

200mA 36V Input Ultra Low Supply Current LDO Regulators

FEATURES

- AEC-Q100 result certification in progress
- Temperature grade 1: -40°C to +125°C, T_A
- 3.5V to 36V Operating Supply Voltage
- Typical Dropout Voltage: 820mV @ $V_{OUT}=3.3V/5V$, $I_{OUT}=200mA$
- Stable with 1μF Ceramic Output Capacitor
- Low Quiescent Current: 2.5μA typical
- Low Shutdown Current: <1μA
- Output Accuracy: ±0.6%
- Fixed Output Voltage: 3.3V, 5V
- Output Short-circuit Protection Circuit
- Over-current Protection Circuit
- Thermal Shutdown
- Output Auto-Discharge in Shutdown
- RoHS Compliant and 100% Lead (Pb)-Free Halogen-Free

APPLICATIONS

- Car Audios
- Car Navigation Systems
- ETC Systems
- Battery Charge Control Unit

TYPICAL APPLICATION

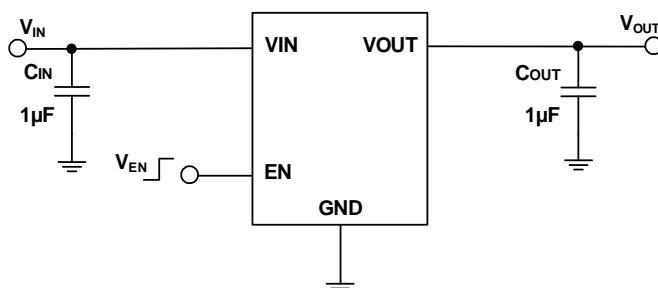
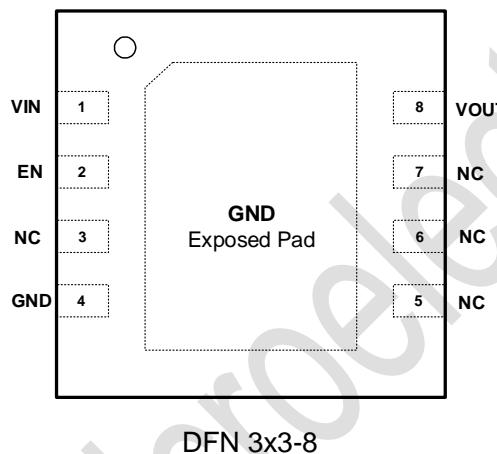


Figure 1. Basic Application Circuit

ABSOLUTE MAXIMUM RATINGS (Note 1)

Parameter	Min	Max	Unit
V _{IN} and V _{EN} Voltage	-0.3	45	V
V _{OUT} Voltage	-0.3	14	V
Storage Temperature Range	-65	150	°C
Junction Temperature (Note2)	-	155	°C
Power Dissipation	-	3.2	W
Lead Temperature (Soldering,10s)	-	260	°C

PACKAGE

DFN 3x3-8

ORDER INFORMATION

Part Number	Package	Top Mark	Quantity/ Reel
TMI6411-33DA-Q1	DFN 3x3-8	T6411EQ TBxxxxx	5000
TMI6411-50DA-Q1	DFN 3x3-8	T6411HQ TBxxxxx	5000

TMI6411-XXDA-Q1 devices are Pb-free and RoHS compliant.

PIN DESCRIPTION

Pin	Name	Function
1	VOUT	Output of the LDO.
2	GND	Ground pin.
3	EN	Enable Pin. Connect this pin to ground or less than 0.4V to disable the device, connect EN to 1.8V or above to enable the device. This pin should not be floated.
4	GND	Ground pin.
5	VIN	Input Supply of the LDO.

ESD RATING

Items	Description	Value	Unit
V_{ESD_HBM}	Human Body Model for all pins	± 2000	V
V_{ESD_CDM}	Charge Device Model for all pins	± 1000	V

JEDEC specification JS-001

RECOMMENDED OPERATING CONDITIONS

Items	Description	Min	Max	Unit
V_{IN}	Voltage Range	3.5	36	V
T_J	Operating Junction Temperature Range	-40	125	°C

THERMAL RESISTANCE (Note 3)

Items	Description	Value	Unit
θ_{JA}	Junction-to-ambient thermal resistance	43	°C/W
θ_{JC}	Junction-to-case thermal resistance	11	°C/W

ELECTRICAL CHARACTERISTICS

$V_{IN}=V_{OUT}+3V$, $-40^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$, unless otherwise noted.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_{IN}	Input Voltage Range (Note 4)			3.5		36	V
I_Q	Quiescent Current	$V_{EN}=2\text{V}$, No load			2.5	8.5	μA
UVLO	Input Under Voltage Lock Off	V_{IN} rising		3.2	3.5		V
	UVLO Hysteresis			300			mV
I_{SD}	Shutdown Current	$V_{IN}=12\text{V}$, $V_{EN}=0\text{V}$				1	μA
V_{EN_H}	Enable Input High Voltage			1.8			V
V_{EN_L}	Enable Input Low Voltage					0.4	V
I_{EN}	EN Input Current	$V_{EN}=5\text{V}$		-0.1		1	μA
V_{OUT}	Output Voltage Accuracy	$V_{OUT}+3\text{V} \leq V_{IN} \leq 36\text{V}$	$T_A=25^{\circ}\text{C}$	-0.6		0.6	%
		$I_{OUT}=1\text{mA}$	$-40^{\circ}\text{C} \leq T_A \leq 125^{\circ}\text{C}$	-1.6		1.6	
V_{LNR}	Output Line Regulation	$V_{OUT}+3\text{V} \leq V_{IN} \leq 36\text{V}$, $I_{OUT}=1\text{mA}$		-0.04	0.01	0.02	%/V
V_{LDR}	Output Load Regulation	$V_{OUT}=3.3\text{V}$, $1\text{mA} \leq I_{OUT} \leq 200\text{mA}$		-45		10	mV
		$V_{OUT}=5\text{V}$, $1\text{mA} \leq I_{OUT} \leq 200\text{mA}$		-65		10	mV
V_{DROP}	Dropout Voltage (Note 5)	$I_{OUT}=200\text{mA}$			820		mV
PSRR	Power Supply Ripple Rejection	$V_{OUT}=3.3\text{V}$, $I_{OUT}=10\text{mA}$, $f=1\text{kHz}$			68		dB
		$V_{OUT}=5\text{V}$, $I_{OUT}=10\text{mA}$, $f=1\text{kHz}$			64		dB
V_{NOISE}	Output Noise Voltage	$BW=10\text{Hz}$ to 90kHz	$V_{OUT}=3.3\text{V}$		68		μV_{RMS}
		$I_{OUT}=10\text{mA}$	$V_{OUT}=5\text{V}$		80		μV_{RMS}
I_{OUTMAX}	Maximum Output Current	$V_{IN} = V_{OUT} + V_{DROP}$		200			mA
R_{DIS}	Resistance of Auto-Discharge				600		Ω
I_{LIMIT}	Output Current Limit	$V_{OUT} = 90\% V_{NOR}$		220	400		mA
I_{SHORT}	Short Current	$V_{IN}=12\text{V}$, $V_{EN}=1.8\text{V}$ V_{OUT} Short to GND			90		mA
T_{SD}	Thermal Shutdown Temperature (Note 6)				160		$^{\circ}\text{C}$
T_{SDHYS}	Thermal Shutdown Hysteresis (Note 6)				20		$^{\circ}\text{C}$

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula: $T_J = T_A + P_D \times \theta_{JA}$.

Note 3: Measured on JESD51-7, 4-layer PCB.

Note 4: The load condition and dropout voltage should be considered in low input voltage application to ensure input voltage have enough headroom for expected load current.

Note 5: The dropout voltage is defined as $V_{IN}-V_{OUT}$, when V_{OUT} is 98% of the normal value of V_{OUT} .

Note 6: Guaranteed by design.

Operation Description

Overview

The TMI6411-XXDA-Q1 is an ultra-low supply current voltage regulator featuring 200mA output current and 36V input voltage. TMI6411-XXDA-Q1 provide fixed output voltage with 3.3V, 5V. The operating temperature range is between -40°C to 125°C , and the maximum input voltage is 36V. It is designed to work with low-ESR ceramic capacitor, reducing the amount of the PCB area. Only a $1\mu\text{F}$ ceramic output capacitor can make the device stable over the whole load range.

As shown in the function block diagram, the TMI6411-XXDA-Q1 is composed of the band gap reference voltage, the error amplifier, P-channel MOSFET pass transistor, internal resistor divider and some additional protection circuits. The reference voltage, connected to the cathode terminal of the error amplifier, compares with the feedback voltage to regulate the output voltage to make it constant over the whole load current range. If the feedback voltage is lower than the reference voltage, the pass transistor gate is pulled lower to increase its conductivity. This allows more current to flow to the output and increase the output voltage. If the feedback voltage is higher than the reference voltage, the pass transistor gate is pulled higher to decrease its conductivity. This allows less current to flow to the output and decrease the output voltage. The feedback point is the output of the internal resistor divider connected to the V_{OUT} pin.

Enable/Shutdown

The TMI6411-XXDA-Q1 is disabled when the EN pin is connected to ground or the voltage less than 0.4V. Connect EN pin to 1.8V or higher voltage to enable the device. This EN pin cannot be floated.

Output Auto Discharge

When the regulator is disabled, an internal 600Ω resister is connected between V_{OUT} and GND to discharge output capacitor C_{OUT} .

Current Limit

The TMI6411-XXDA-Q1 contains an independent current limiter, which monitors and controls the pass transistor's gate voltage, limiting the output current to 0.4A (typ). The current limiting level is reduced to around 0.09A named fold-back current limit when the output voltage is further decreased. The output can be shorted to ground indefinitely without damaging the part.

Thermal Shutdown

The TMI6411-XXDA-Q1 monitors internal temperature. When the junction temperature exceeds 160°C , the over temperature protection (OTP) circuit turn off the pass transistor until the device is cooled down by 20°C . Then the pass transistor resumes. For continue operation, do not exceed absolute maximum junction temperature.

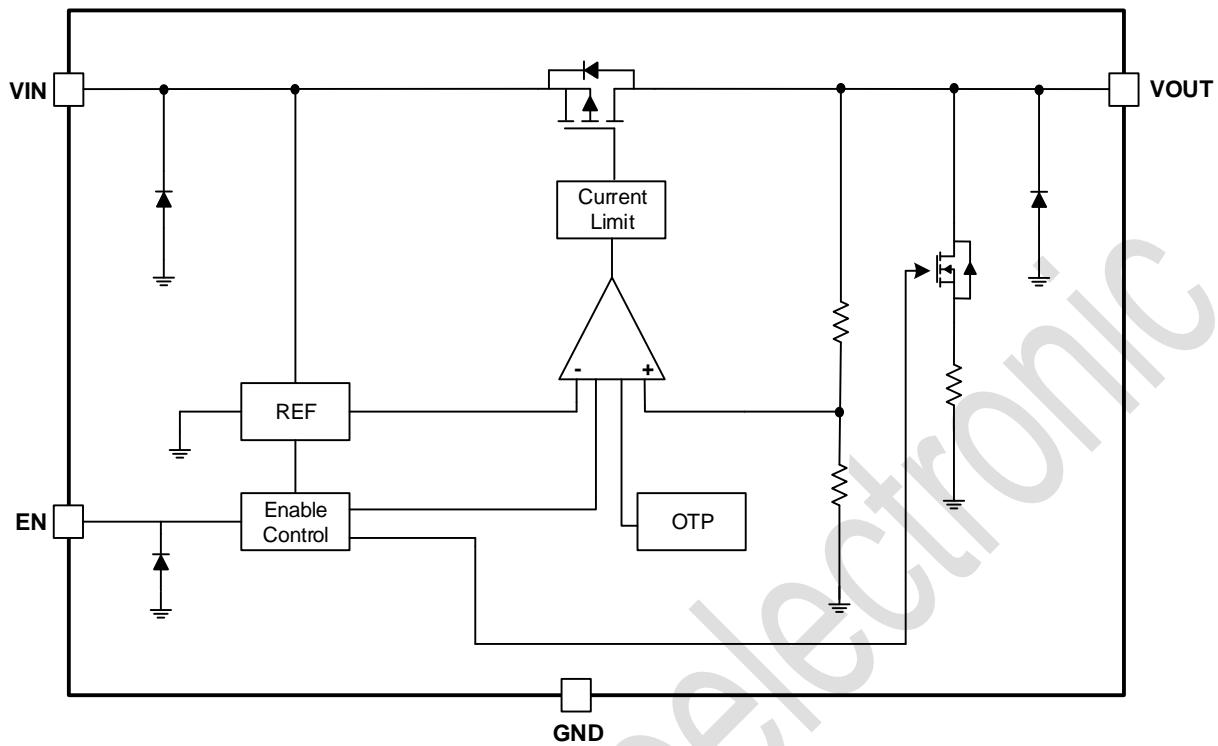
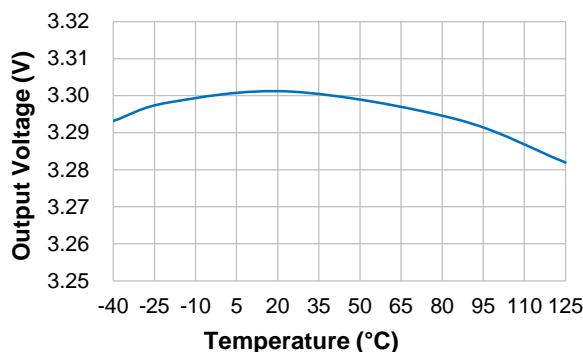
FUNCTIONAL BLOCK DIAGRAM

Figure 2. TMI6411-XXDA-Q1 Block Diagram

TYPICAL CHARACTERISTICS

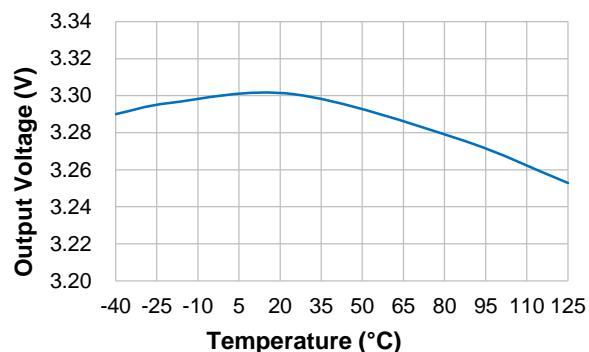
Output Voltage Vs. Temperature

$V_{IN}=6.3V$, $V_{OUT}=3.3V$, $I_{OUT}=1mA$



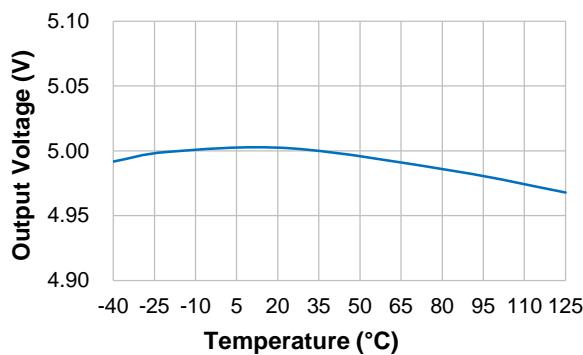
Output Voltage Vs. Temperature

$V_{IN}=6.3V$, $V_{OUT}=3.3V$, $I_{OUT}=50mA$



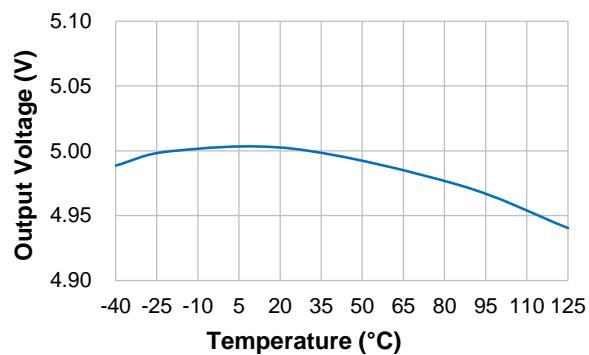
Output Voltage Vs. Temperature

$V_{IN}=8V$, $V_{OUT}=5V$, $I_{OUT}=1mA$



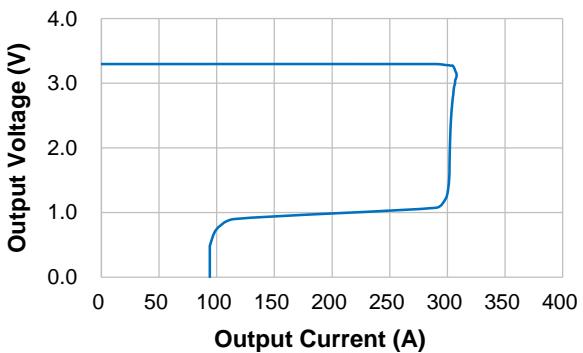
Output Voltage Vs. Temperature

$V_{IN}=8V$, $V_{OUT}=5V$, $I_{OUT}=50mA$



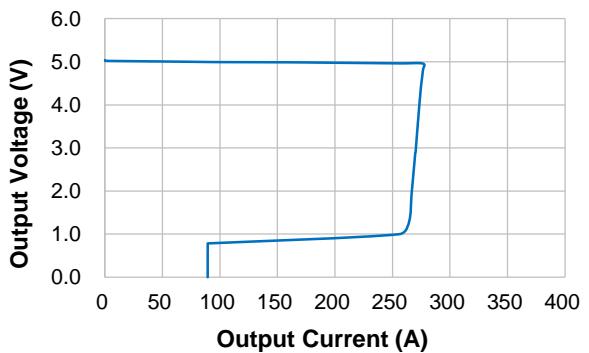
Output Voltage Vs. Output Current

$V_{IN}=6.3V$, $V_{OUT}=3.3V$



Output Voltage Vs. Output Current

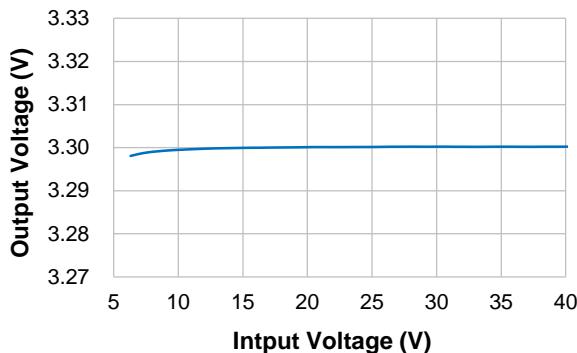
$V_{IN}=8V$, $V_{OUT}=5V$



Typical Performance Characteristics (continued)

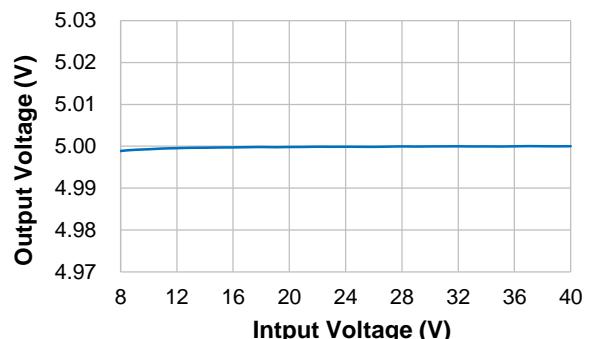
Output Voltage Vs. Input Voltage

$V_{OUT}=3.3V$, $I_{OUT}=1mA$



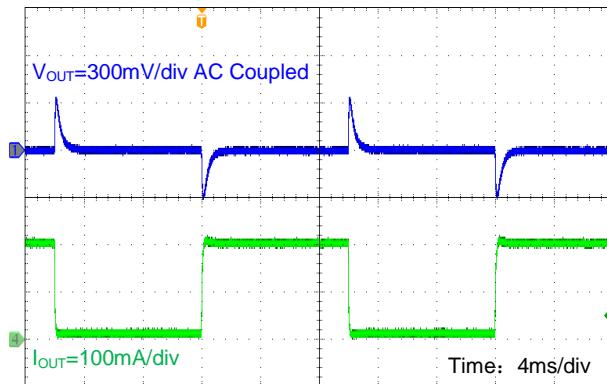
Output Voltage Vs. Input Voltage

$V_{OUT}=5V$, $I_{OUT}=1mA$



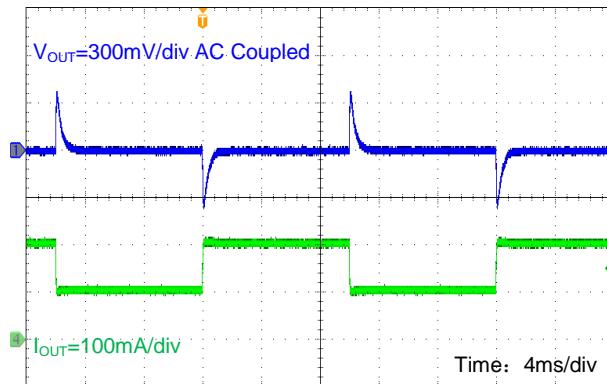
Load Transient

$V_{IN}=6.3V$, $V_{OUT}=3.3V$, $I_{OUT}=1mA$ to $200mA$



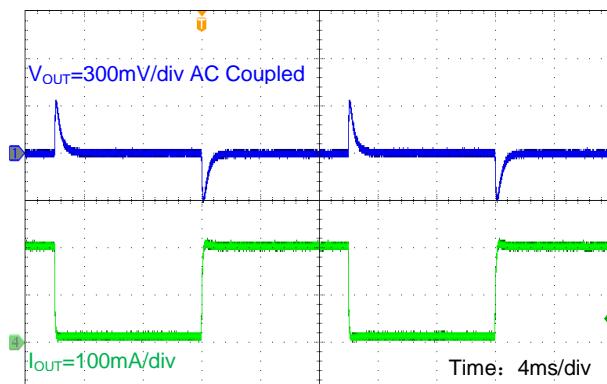
Load Transient

$V_{IN}=6.3V$, $V_{OUT}=3.3V$, $I_{OUT}=100mA$ to $200mA$



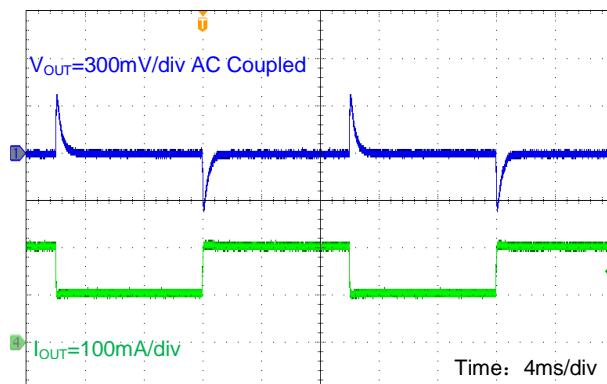
Load Transient

$V_{IN}=8V$, $V_{OUT}=5V$, $I_{OUT}=1mA$ to $200mA$

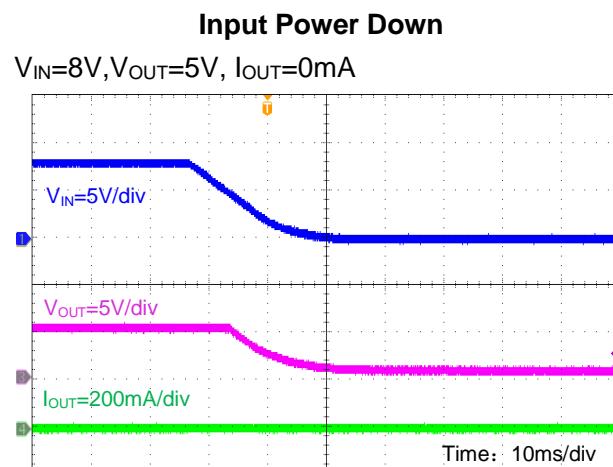
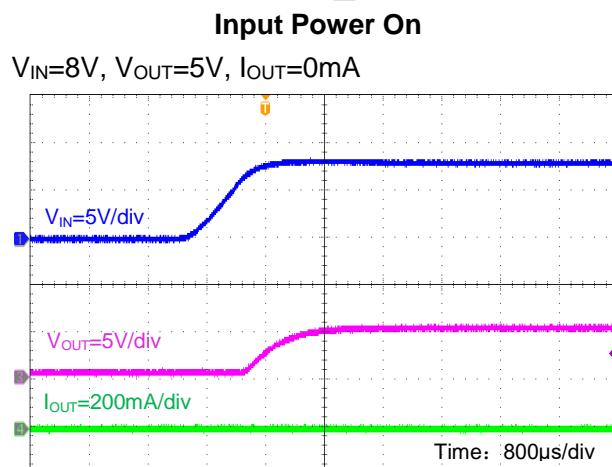
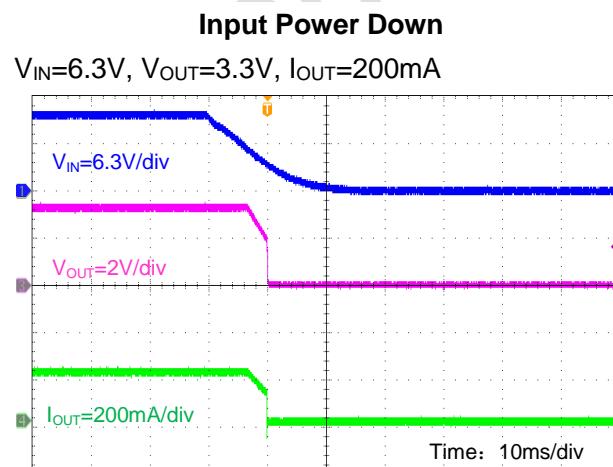
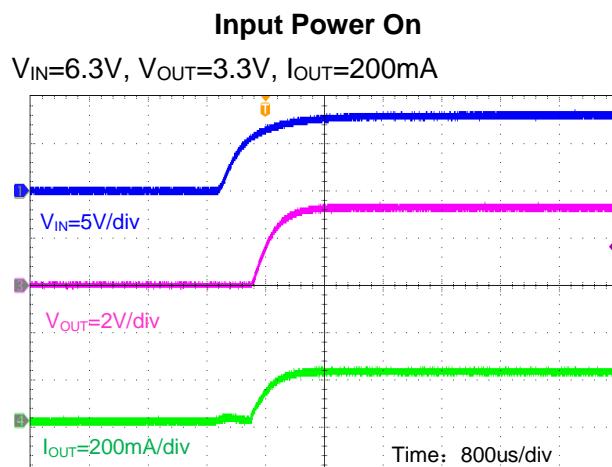
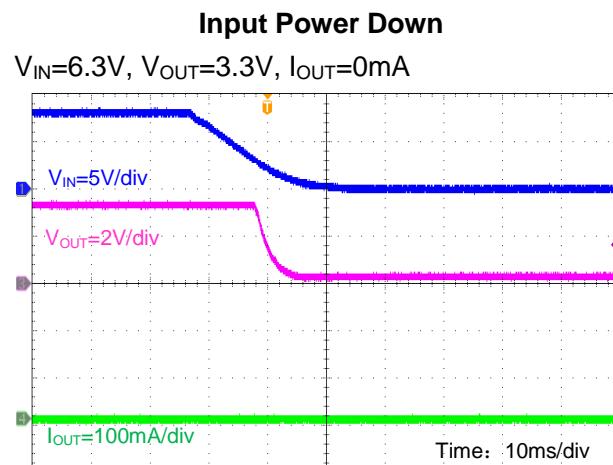
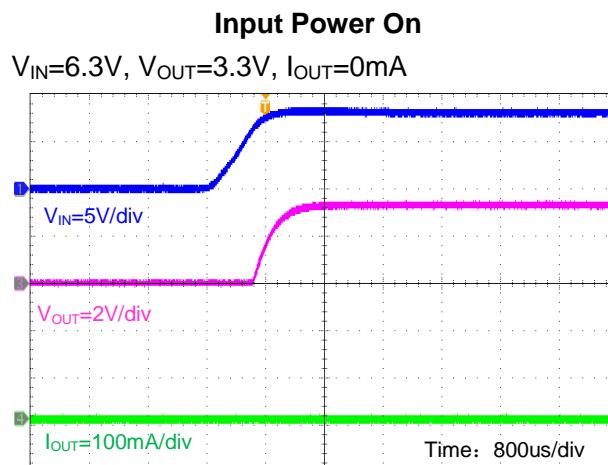


Load Transient

$V_{IN}=8V$, $V_{OUT}=5V$, $I_{OUT}=100mA$ to $200mA$



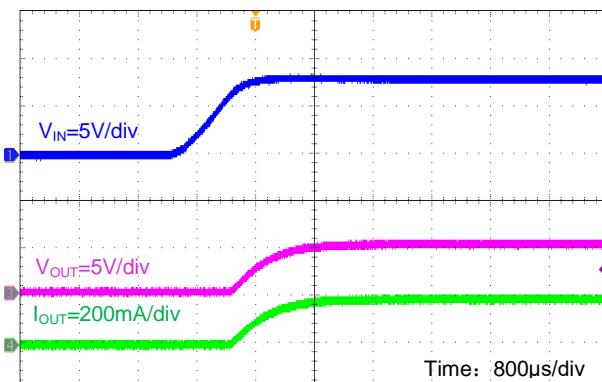
Typical Performance Characteristics (continued)



Typical Performance Characteristics (continued)

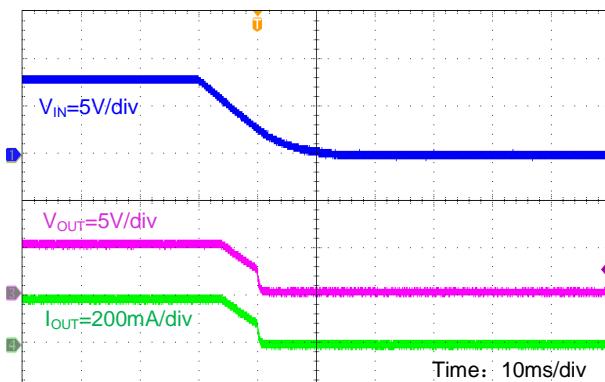
Input Power On

$V_{IN}=8V, V_{OUT}=5V, I_{OUT}=200mA$



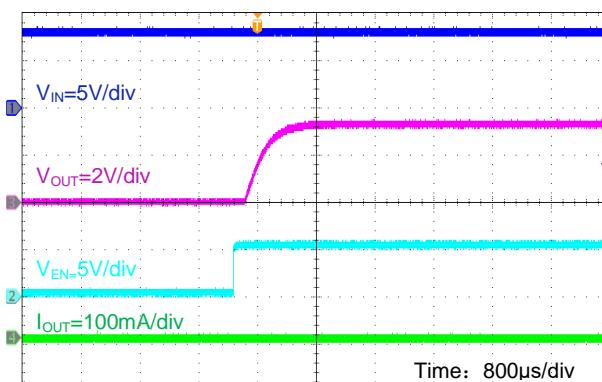
Input Power Down

$V_{IN}=8V, V_{OUT}=5V, I_{OUT}=200mA$



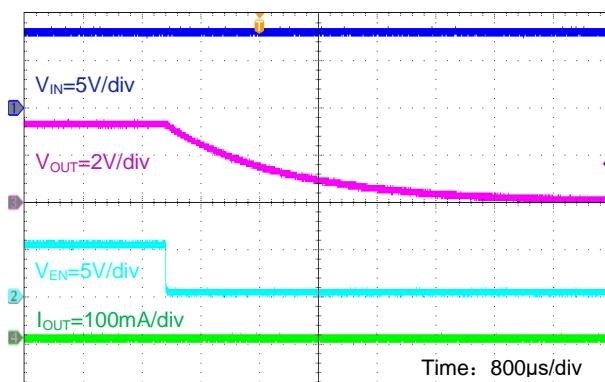
EN Enable Power On

$V_{IN}=6.3V, V_{EN}=5V, V_{OUT}=3.3V, I_{OUT}=0mA$



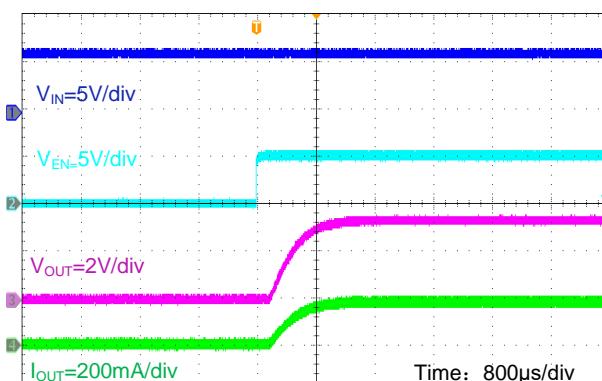
EN Enable Power Down

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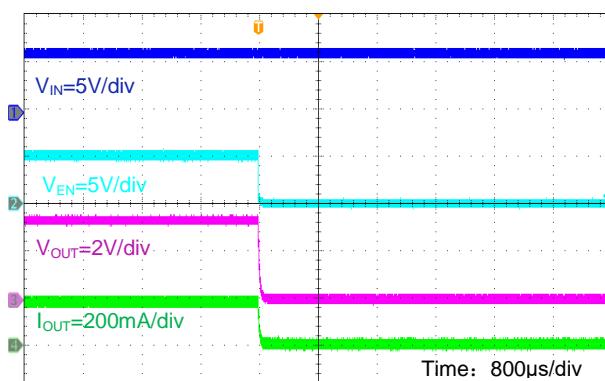
EN Enable Power On

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EN Enable Power Down

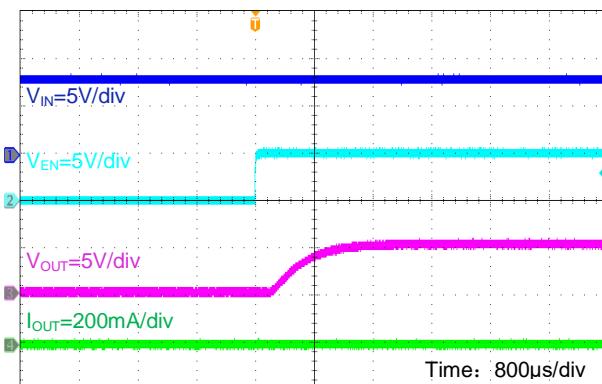
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Typical Performance Characteristics (continued)

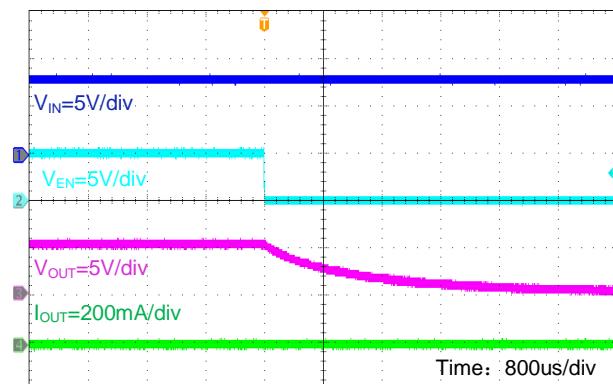
EN Enable Power On

$V_{IN}=8V, V_{EN}=5V, I_{OUT}=0mA$



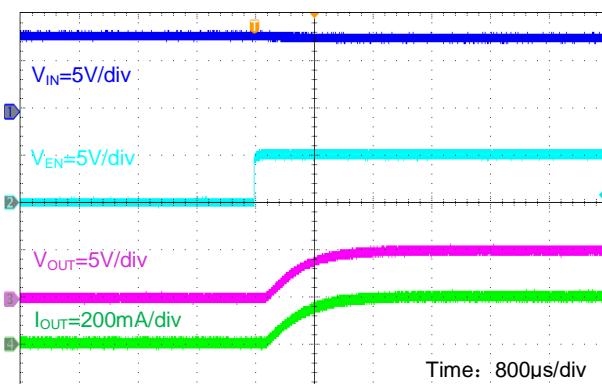
EN Enable Power Down

$V_{IN}=8V, V_{EN}=5V, I_{OUT}=0mA$



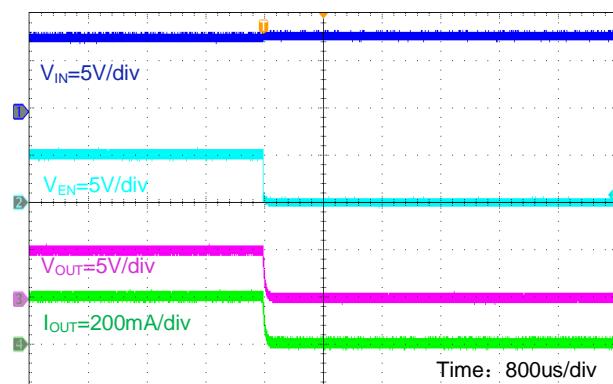
EN Enable Power On

$V_{IN}=8V, V_{EN}=5V, I_{OUT}=200mA$



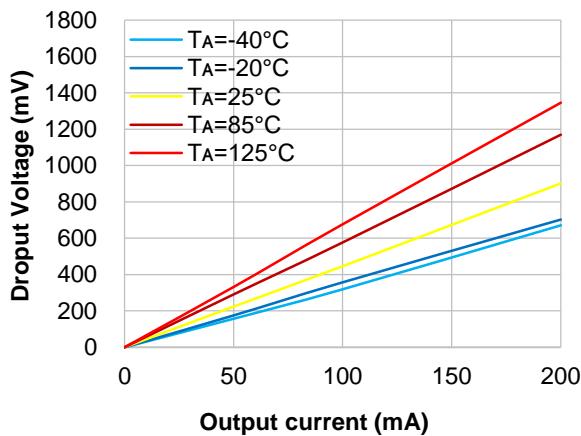
EN Enable Power Down

$V_{IN}=8V, V_{EN}=5V, I_{OUT}=200mA$

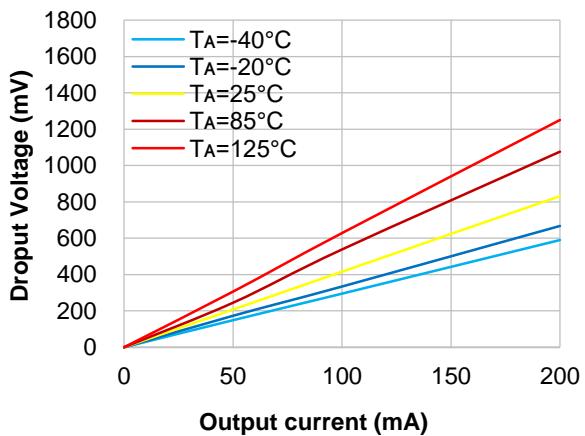


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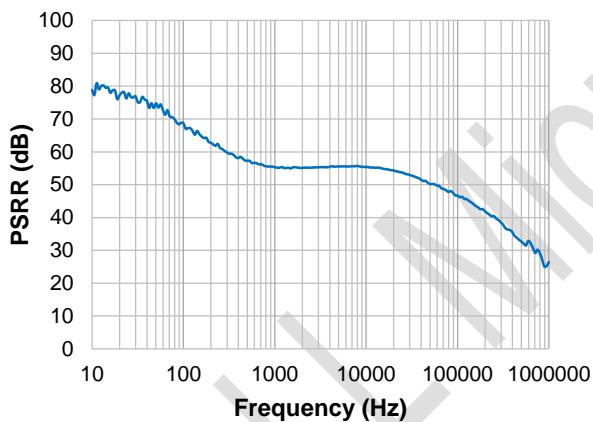
Dropout Voltage Vs. Output Current

 $V_{OUT}=3.3V$ 

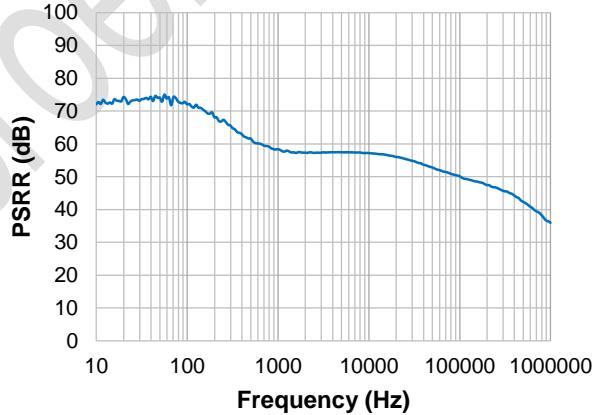
Dropout Voltage Vs. Output Current

 $V_{OUT}=5V$ 

PSRR Vs. Frequency

 $V_{IN}=6.3V, V_{OUT}=3.3V$ $I_{OUT}=50mA, 58.12dB@1kHz$ 

PSRR Vs. Frequency

 $V_{IN}=8V, V_{OUT}=5V$ $I_{OUT}=50mA, 56.45dB@1kHz$ 

Application Information

Input capacitor

A $1\mu\text{F}$ or higher capacitance value ceramic capacitor is required between the V_{IN} pin and the GND pin. Place it as close as possible to the device. There are no requirements for the ESR on the input capacitor, but the tolerance and temperature coefficient must be considered. The ceramic capacitor with $1\mu\text{F}$ or larger rating capacitance, X5R or X7R type dielectrics and 0603 or larger size is recommended as input capacitor.

Output capacitor

An output capacitor (C_{OUT}) is needed to improve transient response and maintain stability. The TMI6411-XXDA-Q1 is stable with very small ceramic output capacitors. A $1\mu\text{F}$ to $10\mu\text{F}$ capacitor is suitable for the most TMI6411-XXDA-Q1 applications. For typical application, the ceramic capacitor with $1\mu\text{F}$ or larger rating capacitance, X5R or X7R type dielectrics and 0603 or larger size is recommended as output capacitor.

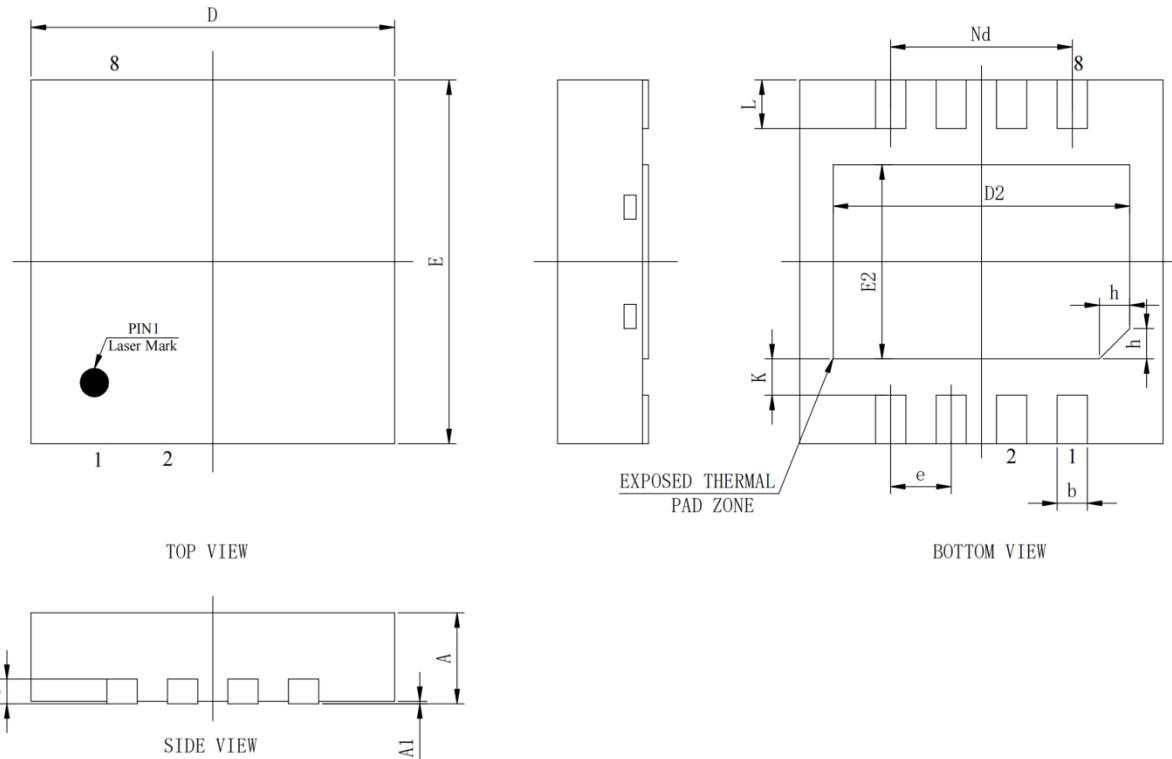
Layout Consideration

PCB layout is very important to achieve good regulation, ripple rejection, transient response and thermal performance. It is highly recommended to duplicate PCB layout for optimum performance. If change is necessary, please follow these guidelines and take PCB for reference.

- 1) Input and output bypass ceramic capacitors are suggested to be put close to the V_{IN} pin and V_{OUT} pin respectively.
- 2) Connect V_{IN} pin, V_{OUT} pin and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability.

PACKAGE INFORMATION

DFN3x3-8



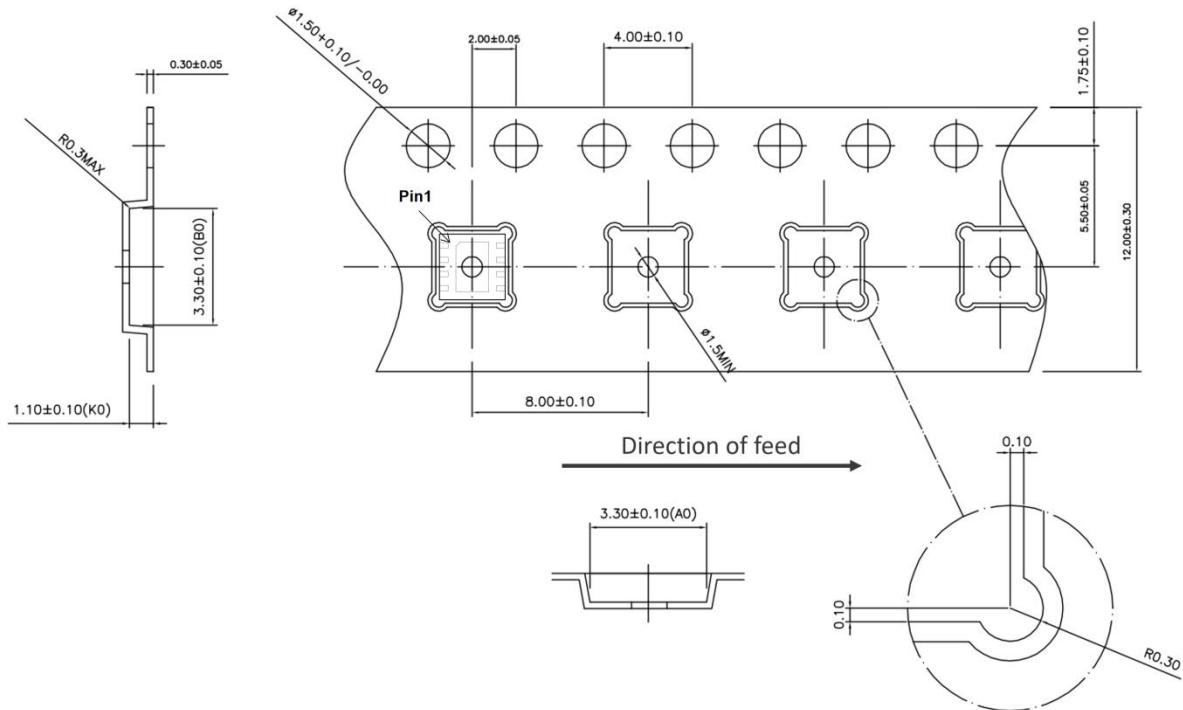
Symbol	Dimensions In Millimeters			Symbol	Dimensions In Millimeters		
	Min	Nom	Max		Min	Nom	Max
A	0.70	0.75	0.80	Nd	1.50 BSC		
A1	0	0.02	0.05	E	2.90	3.00	3.10
b	0.20	0.25	0.30	E2	1.50	1.60	1.70
c	0.203 REF			L	0.35	0.40	0.45
D	2.90	3.00	3.10	h	0.20	0.25	0.30
D2	2.35	2.45	2.55	K	0.30 REF		
e	0.50 BSC						

Note:

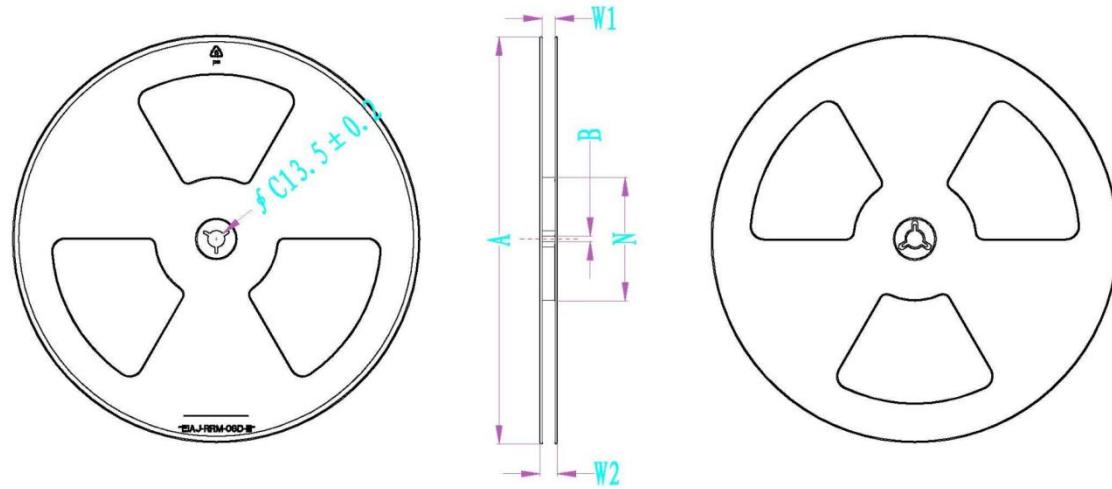
- 1) All dimensions are in millimeters.

TAPE AND REEL INFORMATION

TAPE DIMENSIONS: DFN3x3-8



REEL DIMENSIONS: DFN3x3-8



Unit: mm

Ø A	Ø C	B	W1	W2	N
330±1.0	13.5±0.2	4.7±0.5	13.4±0.5	17.4±0.5	100±0.5

Note:

- 1) All Dimensions are in Millimeter
- 2) Quantity of Units per Reel is 5000
- 3) MSL level is level 1.

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