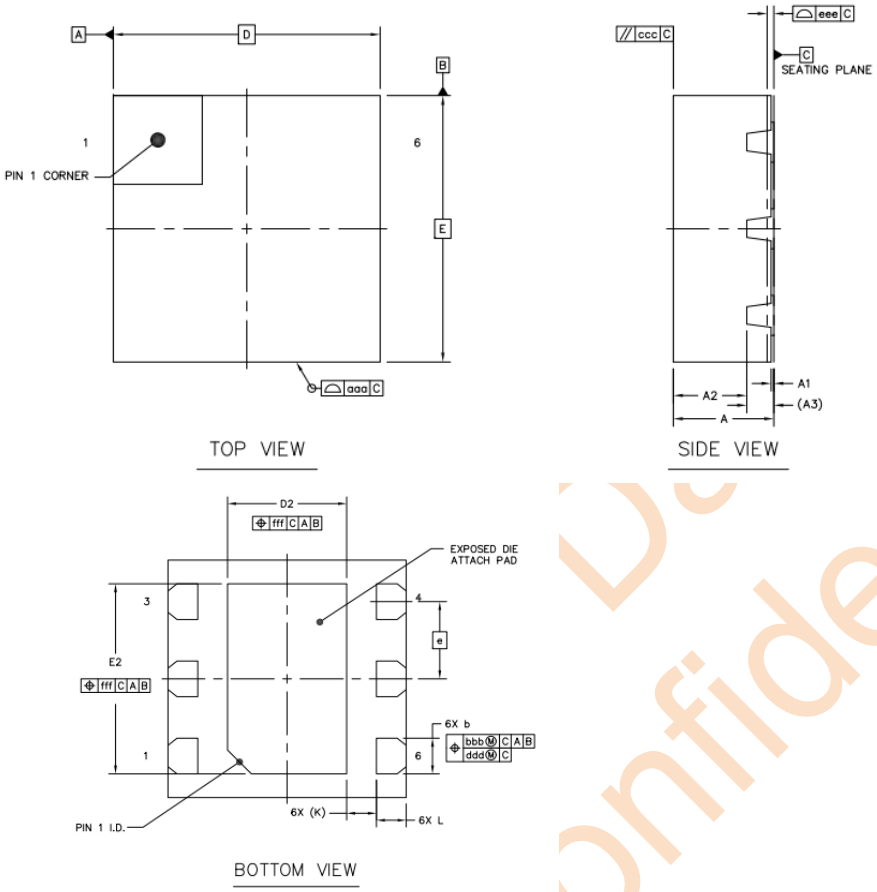
DFN2x2-6



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A2	--	0.55	--
A3		0.203 REF	
b	0.25	0.30	0.35
D		2.0 BSC	
E		2.0 BSC	
e		0.65 BSC	
D2	0.90	1.00	1.10
E2	1.50	1.60	1.70
L	0.20	0.25	0.610
K		0.25 REF	

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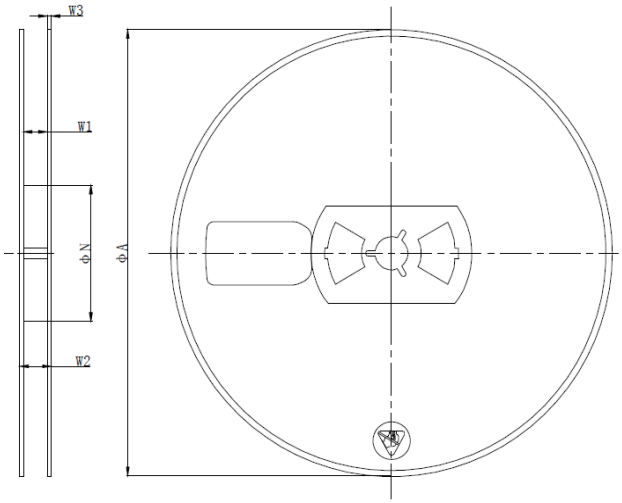
Tape and Reel Information

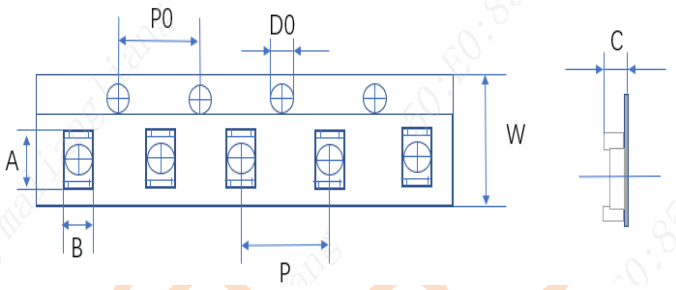
SOT23-5

REEL DIMENSIONS



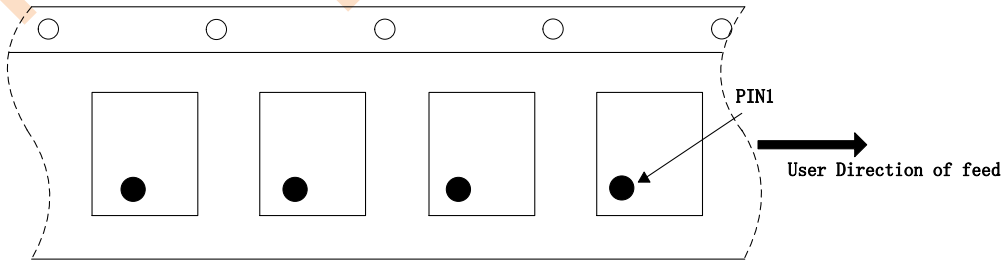
SYMBOL	Dimensions In Millimeters		
	MIN	NOM	MAX
ΦA	176.00	180.00	184.00
W2	10.00	12.00	14.00

TAPE DIMENSIONS



SYMBOL	Dimensions In Millimeters		
	MIN	NOM	MAX
A	3.00	3.20	3.40
B	3.06	3.26	3.46
P0	3.90	4.00	4.10
P	3.90	4.00	4.10
D0	1.35	1.50	1.65
W	7.70	8.00	8.30
C	1.20	1.40	1.60

PIN1 AND TAPE FEEDING DIRECTION



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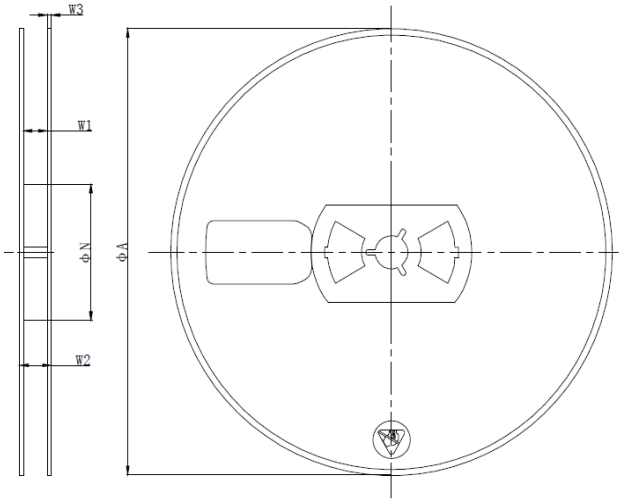
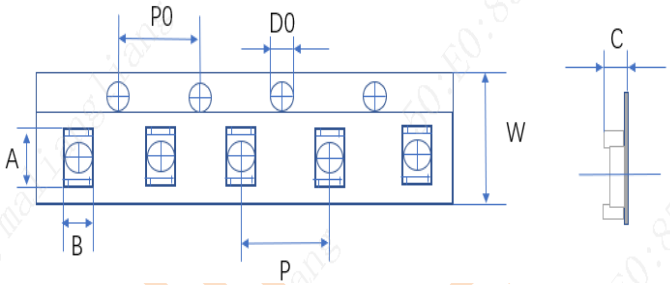
DFN2x2-6

REEL DIMENSIONS



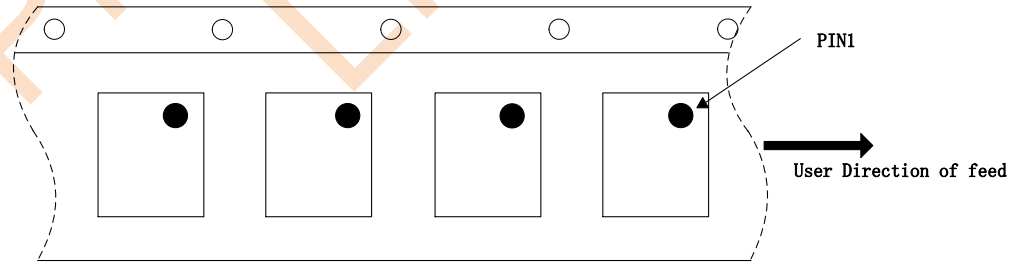
SYMBOL	Dimensions In Millimeters		
	MIN	NOM	MAX
ΦA	176.00	180.00	184.00
W2	9.00	12.00	15.00

TAPE DIMENSIONS



SYMBOL	Dimensions In Millimeters		
	MIN	NOM	MAX
A	1.85	2.15	2.50
B	1.85	2.15	2.50
P0	3.80	4.00	4.20
P	3.80	4.00	4.20
D0	1.30	1.50	1.70
W	7.70	8.00	8.30
C	0.80	1.00	1.20

PIN1 AND TAPE FEEDING DIRECTION



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Revision History

Revision	Date	Change Description
Rev0.1	7/10/2023	First release version
Rev0.2	2/2/2024	Add DFN2x2-6 package

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