6.5V 2A Ultralow Noise High PSRR Fast Transient Response CMOS LDO Regulator

1 FEATURES

- Input Voltage Range: 2.3V to 6.5V
- Maximum load current: 2A
- Low noise: 5µVRMS independent of output Voltage at 100Hz to 100kHz
- Fast transient response: 1.5us for 1mA to 1.5A load step
- 60dB PSRR at 100kHz
- Low dropout voltage: 150mV at 2A load, V_{OUT}=3V
- Initial accuracy: -1%(minimum), +1%(maximum)
- Accuracy over line, load, and temperature: ±1.5%
- Quiescent current, I_{GND}=0.7mA with no load
- Low shutdown current: 0.25uA at V_{IN}=5V
- Stable with small 2.2uF ceramic output capacitor
- Adjustable output from 1.2V to V_{IN}-V_{DO}
- Precision enables
- Adjustable soft start
- 8-lead 3mm x 3mm DFN

2 APPLICATIONS

- Communications and infrastructure
- Medical and healthcare
- Industrial and instrumentation
- Noise sensitive applications: ADC/DAC precision amplifiers, PLL/VCOs and clocking Ics

3 ORDERING INFORMATION

TYPE	MARKING	PACKAGE
GBI5129NMCR	5129	DFN3*3-8L

4 DISCRIPTION

The GBI5129 is a CMOS low-noise, low-dropout linear regulator (LDO) that operates from 2.3V to 6.5V and provides up to 2A output current. This high output current LDO is ideal for regulation of high-performance analog and mixed-signal circuits operating from 6V down to 1.2V rails. The device provides high power supply rejection and low noise, and achieves excellent line and load transient response with just a small 2.2uF ceramic output capacitor. Load transient response is typically 1.5us for a 1mA to 1.5A load step.

The GBI5129 allows output voltages that range from 1.2V to V_{IN} - V_{DO} with an external feedback resistor divider. Inrush current can be controlled by adjusting the start-up time via the soft start pin. The typical start-up time with a 1nF soft start capacitor is 1ms.

The GBI5129 regulator output noise is 5uVrms, independent of the output voltage. The GBI5129 is available in an 8-lead 3mm x 3mm DFN package, making it not only a very compact solution, but also providing excellent thermal performance for applications requiring up to 2A of output current in a small, low-profile footprint.

5 Typical Application

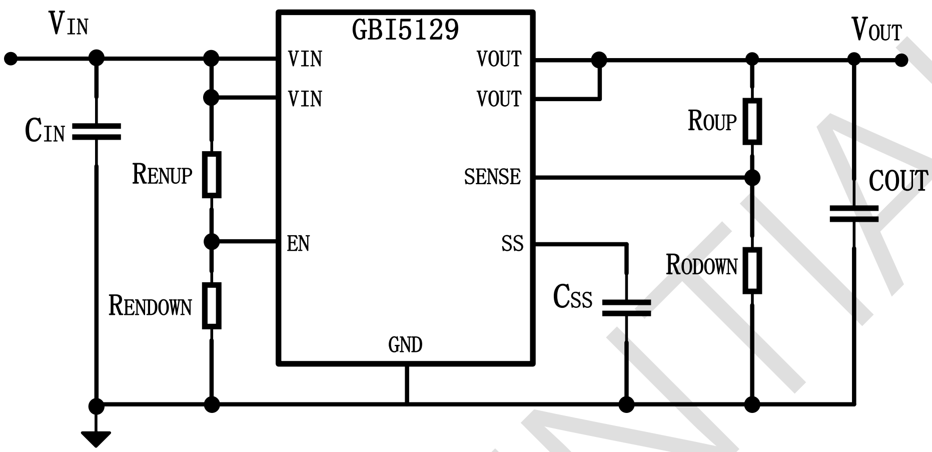


Figure 5.1. Typical Application

6 PIN CONFIGURATION

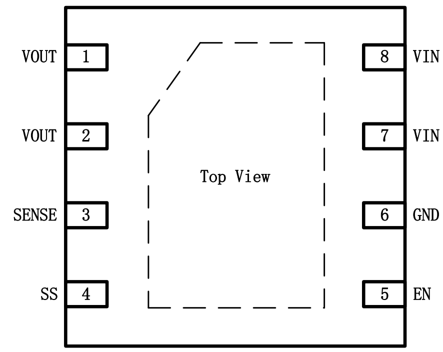


Figure 6.1. Pin Configuration

Table 1. GBI5129 PIN CONFIGURATION

PIN OUT NAME	PIN OUT NO.	I/O	PIN FUNCTION
VOUT	1	O	Regulated Output Voltage. Bypass this pin to GND with a 2.2uF or greater capacitor. Pin1 and Pin2 are internally connected together.
VOUT	2	O	
SENSE	3	I	Sense Input. Connect this pin as close as possible to the load for the best load regulation. Use external resistor divider to set the output voltage higher than the fixed output voltage.
SS	4	O	Soft Start. A 1nF external capacitor connected to SS results in 1ms start-up time.
EN	5	I	Regulator Enable. Drive EN high to turn on the regulator; drive EN low to turn off the regulator. For automatic startup, connect EN to VIN.
GND	6		Ground pin.
VIN	7		Regulator Input Supply. Bypass this pin to GND with a 4.7uF or greater capacitor. Pin7 and Pin8 are internally connected together.
VIN	8		
EP			Exposed Pad. The exposed pad is on the bottom of the package. The exposed pad enhances thermal performance and is electrically connected to GND inside the package. Connect the exposed pad to the ground plane on the board to ensure proper operation.

7 SPECIFICATIONS

7.1 ABSOLUTE MAXIMUM RATINGS

Over operating free-air temperature unless otherwise noted

DESCRIPTION	PARAMETER	MIN	MAX	UNIT
Input Voltage	VIN, EN, SENSE to GND	-0.3	7	V
	SS to GND	-0.3	V_{IN}	V
Output Voltage	VOUT to GND	-0.3	V_{IN}	V
Operating junction temperature	T_J	-40	125	°C
Storage temperature	T_{STG}	-65	150	°C

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these of any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

7.2 ESD RATINGS

PARAMETER	DEFINITION	MIN	MAX	UNIT
V_{ESD}	Human Body Model (HBM), per ANSI-JEDEC-JS-001-2014 specification, all pins (1)	-2	+2	kV
	Charged Device Model (CDM), per ANSI-JEDEC-JS-002-2014 specification, all pins (1)	-500	+500	V

(1) HBM and CDM stressing are done in accordance with the ANSI/ESDA/JEDEC JS-001/002-2014 specification

7.3 RECOMMENDED OPERATING CONDITIONS

Over operating free-air temperature range unless otherwise noted

PARAMETER	DEFINITION	MIN	NOM	MAX	UNIT
V_{IN}	Input supply voltage range	2.3		6.5	V
V_{OUT}	Output voltage range	1.2		V_{IN}	V
V_{EN}	Enable voltage range	0		V_{IN}	V
I_{OUT}	Output current	0		2	A
C_{IN}	Input capacitor	4.7	10		uF
C_{OUT}	Output capacitor	2.2	10		uF

R_{ESR}	Output capacitor ESR			0.05	Ω
T_J	Operating junction temperature	-40		125	℃

7.4 THERMAL INFORMATION

PARAMETER	THERMAL METRIC	DFN-8	UNIT
$R_{\theta JA}$	Junction to ambient thermal resistance	36.1	°C/W
$R_{\theta JC}$	Junction to case thermal resistance	22.7	°C/W
ψ_{JB}	Junction to board characterization parameter	13.1	°C/W

7.5 ELECTRICAL CHARACTERISTICS

V_{IN} =2.3V or V_{IN} = $V_{OUT(nom)}$ + 0.5V(whichever is greater), V_{EN} = V_{IN}, C_{IN} = C_{OUT}=4.7uF, I_{load}=10mA, Ta = 25℃ for typical specifications, T_j=-40℃ to +125℃ for minimum/maximum specifications, unless otherwise noted.

SYMBOL	PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
Power Supply						
V_{IN}	Input supply voltage range		2.3		6.5	V
I_{load}	Load Current		0		2	A
I_{GND}	Operating Supply Current	I_{load} =0		0.65	2	mA
		I_{load} =2A		3.5	6.7	mA
$I_{GND\text{-}SD}$	Shutdown Current	EN=GND V_{IN}=5V		0.25	5	uA
EN_{STBY_H}	EN Input Logic High	2.3V≤V_{IN}≤6.5V	1.1			V
EN_{STBY_L}	EN Input Logic Low				0.4	V
EN_{STBY_hys}	EN Input Logic Hysteresis			85		mV
EN_{High}	EN Precision Input Logic High	2.3V≤V_{IN}≤6.5V	1.1	1.18	1.25	V
EN_{Low}	EN Precision Input Logic Low		1	1.1	1.2	V
EN_{hys}	EN Precision Input Logic Hysteresis			80		mV
I_{EN_LKG}	EN=V_{IN} or GND			0.01		uA
T_{EN_DLY}	EN Input Delay Time	From EN rising edge to 0.1xV_{OUT}		127		us

SYMBOL	PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
V_{OUT}	Fixed Output Voltage Accuracy	I_{load}=10mA, T_j=25	-1		+1	%
		100uA<I_{load}<2A, V_{IN}=(V_{OUT}+0.5V) to 6.5V	-1.5		+1.5	%
V_{SENSE}	Adjustable Output Voltage Accuracy	I_{load}=10mA	1.188	1.200	1.212	V
		100uA<I_{load}<2A, V_{IN}=(V_{OUT}+0.5V) to 6.5V	1.182		1.218	V
$\Delta V_{OUT}/\Delta V_{IN}$	Line Regulation	V_{IN}=(V_{OUT}+0.5V) to 6.5V	-0.1		+0.1	%/V
$\Delta V_{OUT}/\Delta I_{load}$	Load Regulation	I_{load}=100uA to 2A		0.1	0.3%	%/A
$SENSE_{I-BIAS}$	Sense Input Bias Current	100uA<I_{load}<2A, V_{IN}=(V_{OUT}+0.5V) to 6.5V		10		nA
$V_{dropout}$	Dropout Voltage	I_{load}=500mA, V_{OUT}=3V		32		mV
		I_{load}=1A, V_{OUT}=3V		69		mV
		I_{load}=2A, V_{OUT}=3V		144		mV
OUT_{NOISE}	Integrated Noise	10Hz to 100kHz, all fixed output voltages		6		uVrms
		100Hz to 100kHz, all fixed output voltages		5		uVrms
	Noise Spectral Density	100Hz, all fixed output voltages		100		nV/√Hz
		1kHz, all fixed output voltages		30		nV/√Hz
		10kHz, all fixed output voltages		18		nV/√Hz
		100kHz, all fixed output voltages		12		nV/√Hz
PSRR	Power Supply Rejection Ratio	100kHz, V_{IN}=3.8V, V_{OUT}=3V, I_{load}=1.5A, Css=0nF		60		dB
		100kHz, V_{IN}=3.5V, V_{OUT}=3V, I_{load}=1.5A, C_{SS}=0nF		53		dB

SYMBOL	PARAMETER	TEST CONDITION	MIN	TYP	MAX	UNIT
		1MHz, V_{IN}=3.8V, V_{OUT}=3V, I_{load}=1.5A, C_{SS}=0nF		30		dB
		1MHz, V_{IN}=3.5V, V_{OUT}=3V, I_{load}=1.5A, C_{SS}=0nF		20		dB
$T_{tr\text{-}rec}$	Transient Load Response	Time for output voltage to settle for a 1mA to 1.5A load step, load step rise time=400ns		1.5		uS
V_{DEV}		Output voltage deviation due to 1mA to 1.5A load step		40		mV
V_{SETTLE}		Output voltage deviation after transient load response time (Ttr-rec) has passed, V_{OUT}=5V, C_{OUT}=2.2uF		0.12		%
$T_{start\text{-}up}$	Startup time	V_{OUT}=5V, C_{SS}=0		270		us
		V_{OUT}=5V, C_{SS}=1nF		1		ms
I_{SS}	Soft Start Current	V_{IN} =6.5V, I_{OUT} = 5mA	0.7	1	1.3	uA
I_{limit}	Output Current Limit			3		A
$R_{pull\text{-}down}$	V_{OUT} Pull Down Resistance	EN=0, V_{OUT}=1V		11		kΩ
UVLO	Under Voltage Lockout Threshold	V_{IN} rising		2.2	2.29	V
		V_{IN} falling	1.87	2		V
		Threshold		200		mV
T_{SD}	Thermal shutdown temperature	Shutdown, temperature increasing		150		℃
		Reset, temperature decreasing		135		℃
T_J	Operating junction temperature		-40		125	℃

8 Theory of Operation

The GBI5129 is a low quiescent current, low dropout linear regulator that operate from 2.3V to 6.5V and provides up to 2A of load current. Drawing a low 3mA of quiescent current(typical) at full load makes the GBI5129 ideal for portable equipment. Typical shutdown current consumption is 0.25uA at room temperature.

Optimized for use with small 2.2uF ceramic capacitors, the GBI5129 provides excellent transient response.

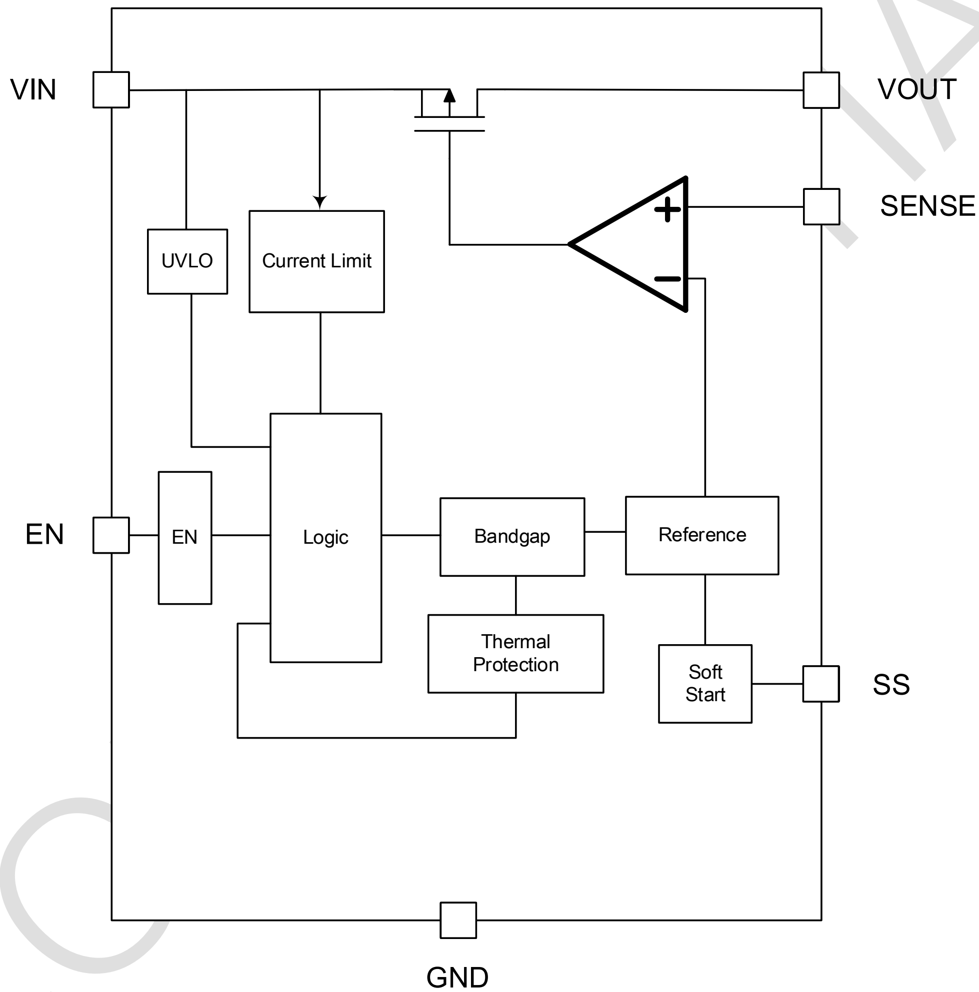


Figure 8.1. GBI5129 Block Diagram

Internally, the GBI5129 consists of a reference, an error amplifier, logic, protection circuits and a PMOS pass transistor. Output current is delivered through the PMOS pass device, which is controlled by the error amplifier. The error amplifier amplifies the difference between the reference voltage and the feedback voltage from the output.

Use a value of less than 200kΩ for R_{ODOWN} to minimize errors in the output voltage caused by the SENSE pin input current. For example, when R_{OUP} and R_{ODOWN} each equal 200kΩ and the default output voltage is 1.2V, the adjusted output voltage is 2.4V.

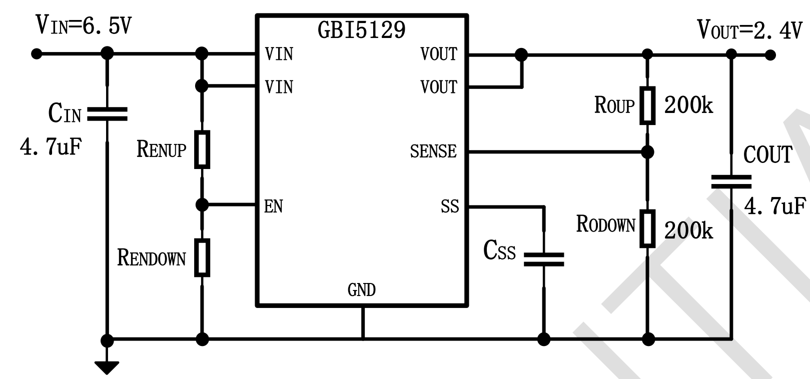


Figure 8.2. Typical Adjustable Output Voltage Application Schematic

The GBI5129 uses the EN pin to enable and disable the V_{OUT} pins under normal operating conditions. When EN is high, V_{OUT} turns on; when EN is low, V_{OUT} turns off. For automatic startup, tie EN to V_{IN}(pin 7 or pin 8).

9 Application Information

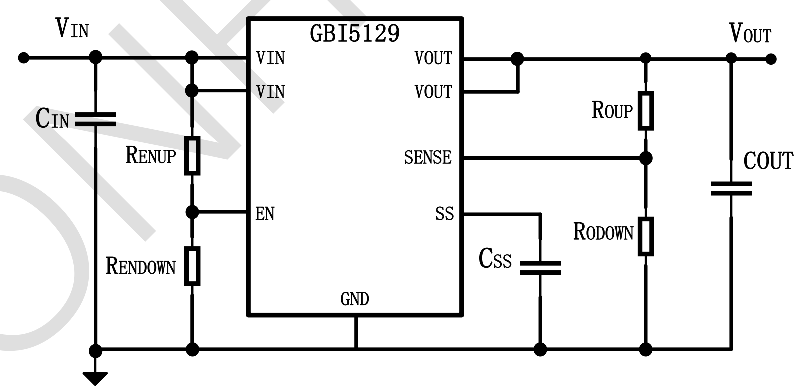


Figure 9.1. Typical Application

CAPACITOR SELECTION

Multilayer ceramic capacitors (MLCC) combine small size, low effective series resistance (ESR), low ESL, and wide operating temperature range, making them an ideal choice for bypass capacitors. However, the capacitance of MLCC can vary dramatically with temperature, dc bias, and ac signal level, depending on the dielectric material. Therefore, selecting the proper capacitor results in the best circuit performance.

Output Capacitor

The GBI5129 is designed for operation with small, space-saving ceramic capacitors but functions with most commonly used capacitors as long as care is taken with regard to the ESR value. The ESR of the output capacitor affects the stability of the LDO control loop. A minimum of 2.2uF capacitance with an ESR of 0.05Ω or less is recommended to ensure the stability of the GBI5129. Transient response to change in load current is also affected by output capacitance. Using a larger value of output capacitance improves the transient response of the GBI5129 to large change in load current.

Input Bypass Capacitor

Connecting a 4.7uF capacitor from V_{IN} to GND reduces the circuit sensitivity to PCB layout, especially when long input traces or a high source impedance is encountered. If greater than 4.7uF of output capacitance is required, increase the input capacitor to match it.

Programmable Precision ENABLE

The GBI5129 uses the EN pin to enable and disable the V_{OUT} pins under normal operating conditions. When a rising voltage on EN crosses the upper threshold, typically 1.18V, V_{OUT} turns on. When a falling voltage on EN crosses the low threshold, typically 1.1V, V_{OUT} turns off. The hysteresis of the EN threshold is approximately 80mV.

The upper and lower thresholds are user programmable and can be set higher than the nominal 1.18 V threshold by using two resistors. The resistance values, R_{ENUP} and R_{ENDOWN}, can be determined from

$$\boldsymbol{R_{ENUP} = R_{ENDOWN} * (V_{INON} - 1.18V)/1.18V}$$

Where:

R_{ENDOWN} is normally 10kΩ-100kΩ

V_{INON} is the desired turn on input voltage

Under Voltage Lockout

The GBI5129 also incorporates an internal under voltage lockout circuit to disable the output voltage when the input voltage is less than the minimum input voltage rating of the regulator. The upper and lower thresholds are internally fixed with about 200mV of hysteresis. The hysteresis prevents on/off oscillations that can occur when caused by noise on the input voltage as it passed through the threshold points.

Soft Start

The GBI5129 uses an internal soft start to limit the inrush current when the output is enabled. If SS pin is open, the start-up time is approximately 270us from the time the EN active threshold is crossed to when the output reaches 90% of its final value. The start-up time is nearly independent of the output voltage setting. If there is a capacitor on SS pin, the soft start time is the charging time of capacitor plus the fixed time 270us. The start-up time is determined by equation below:

$$T_{ss} = 270us + 0.7 * C_{ss}/I_{ss}$$

Where:

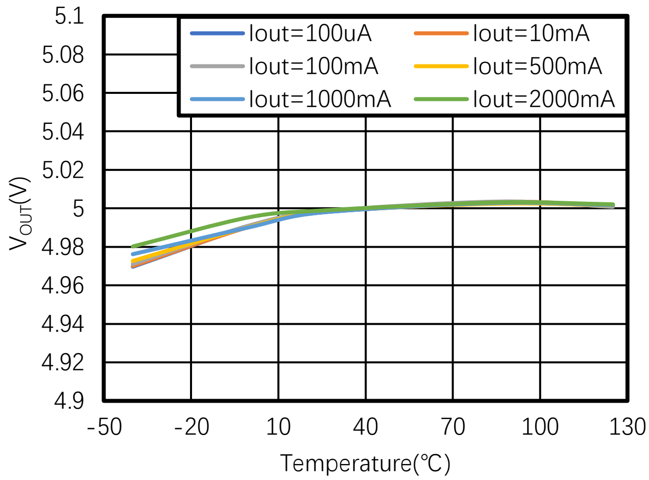
T_{SS} is the soft start-up time

C_{SS} is the soft start-up capacitor connected to pin SS

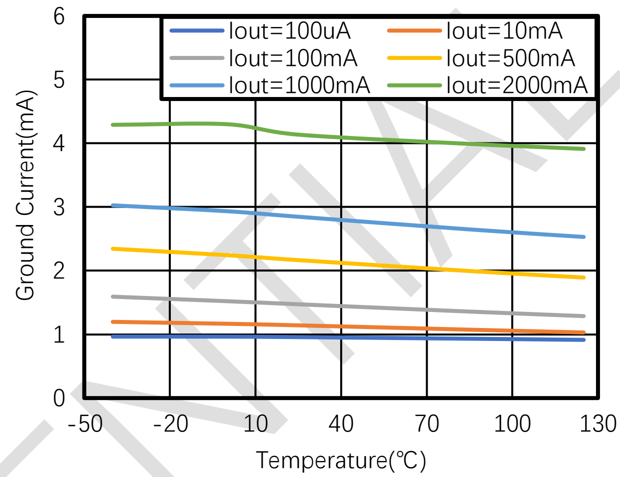
I_{SS} is the soft start-up current (1uA typ.)

10 TYPICAL PERFORMANCE CHARACTERISTICS

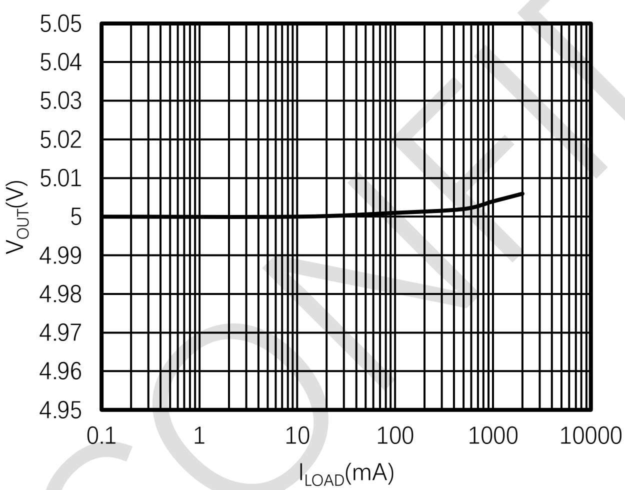
V_{IN} =2.3V or V_{IN} = $V_{OUT(nom)}$ + 0.5V(whichever is greater), V_{EN} = 5V, C_{IN} = C_{OUT}=4.7uF, Ta = 25℃, unless otherwise noted



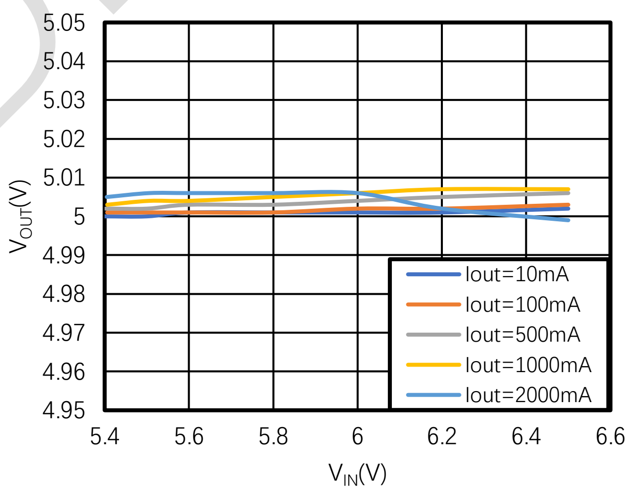
Output Voltage vs Junction Temperature,V_{OUT}=5V



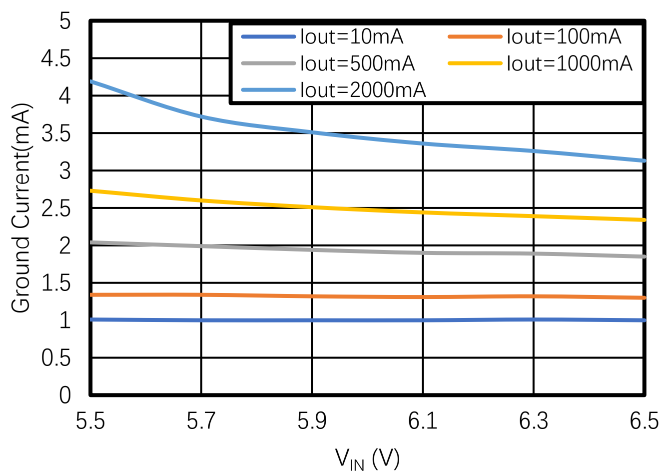
Ground Current vs Junction Temperature,V_{OUT}=5V



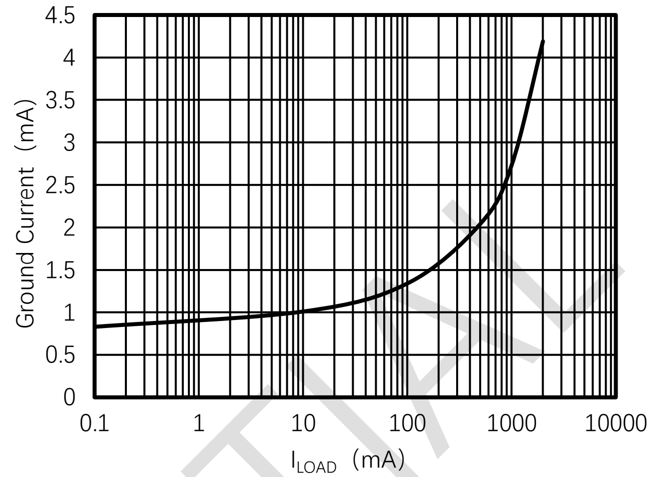
Output Voltage vs. Load Current (I_{LOAD}), V_{OUT} = 5 V



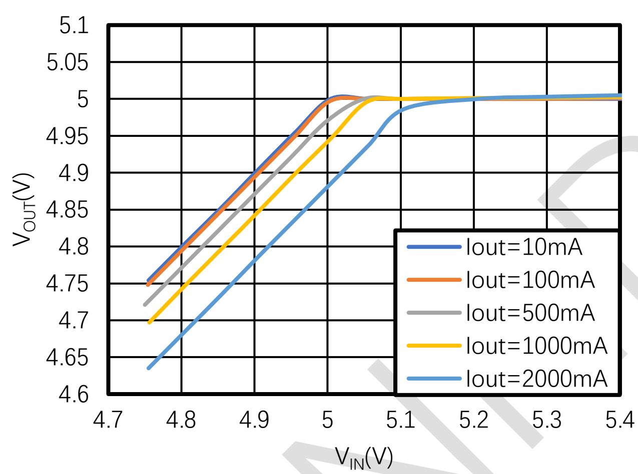
Output Voltage vs. Input Voltage (V_{IN}) in Dropout V_{OUT} = 5 V



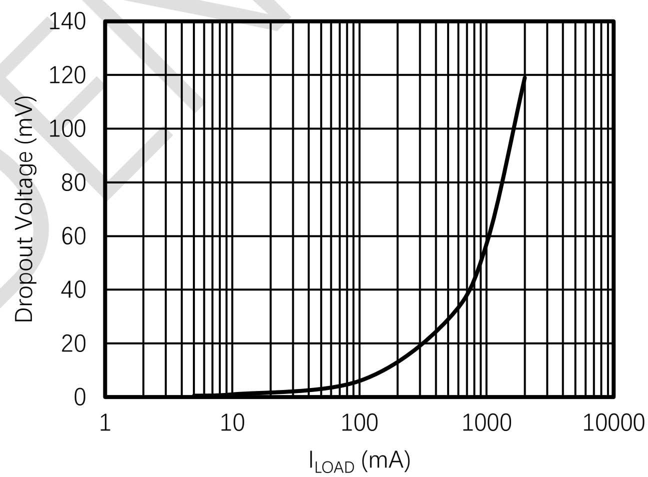
Ground Current vs. Input Voltage (V_{IN}),V_{OUT}=5V



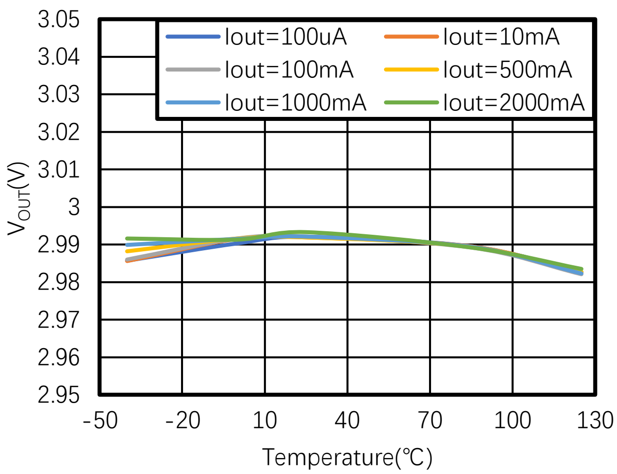
Ground Current vs. Load Current (I_{LOAD}), V_{OUT} = 5V



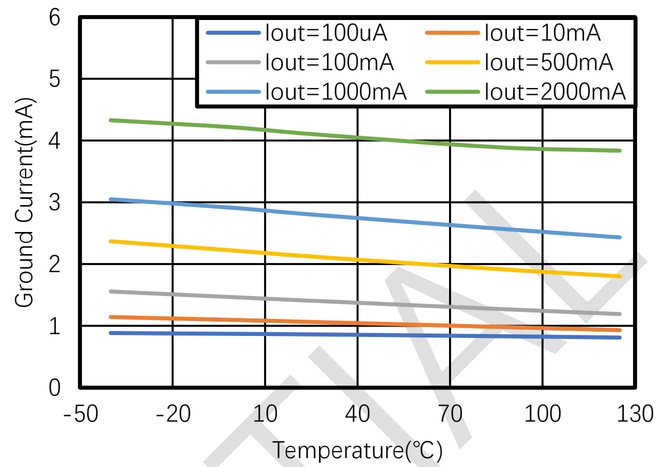
Output Voltage vs. Input Voltage (V_{IN}) in Dropout
V_{OUT} = 5 V



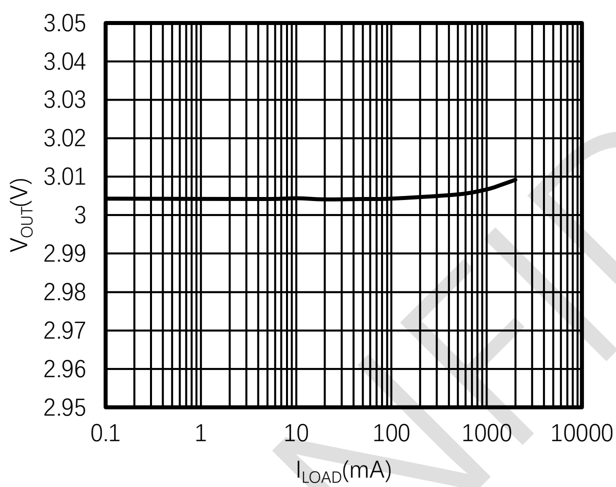
Dropout Voltage vs. Load Current (I_{LOAD}), V_{OUT} = 5 V



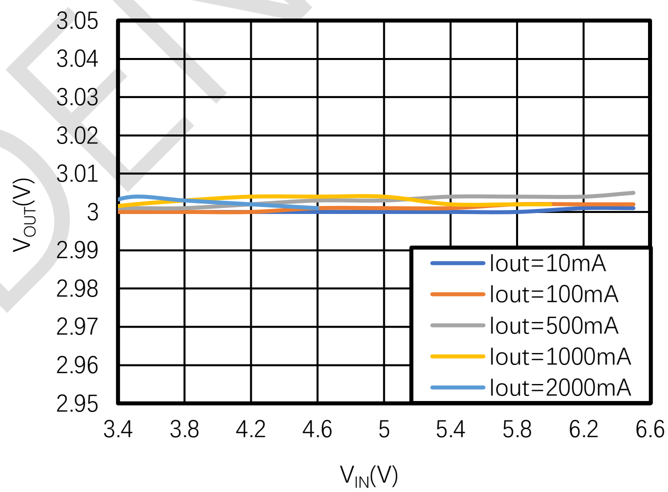
Output Voltage vs Junction Temperature,V_{OUT}=3V



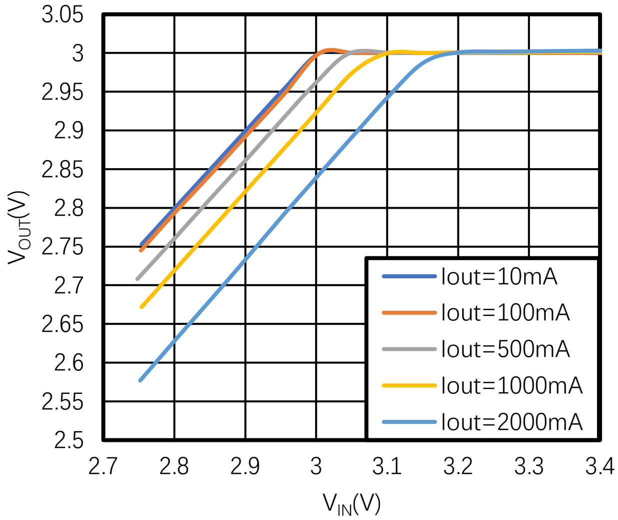
Ground Current vs Junction Temperature,V_{OUT}=3V



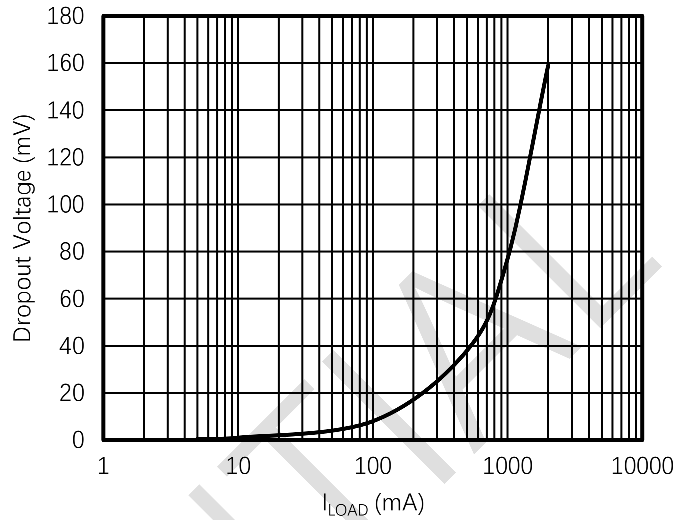
Output Voltage vs Load Current (I_{LOAD}),V_{OUT} = 3 V



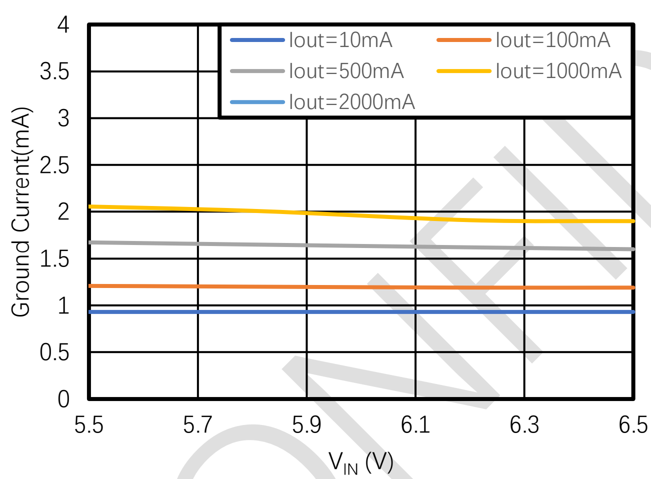
Output Voltage (V_{OUT}) vs Input Voltage (V_{IN}) ,V_{OUT} = 3 V



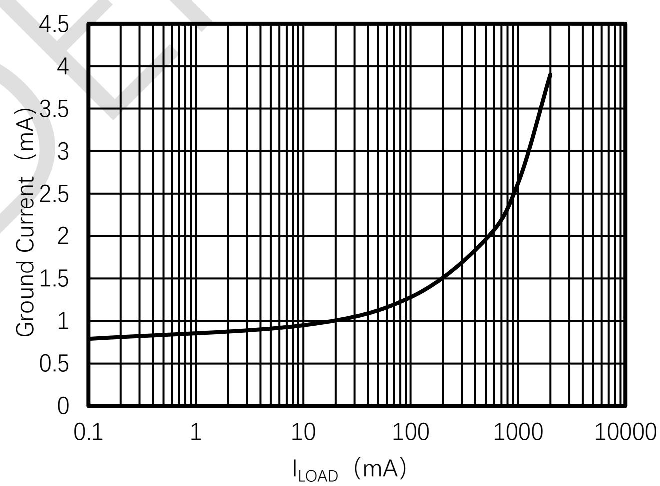
Output Voltage vs. Input Voltage (V_{IN}) in Dropout
VOUT = 3 V



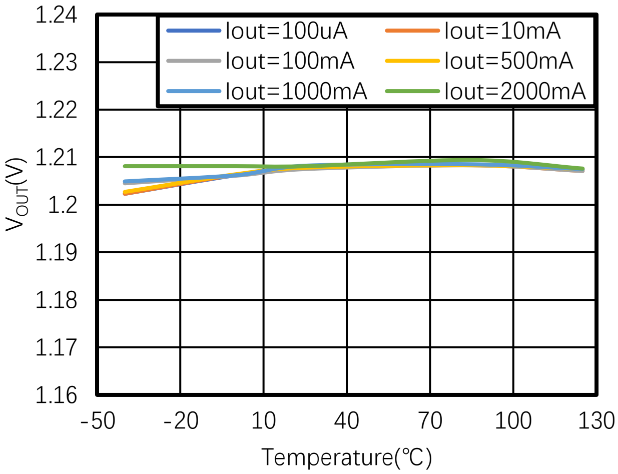
Dropout Voltage vs. Load Current (I_{LOAD}), V_{OUT} = 3 V



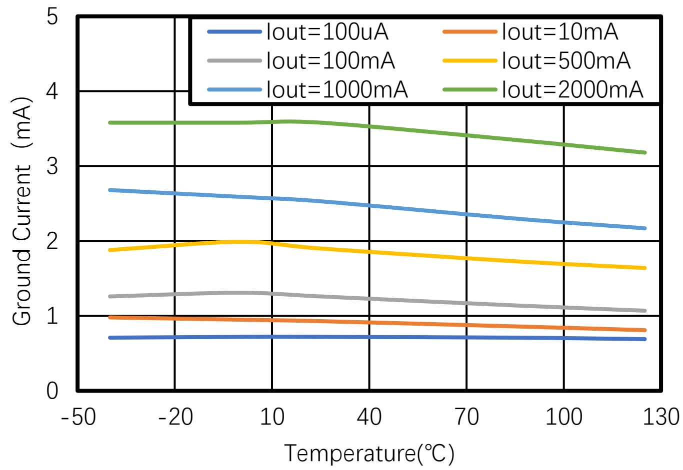
Ground Current vs. Input Voltage (V_{IN}),V_{OUT}=3V



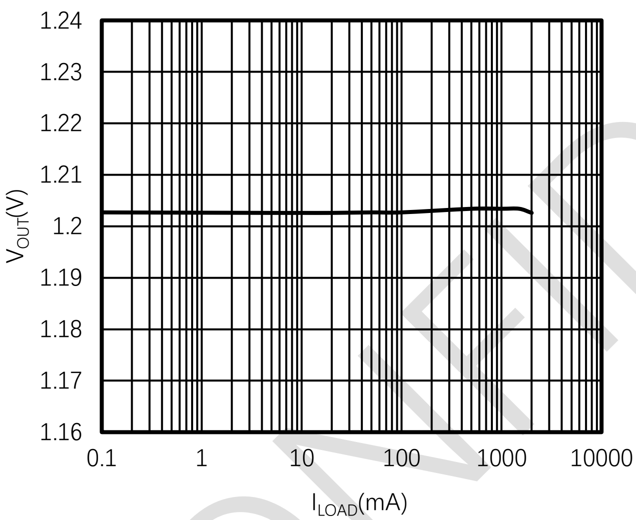
Ground Current vs. Load Current (I_{LOAD}), V_{OUT} = 3V



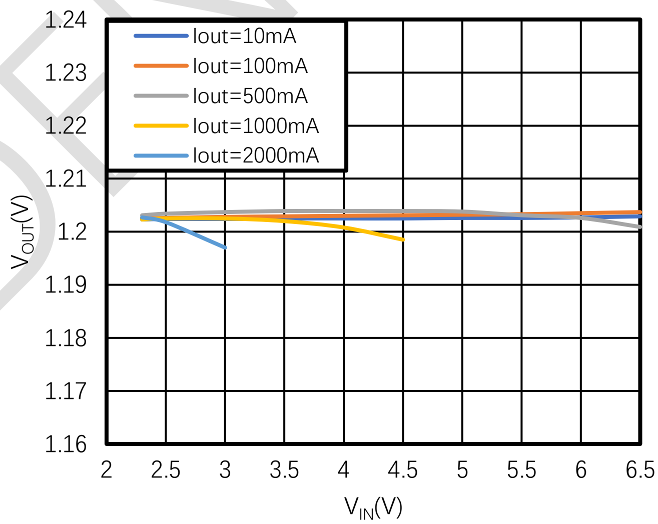
Output Voltage vs Junction Temperature,V_{OUT}=1.2V



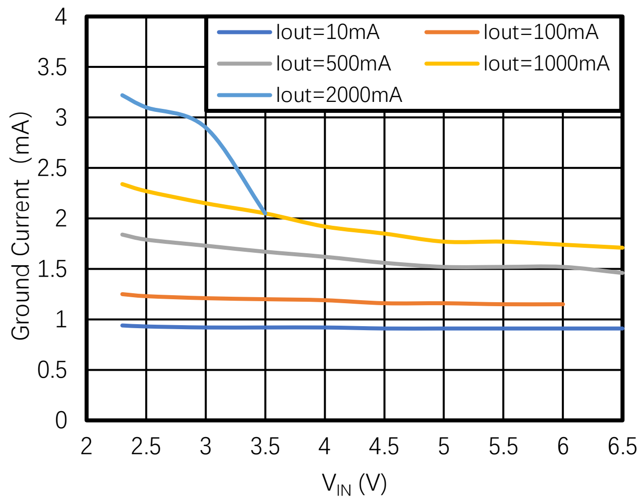
Ground Current vs Junction Temperature,V_{OUT}=1.2V



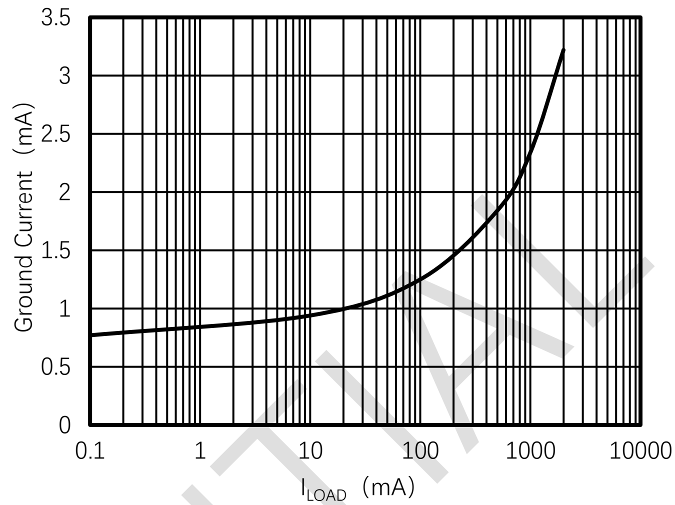
Output Voltage vs. Load Current (I_{LOAD}), V_{OUT} = 1.2 V



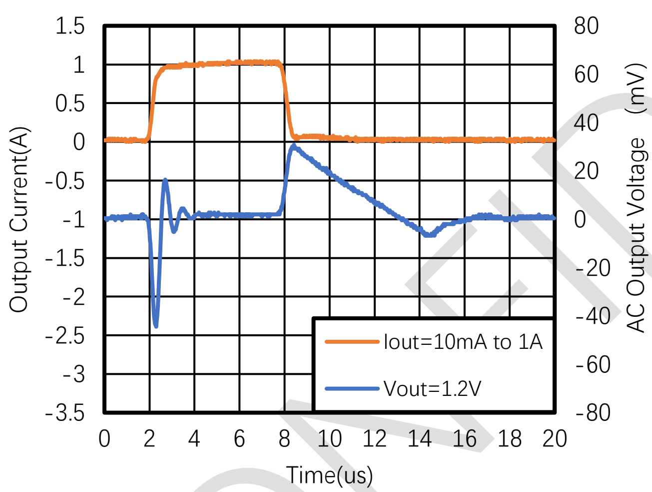
Output Voltage vs Input Voltage (V_{IN}), V_{OUT} = 1.2 V



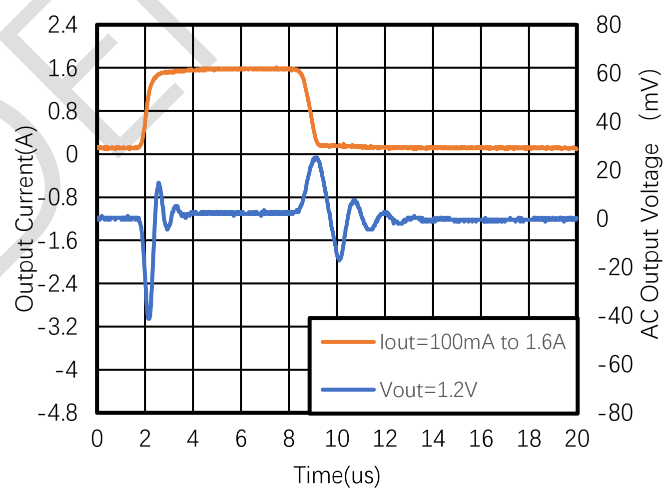
Ground Current vs Input Voltage (V_{IN}),V_{OUT}=1.2V



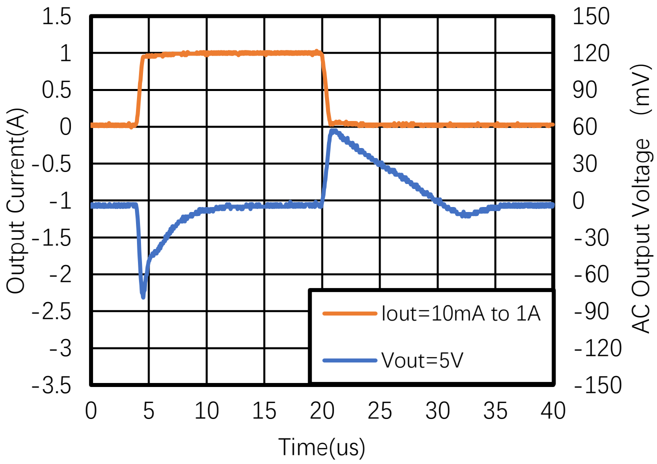
Ground Current vs Load Current (I_{LOAD}), V_{OUT} = 1.2V



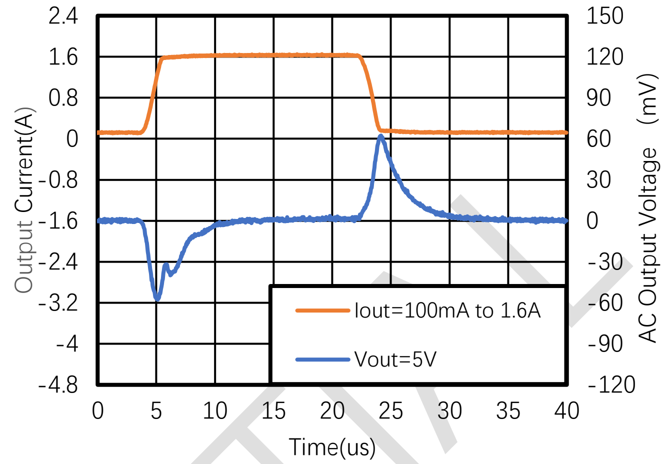
Load Transient, I_{LOAD} = 10 mA to 1 A C_{OUT}=2.2uF
Adjustable Version, V_{OUT} = 1.2 V, V_{IN} = 2.5 V



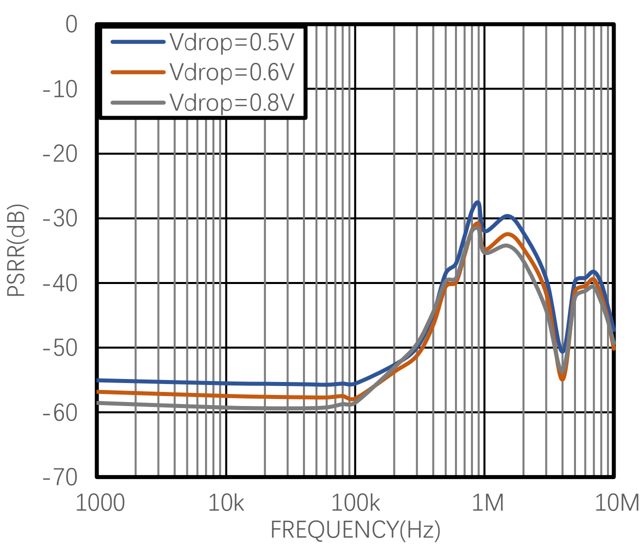
Load Transient, I_{LOAD} = 100 mA to 1.6 A C_{OUT}=2.2uF
Adjustable Version, V_{OUT} = 1.2 V, V_{IN} = 2.5 V



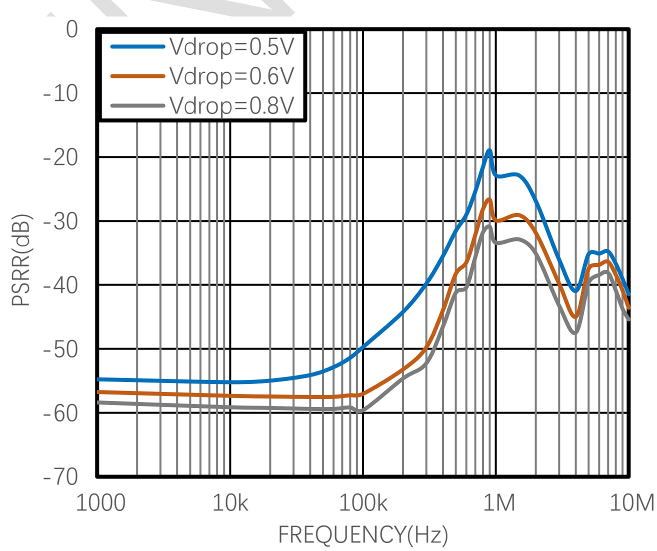
Load Transient, I_{LOAD} = 10 mA to 1 A C_{OUT}=2.2uF Adjustable Version, V_{OUT} = 5 V, V_{IN} = 5.5 V



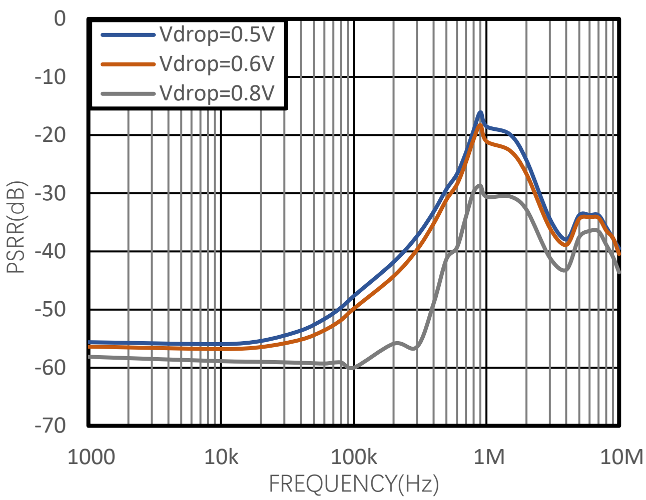
Load Transient, I_{LOAD} = 100 mA to 1.6 A C_{OUT}=2.2uF Adjustable Version, V_{OUT} = 5 V, V_{IN} = 5.5 V



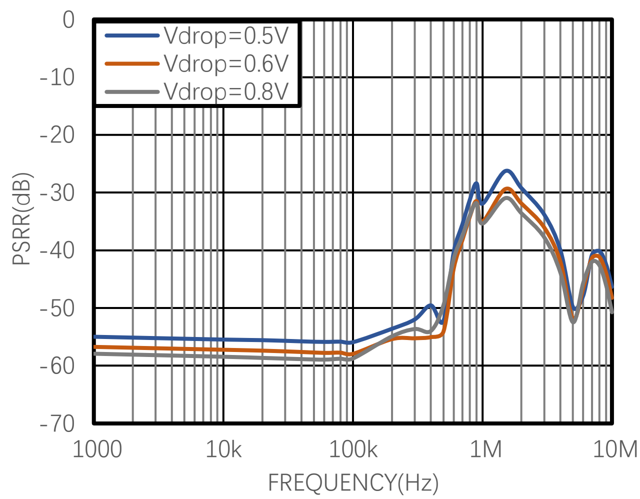
PSRR vs. Frequency, Iout=1A, Vout=3V



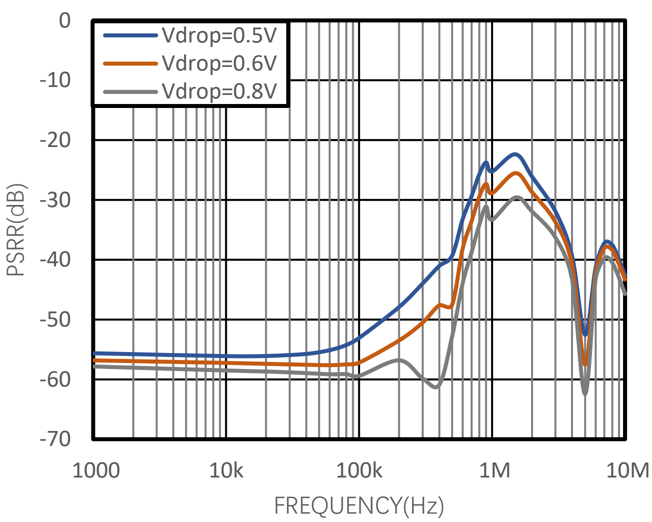
PSRR vs. Frequency, Iout=1.5A, Vout=3V



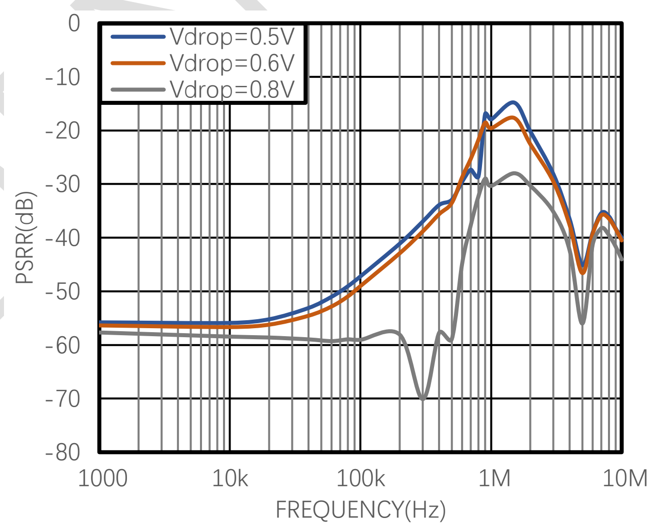
PSRR vs. Frequency, Iout=2A, Vout=3V



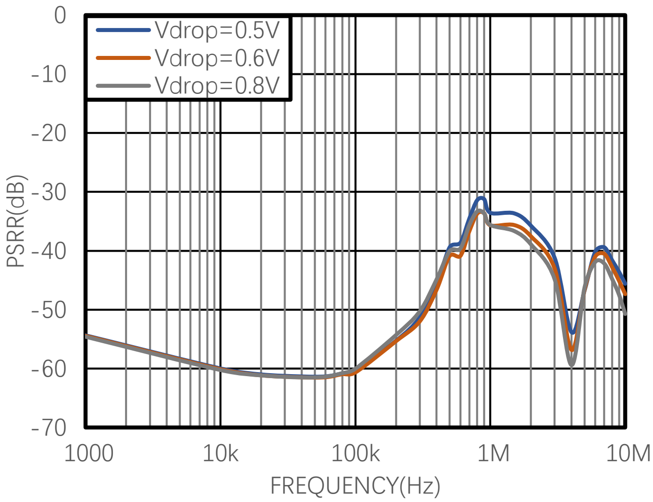
PSRR vs. Frequency, Iout=1A, Vout=5V



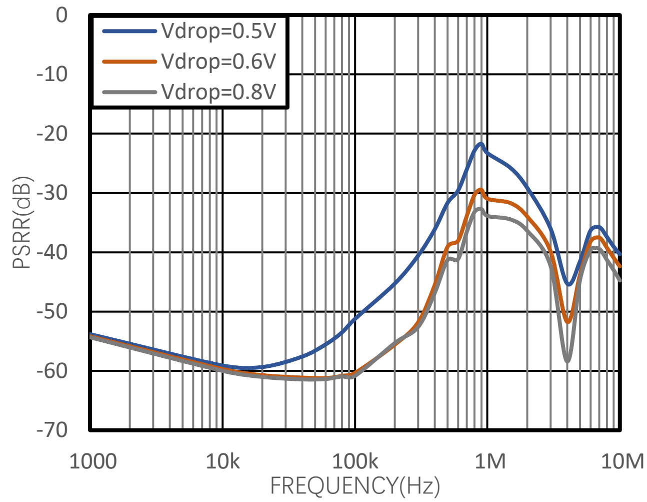
PSRR vs. Frequency, Iout=1.5A, Vout=5V



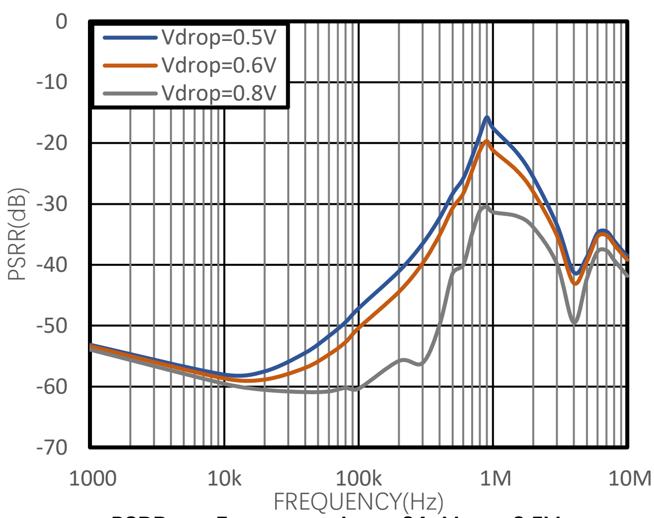
PSRR vs. Frequency, Iout=2A, Vout=5V



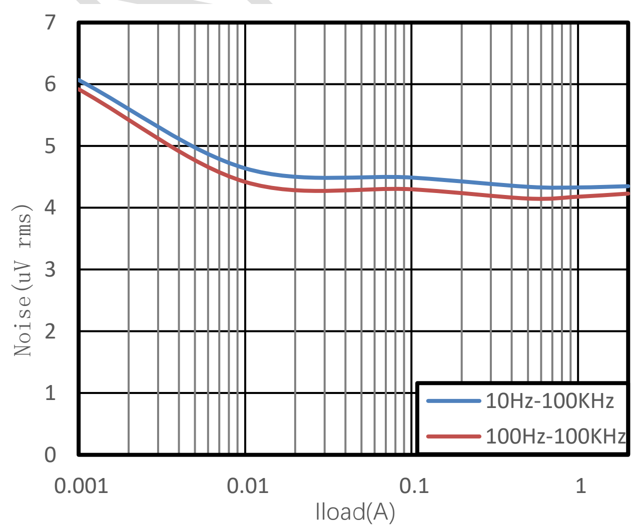
PSRR vs. Frequency, Iout=1A, Vout=2.5V



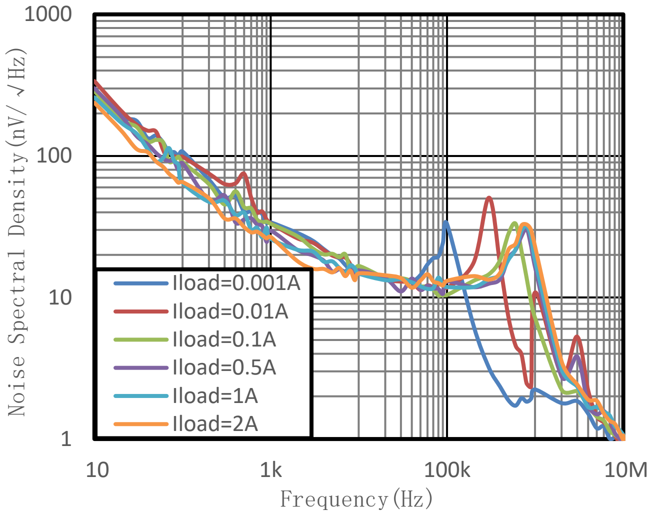
PSRR vs. Frequency, Iout=1.5A, Vout=2.5V



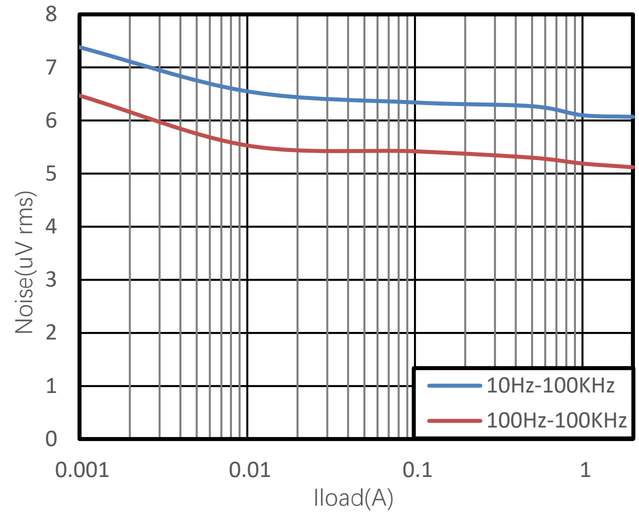
PSRR vs. Frequency, Iout=2A, Vout=2.5V



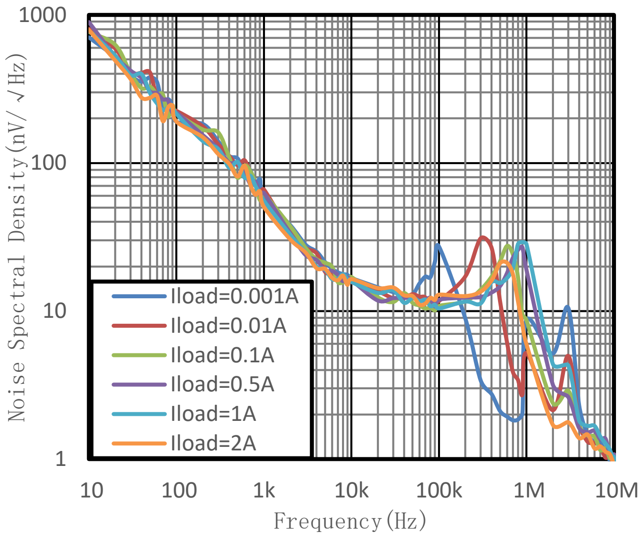
RMS Output Noise vs. Load Current (ILOAD), Vout = 1.2V



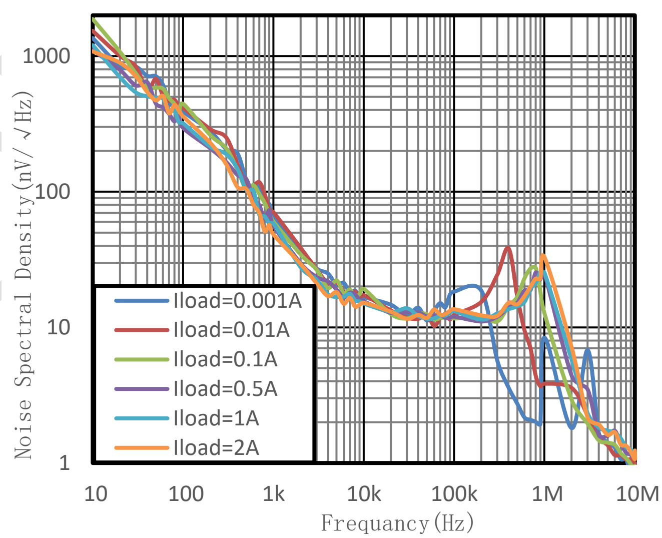
Output Noise Spectral Density, Vout= 1.2V



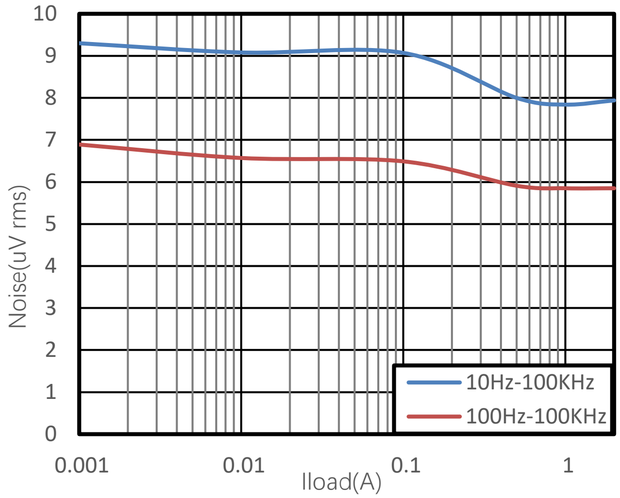
RMS Output Noise vs. Load Current (ILOAD), Vout = 3V



Output Noise Spectral Density, Vout= 3V



Output Noise Spectral Density, Vout= 5V



RMS Output Noise vs. Load Current (ILOAD), Vout = 5V

11 Recommended PCB Design

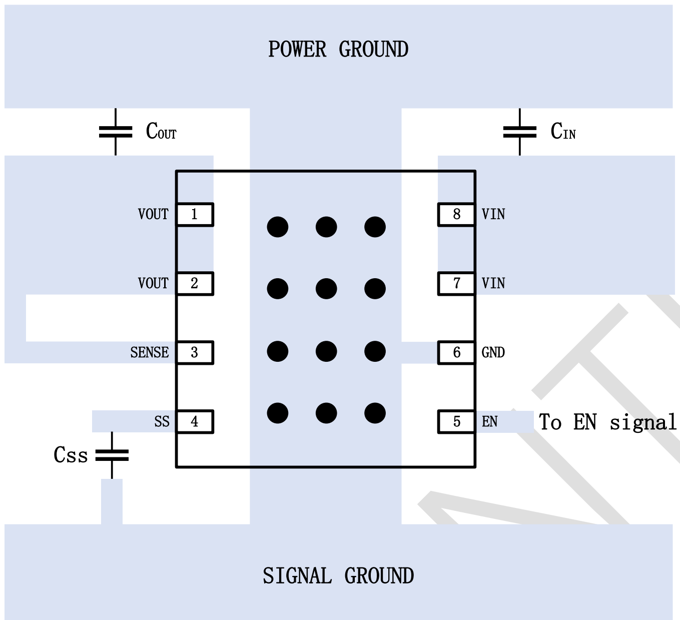


Figure 10.1. Fixed output

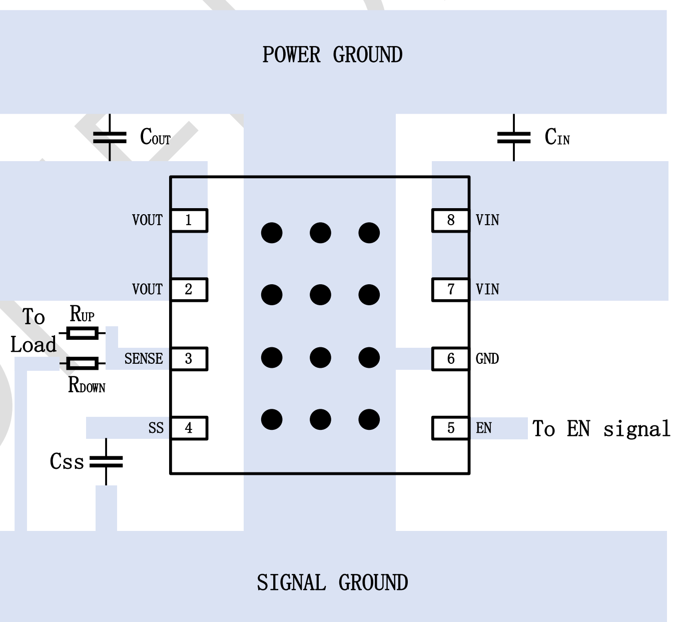
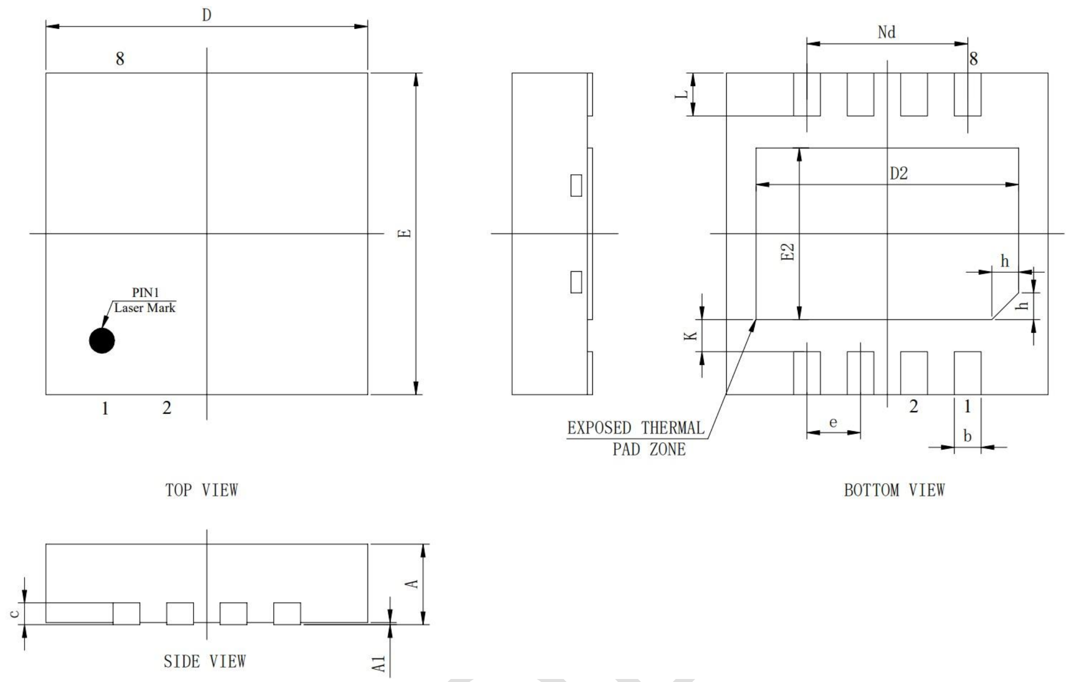


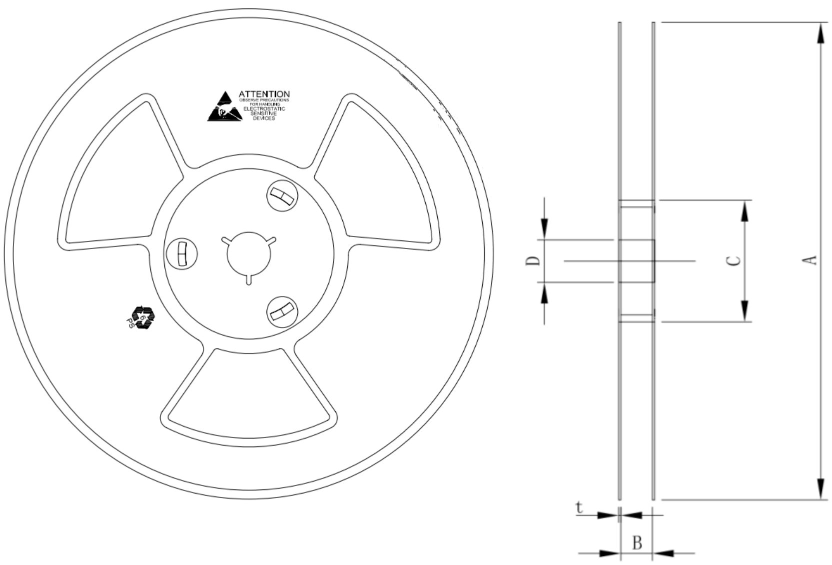
Figure 10.2. Programmable output

PACKAGE INFORMATION



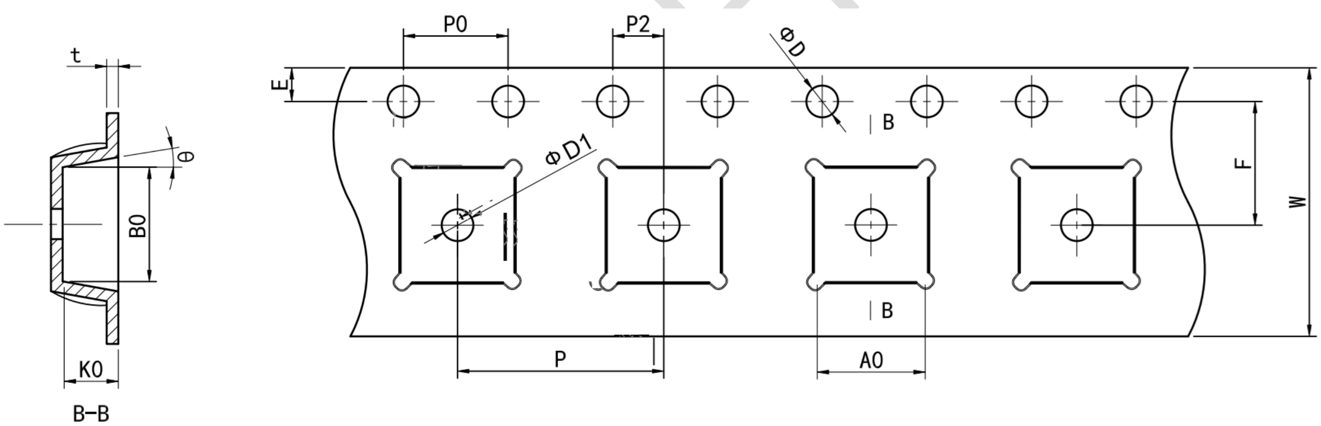
SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0	0.02	0.05
b	0.20	0.25	0.30
c	0.203REF		
D	2.90	3.00	3.10
D2	2.35	2.45	2.55
e	0.50BSC		
Nd	1.50BSC		
E	2.90	3.00	3.10
E2	1.50	1.60	1.70
L	0.35	0.40	0.45
h	0.20	0.25	0.30
K	0.30REF		

TAPE AND REEL INFROMATION



Unit: mm

A	B	C	D	t
329	12.4	100	13.3	2.0



E	F	D	D1	t	θ
1.75	5.50	1.55	1.55	0.30	3°-5°

Part Number	Pins	Package Quantity	A0 (mm)	B0 (mm)	K0 (mm)	W (mm)	P (mm)	P0 (mm)	P2 (mm)
GBI5129NMCR	6	3000	3.30	3.30	1.10	12.00	8.00	4.00	2.00