

### General Description

The SA21309A is a 1A current linear regulator featuring ultra-low ground current and low drop out voltage.

The SA21309A offers an adjustable output voltage with  $\pm 1\%$  reference accuracy over temperature. It also includes comprehensive protection features including over current limiting, short circuit protection, and over-temperature operation.

The SA21309A is available in a compact DFN3x3-8 package.

### Applications

- Infotainment Power Supplies
- Automotive Cluster Displays
- Cameras
- Telematics Control Units
- General Purpose Automotive

### Features

- Input Voltage Range: 1.5V to 6V
- Adjustable Output Voltage : 0.55V to 5.5V
- Low Dropout Voltage: 240mV(Typ.) at 1A(3.3V V<sub>OUT</sub>)
- Power Supply Rejection Ratio (PSRR): 55dB@1kHz
- Output Accuracy:
  - $\pm 0.85\%$  at 25°C
  - $\pm 1\%$  from -40°C to 125°C
- Stable with a Minimum of 2.2 $\mu$ F or Larger Ceramic Output Capacitor
- Low Current Consumption: Typical 25 $\mu$ A Quiescent and 0.1 $\mu$ A at Shutdown
- Over Current Limit and Short Circuit Protection
- Over Temperature Protection with Auto Recovery
- Moisture Sensitivity Level (MSL): 1
- Compact DFN3x3-8 Package
- Automotive AEC-Q100 Grade 1 Qualified

### Typical Application

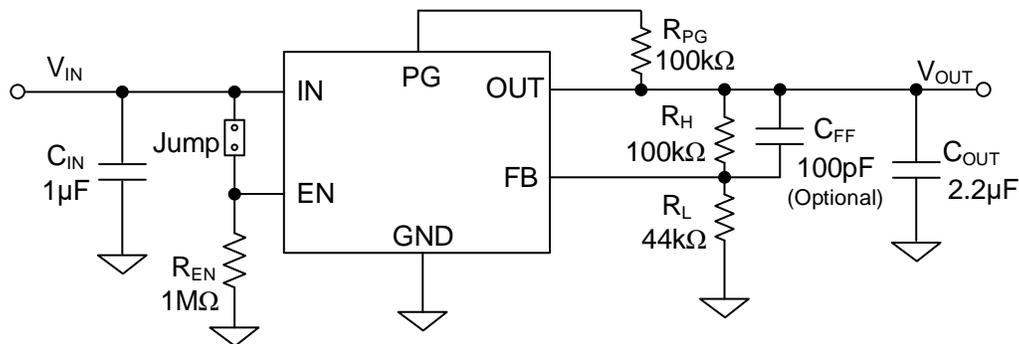
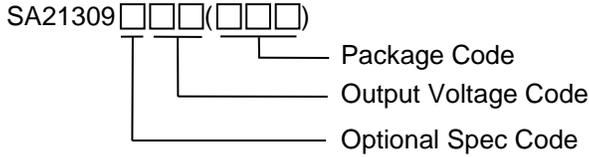


Figure 1 Typical Application Schematic

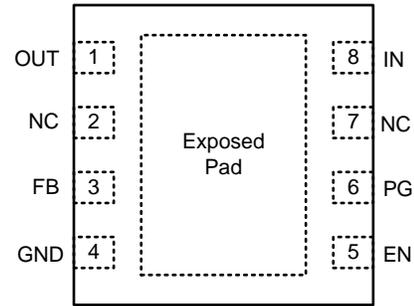
## Ordering Information



Ordering Part Number	Output Version	Package Type	Top Mark
SA21309A00DAD	Adjustable	DFN3x3-8 (RoHS Compliant and Halogen Free)	HFWxyz

*x=year code, y=week code, z= lot number code*

## Pinout (Top View)



DFN3x3-8

## Pin Description

Pin No.	Pin Name	Description
1	OUT	Output voltage pin. Decouple this pin to GND with a minimum 2.2μF ceramic capacitor.
2,7	NC	No connection, leave it floating or connected to GND.
3	FB	Feedback pin. This pin is the input to the control loop error amplifier and is used to set the output voltage of the device.
4	GND	Device GND. Connect to the device thermal pad.
5	EN	Enable pin. This pin turns the LDO on and off. If $V_{EN} \geq V_{EN(HI)}$ , the regulator is enabled. If $V_{EN} \leq V_{EN(LO)}$ , the regulator is disabled. The EN pin must be connected to IN if the enable function is not used.
6	PG	Open-drain power-good indicator pin for the LDO output voltage. A 10kΩ to 100kΩ external pull-up resistor is required. This pin can be left floating or connected to GND if not used.
8	IN	Input pin. Decouple this pin to GND with a recommended 1μF or larger ceramic capacitor.
Exposed Pad		The exposed paddle is electrically connected to the GND node. Connect to the GND plane for improved thermal performance.

## Block Diagram

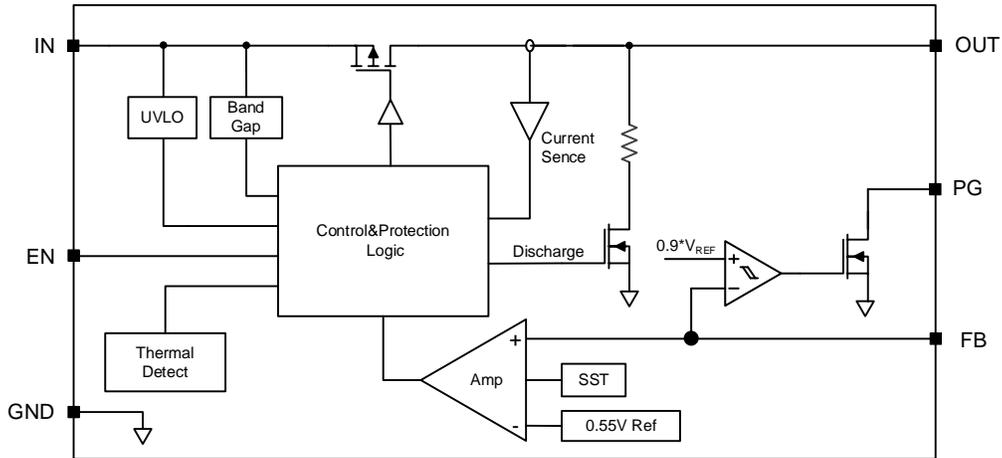


Figure2. Block Diagram

## Absolute Maximum Ratings

Parameter (Note 1)	Min	Max	Unit
IN,EN,PG,OUT	-0.3	6.5	V
FB	-0.3	2	V
Junction Temperature, Operating	-40	150	°C
Lead Temperature (Soldering, 10s)		260	
Storage Temperature	-65	150	
VESD Electrostatic Discharge	Human-body model(HBM), per ANSI/ESDA/JEDEC JS-001		±2000
	Charged-device model(CDM), per JEDEC specification JESD22-C101		±750

## Thermal Information

Parameter (Note 2)	Typ	Unit
$\theta_{JA}$ Junction to Ambient Thermal Resistance	60.1	°C/W
$\theta_{JC,Top}$ Junction to Top of the Case Thermal Resistance	46.1	
$\theta_{JC,Bot}$ Junction to Bottom of the Case Thermal Resistance	12.4	
PD Power Dissipation $T_A = 25^\circ\text{C}$	2.08	W

## Recommended Operating Conditions

Parameter (Note 3)	Min	Max	Unit
IN	1.5	6	V
OUT	0.55	5.5	
Output Current	0.001	1	A
Ambient Temperature, Range	-40	125	°C

## Electrical Characteristics

( $V_{IN}=V_{OUT(NOM)}+1V$ ,  $I_{OUT}=1mA$ ,  $V_{EN}=V_{IN}$ ,  $C_{IN}=1\mu F$ ,  $C_{OUT}=2.2\mu F$ ,  $T_J = -40^{\circ}C\sim 125^{\circ}C$ , unless otherwise specified, all typical values are at  $T_J=25^{\circ}C$ (Note 4)).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit	
Input	Voltage	$V_{IN}$	1.5		6	V	
	UVLO,rising	$V_{ULVO,rising}$	$V_{IN}$ rising	1.20	1.34	1.50	V
	UVLO,falling	$V_{ULVO,falling}$	$V_{IN}$ falling	1.16	1.30	1.46	V
	UVLO Hysteresis	$V_{UVLO\_HYS}$	$V_{IN}$ hysteresis		40		mV
	Shutdown Current	$I_{SHDN}$	$V_{EN}=0V, -40^{\circ}C \leq T_J \leq 125^{\circ}C$		0.1	1.5	$\mu A$
	Ground Current	$I_{GND}$	$I_{OUT}=0mA, T_J=25^{\circ}C$			50	$\mu A$
$I_{OUT}=0mA, -40^{\circ}C \leq T_J \leq 125^{\circ}C$				25	55		
Output	Voltage	$V_{OUT}$	0.55		5.5	V	
	Output Accuracy (Note 6)	$V_{OUT\_ACC}$	$T_J=25^{\circ}C$	-0.85		0.85	%
			$-40^{\circ}C \leq T_J \leq 125^{\circ}C$	-1		1	
	Line Regulation	$\Delta V_{LNR}$	$V_{OUT(NOM)}+0.5V \leq V_{IN} \leq 6V$		2	7.5	mV
Load Regulation	$\Delta V_{LDR}$	$V_{IN} \geq 2.0V, 0.1mA \leq I_{OUT} \leq 1A$		0.03		V/A	
Feedback	Voltage	$V_{FB}$		0.55		V	
	Feedback Pin Current	$I_{FB}$		0.01	0.1	$\mu A$	
Enable	High Voltage	$V_{EN(HI)}$	1.1			V	
	Low Voltage	$V_{EN(LO)}$			0.3		
	Enable Pin Current	$I_{EN}$	$V_{IN}=V_{EN}=6V$		10	nA	
Current Limit	Output Current Limit	$I_{CL}$	$V_{IN}=2V, V_{OUT(NOM)} < 1V, V_{OUT}=V_{OUT(NOM)}-0.2V; V_{IN}=V_{OUT(NOM)}+1V, V_{OUT(NOM)} \geq 1V, V_{OUT}=V_{OUT(NOM)} \times 0.85$	1000	1500	2100	mA
	Short-Circuit Current Limit	$I_{SC}$	$V_{IN}=2V, V_{OUT(NOM)} < 1V, V_{OUT}=0V; V_{IN}=V_{OUT(NOM)}+1V, V_{OUT(NOM)} \geq 1V, V_{OUT}=0V$	400	600	800	mA
Power Good	High Threshold	$PG_{HTh}$	$V_{OUT}$ increasing	88	92	96	$\%V_{OUT}$
	Low Threshold	$PG_{LTh}$	$V_{OUT}$ decreasing	85	90	94	$\%V_{OUT}$
	Hysteresis	$PG_{Hyst}$			2		$\%V_{OUT}$
	PG Pin Low-Level Output Voltage	$V_{OL(PG)}$	$V_{IN} \geq 2.75V, I_{SINK}=2.0mA$			300	mV
	Leakage Current	$I_{lk(PG)}$	$V_{OUT} > PG_{HTh}, V_{PG}=6V$		7	50	nA
	PG Delay Time Rising	$t_{PGDH}$	Time from 92% $V_{OUT}$ to 20% of PG	40	165	290	$\mu s$
	PG Delay Time Falling	$t_{PGDL}$	Time from 90% $V_{OUT}$ to 80% of PG		7		$\mu s$

## Electrical Characteristics (Cont.)

( $V_{IN}=V_{OUT(NOM)}+1V$ ,  $I_{OUT}=1mA$ ,  $V_{EN}=V_{IN}$ ,  $C_{IN}=1\mu F$ ,  $C_{OUT}=2.2\mu F$ ,  $T_J = -40^{\circ}C\sim 125^{\circ}C$ , unless otherwise specified ,all typical values are at  $T_J=25^{\circ}C$ (Note 4)).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Dropout Voltage	$\Delta V_{DROP}$	$I_{OUT}=1A, V_{OUT}=0.95\times V_{OUT(NOM)}$ , $1.5V\leq V_{OUT}<2V$		440	680	mV
		$I_{OUT}=1A, V_{OUT}=0.95\times V_{OUT(NOM)}$ , $2V\leq V_{OUT}<2.5V$		320	500	mV
		$I_{OUT}=1A, V_{OUT}=0.95\times V_{OUT(NOM)}$ , $2.5V\leq V_{OUT}<3.3V$		250	420	mV
		$I_{OUT}=1A, V_{OUT}=0.95\times V_{OUT(NOM)}$ , $3.3V\leq V_{OUT}\leq 5.5V$		220	370	mV
Startup Time	$t_{STR}$	From EN low-to-high transition to $V_{OUT}=V_{OUT(NOM)}\times 0.95$	200	500	850	$\mu s$
Power Supply Rejection Ratio (Note 5)	PSRR	$V_{IN}=2.8V, V_{OUT}=1.8V, I_{OUT}=1A$ , $f=1kHz$		55		dB
		$V_{IN}=2.8V, V_{OUT}=1.8V, I_{OUT}=1A$ , $f=100kHz$		35		dB
		$V_{IN}=2.8V, V_{OUT}=1.8V, I_{OUT}=1A$ , $f=1MHz$		30		dB
Pull Down Resistance	$R_{PULLDOWN}$	$V_{IN}=6V, V_{EN}=0V$		95		$\Omega$
Thermal Shutdown Temperature (Note 5)	$T_{SD}$			170		$^{\circ}C$
Thermal Shutdown Reset (Note 5)	$T_{Reset}$			155		$^{\circ}C$

**Note 1:** Stresses beyond the “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**Note 2:** Measured under the natural convection at  $T_A = 25^{\circ}C$  on a thermal conductivity test board with vias, based on JEDEC 51-5,7.

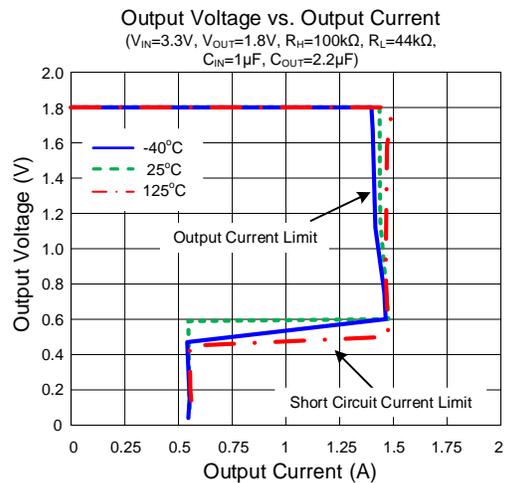
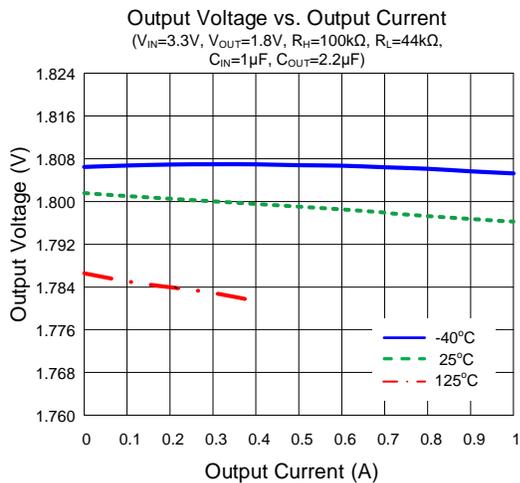
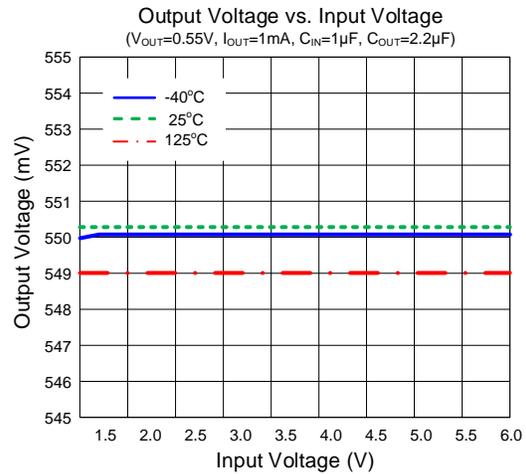
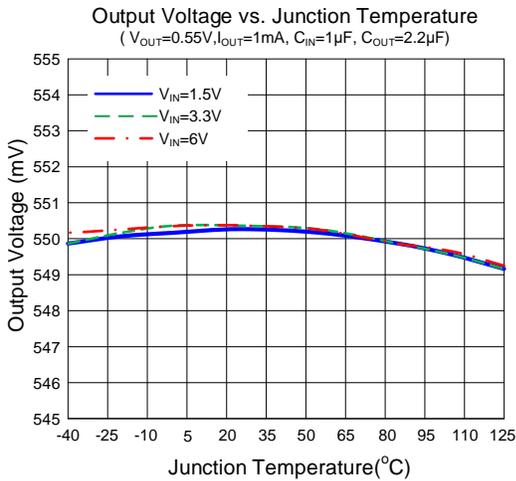
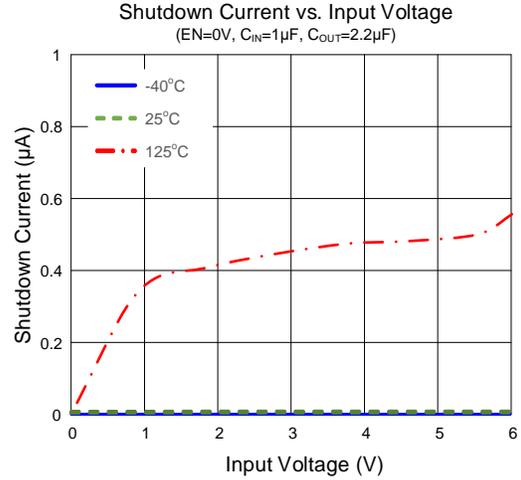
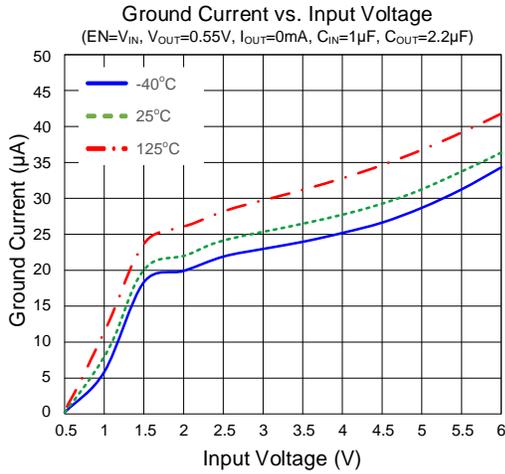
**Note 3:** The device is not guaranteed to function outside its operating conditions.

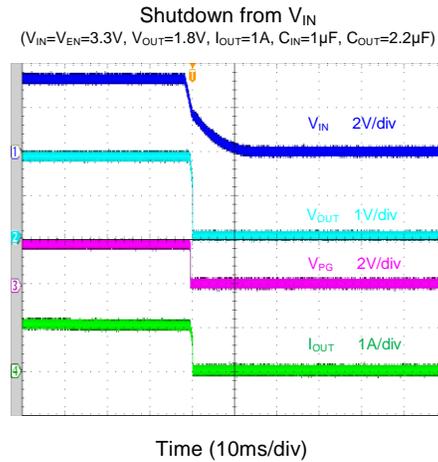
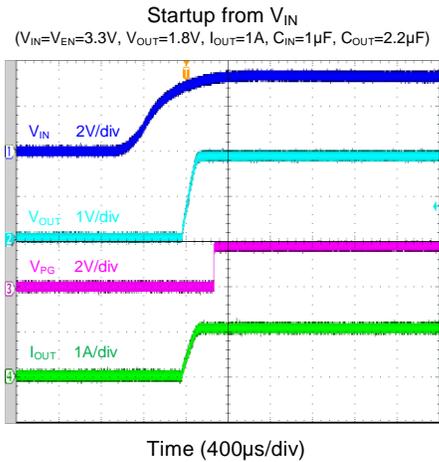
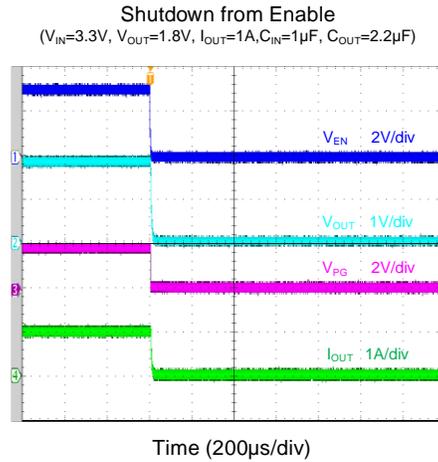
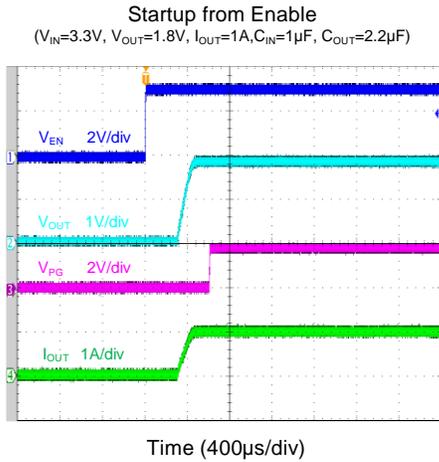
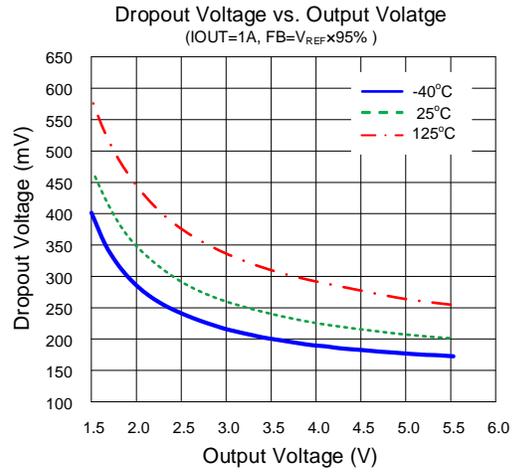
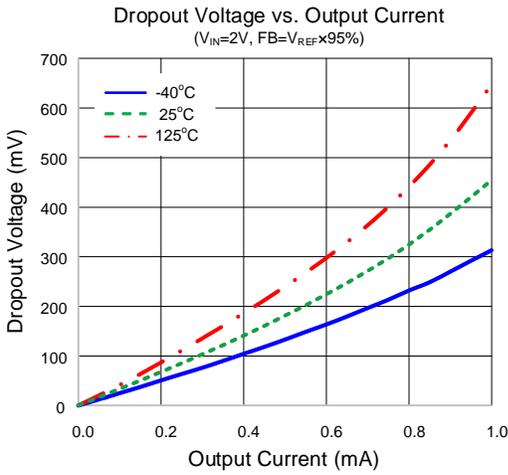
**Note 4:** Unless otherwise stated, limits are 100% production tested under pulsed load conditions such that  $T_A \cong T_J= 25^{\circ}C$ . Limits over the operating temperature range (see recommended operating conditions) and relevant voltage range(s) are guaranteed by design, test, or statistical correlation.

**Note 5:** Guaranteed by design or statistical correlation and not production tested.

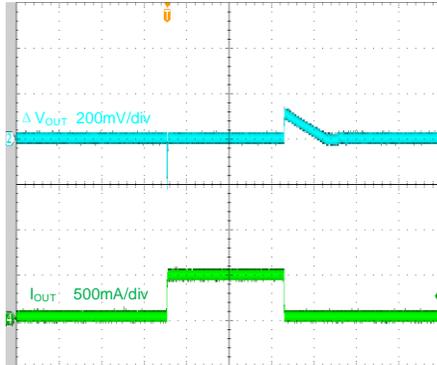
**Note 6:** Tolerances of the external feedback resistors are not considered. .

## Typical Performance Characteristics



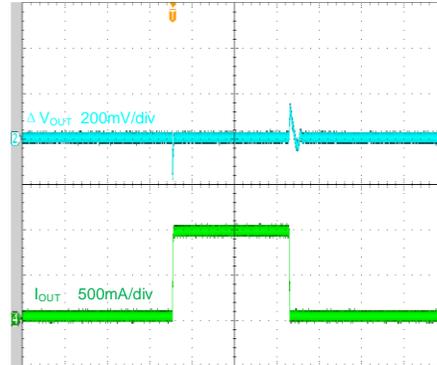


**Load Transient**  
 $(V_{IN}=3.3V, V_{OUT}=1.8V, I_{OUT}=1mA-500mA-1mA,$   
 $C_{IN}=1\mu F, C_{OUT}=2.2\mu F)$



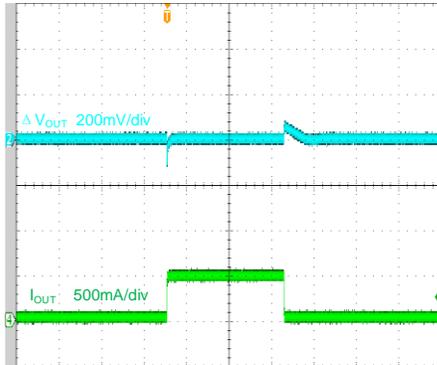
Time (200μs/div)

**Load Transient**  
 $(V_{IN}=3.3V, V_{OUT}=1.8V, I_{OUT}=10mA-1A-10mA,$   
 $C_{IN}=1\mu F, C_{OUT}=2.2\mu F)$



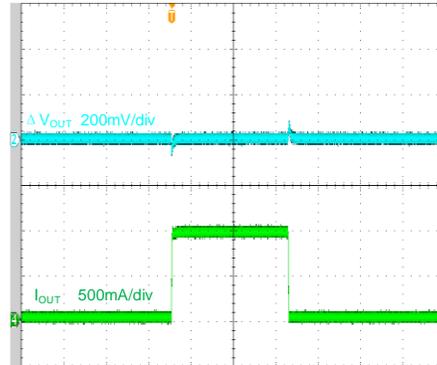
Time (200μs/div)

**Load Transient**  
 $(V_{IN}=3.3V, V_{OUT}=1.8V, I_{OUT}=1mA-500mA-1mA,$   
 $C_{IN}=1\mu F, C_{OUT}=2.2\mu F, C_{FF}=100pF)$



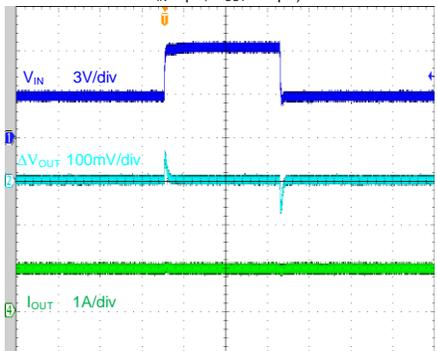
Time (200μs/div)

**Load Transient**  
 $(V_{IN}=3.3V, V_{OUT}=1.8V, I_{OUT}=10mA-1A-10mA,$   
 $C_{IN}=1\mu F, C_{OUT}=2.2\mu F, C_{FF}=100pF)$



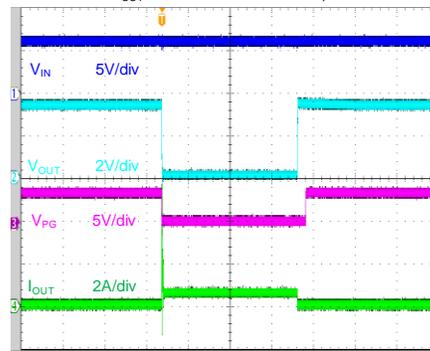
Time (200μs/div)

**Line Transient**  
 $(V_{IN}=2.8V-6V-2.8V, V_{OUT}=1.8V, I_{OUT}=1A,$   
 $C_{IN}=1\mu F, C_{OUT}=2.2\mu F)$

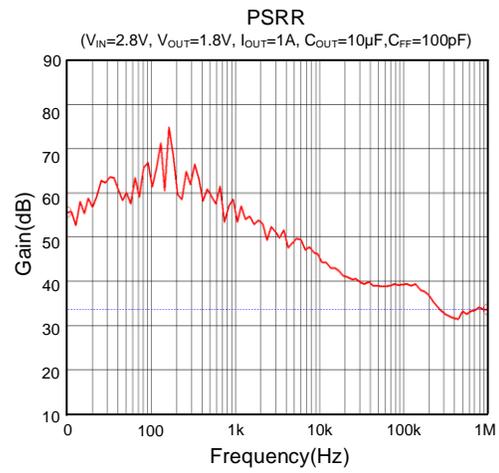
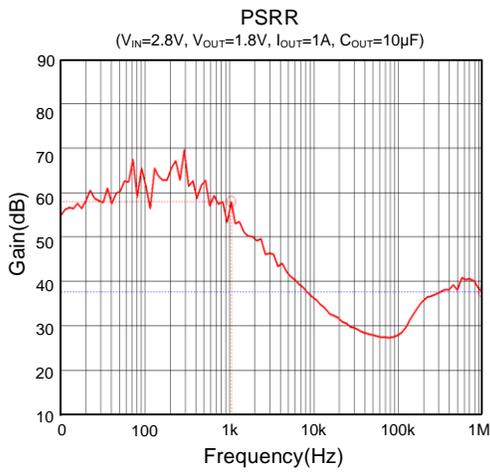
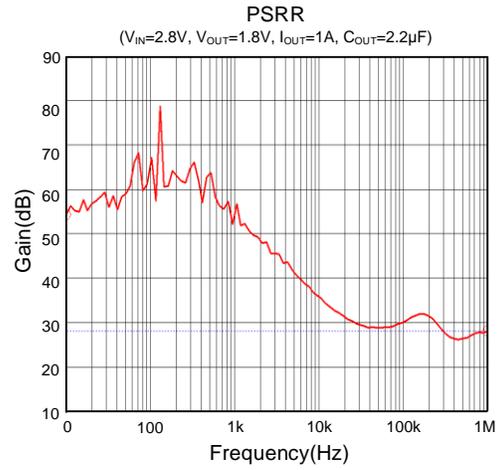
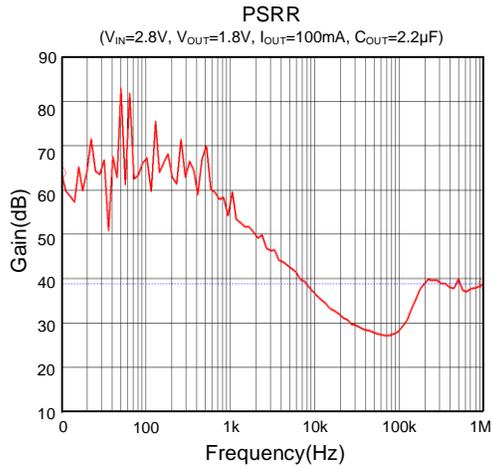


Time (200μs/div)

**Short Circuit Protection**  
 $(V_{IN}=6V, V_{OUT}=3.3V, C_{IN}=1\mu F, C_{OUT}=2.2\mu F,$   
 $I_{OUT}=Null-Short\ Circuit-Null)$



Time (2ms/div)



## Detailed Description

### General Features

#### Input Under Voltage Lock-Out (UVLO)

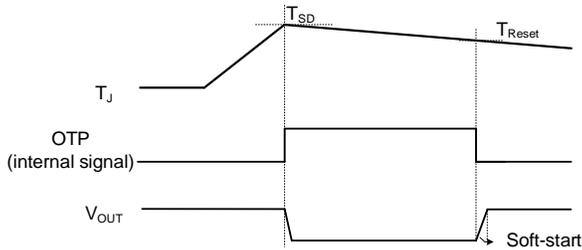
To prevent operation before all internal circuitry is ready, the device remains in a shutdown state until  $V_{IN}$  exceeds the UVLO (rising) threshold. Once this threshold is met and EN is enabled, the device initiates a soft-start ramp. If  $V_{IN}$  subsequently falls below the UVLO falling threshold (defined as  $V_{IN, UVLO}$  minus the UVLO hysteresis) the device shuts down again.

#### Enable Function (EN)

The enable pin for the SA21309A is active high. The output voltage is enabled when the voltage at the enable pin exceeds  $V_{EN(HI)}$  and disabled when the voltage falls below  $V_{EN(LO)}$ . If independent control of the output voltage is not required, connect the enable pin to the input.

#### Over Temperature Protection (OTP)

The SA21309A includes over-temperature protection (OTP) circuitry to prevent overheating due to excessive power dissipation. The device will turn off when the junction temperature exceeds  $170^{\circ}\text{C}$ . Once the junction temperature cools down by approximately  $15^{\circ}\text{C}$ , the device will resume normal operation.



#### Over Current Limit and Short Circuit Protection (OCL&SCP)

The device includes over current limiting and output short-circuit protection. The current limitation circuit regulates the output current to its limitation threshold ( $I_{CL}$ ) to prevent device damage. If  $V_{OUT}$  drops below approximately 40% of the OUT set point, the short-circuit protection reduces the output current to the fold-back short-circuit current limit ( $I_{SC}$ ) to further decrease the power dissipation. Under over current or short-circuit conditions, the power loss of the device is relatively high, potentially triggering thermal protection.

#### Power Good Function (PG)

The device features an open-drain power good (PG) output that goes high when the feedback voltage ( $V_{FB}$ ) exceeds the power good high threshold ( $PG_{HTH}$ ). Conversely, PG is pulled low when the  $V_{FB}$  drops below the power good low threshold ( $PG_{LTH}$ ). PG is an open-

drain output, requiring a pull-up resistor (typically between  $10\text{ k}\Omega$  and  $100\text{ k}\Omega$ ) connected to a stable active supply voltage rail. Additionally, PG is pulled low if the device encounters other fault conditions, such as over-temperature protection (OTP) and under-voltage lockout (UVLO).

#### Input Capacitor $C_{IN}$

For normal operation, it is recommended to place a  $1\mu\text{F}$  low-ESR ceramic capacitor (X7R grade or better) close to the IN and GND pins. Using a larger input ceramic capacitor can help minimize the potential noise problem and improve the power-supply rejection ratio (PSRR) and transient response. Care should be taken to minimize the loop area formed by  $C_{IN}$  and the IN/GND pins.

#### Output Capacitor $C_{OUT}$

For stable operation across the entire temperature range, a minimum of  $2.2\mu\text{F}$  low-ESR ceramic capacitor is recommended. Use Larger output capacitor values, such as  $10\mu\text{F}$  to reduce noise, improve load transient response, and enhance PSRR. Some ceramic dielectrics exhibit significant variations in capacitance and equivalent series resistance (ESR) with temperature.

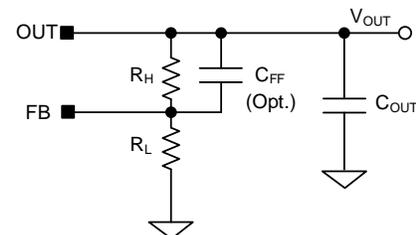
#### Feedback Resistor Dividers $R_H$ and $R_L$

Select resistors  $R_H$  and  $R_L$  to program the desired output voltage. To minimize power consumption under light loads, select large resistance values (between  $1\text{ k}\Omega$  and  $1\text{ M}\Omega$ ) for both resistors. For example, if  $V_{OUT}$  is  $1.8\text{ V}$  and  $R_H$  is chosen to be  $100\text{ k}\Omega$ , then  $R_L$  can be calculated using the following equation to be  $44\text{ k}\Omega$ :

$$R_L = \frac{0.55V}{V_{OUT} - 0.55V} \times R_H$$

#### Feedforward Capacitor ( $C_{FF}$ )

The SA21309A integrates compensation components to achieve good stability and transient response. In some applications, adding a small ceramic capacitor (with a typical value between  $10\text{ pF}$  and  $1\text{ nF}$ ) in parallel with  $R_H$  may further enhance the load transient response, therefore, it is recommended for applications with significant load transient step requirements.



## Dropout Voltage

The SA21309A features a very low dropout voltage attributed to the extra low  $R_{DS(ON)}$  of the main PMOS, which determines the minimum usable supply voltage.

$$V_{DROPOUT} = V_{IN} - V_{OUT} = R_{DS(ON)} \times I_{OUT}$$

## Thermal Design Considerations

The SA21309A can deliver a current of up to 1 A across the full operating temperature range. However, the maximum output current must be derated at a higher ambient temperature. Under all conditions, the junction temperature must remain within the specified range for operating conditions. Power dissipation can be calculated based on the output current and the voltage drop across the regulator.

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

Maximum power dissipation depends on the thermal resistance of the device package, the PCB layout, the surrounding airflow, and the difference between the junction and ambient temperatures. The maximum power dissipation can be calculated using the following thermal equation:

$$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$$

Where  $T_{J(MAX)}$  is the maximum junction temperature,  $T_A$  is the ambient temperature, and  $\theta_{JA}$  is the thermal resistance from the junction to the ambient.

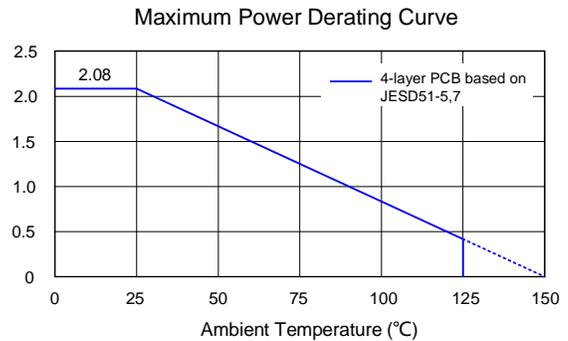
To comply with the recommended operating conditions, the maximum junction temperature is 150 °C, and the junction-to-ambient thermal resistance,  $\theta_{JA}$ , is layout-dependent. For the DFN3x3-8 package, the thermal resistance  $\theta_{JA}$  is 60.1 °C/W when measured on a four-layer thermal test board with thermal vias, based on JESD51-5 and JESD51-7.

The maximum power dissipation at  $T_A = 25$  °C may be

calculated by the following formula:

$$P_{D(MAX)} = (150 \text{ °C} - 25 \text{ °C}) / (60.1 \text{ °C/W}) = 2.08 \text{ W}$$

The maximum power dissipation depends on the operating ambient temperature for fixed  $T_{J(MAX)}$  and thermal resistance  $\theta_{JA}$ . Use the derating curve in the figure below to calculate the effect of rising ambient temperature on the maximum power dissipation.



## Layout Design

For optimal performance of the SA21309A, the following guidelines must be strictly followed:

1. Place the input/output capacitors as close to the device as possible, minimizing the loop formed by these connections to improve transient performance.
2. Keep all power traces as short and wide as possible. The exposed pad should be connected to a large ground copper area and include multiple GND vias for efficient heat dissipation and noise reduction.
3. A 2-layer or 4-layer board is recommended for thermal performance and better current-handling capability.

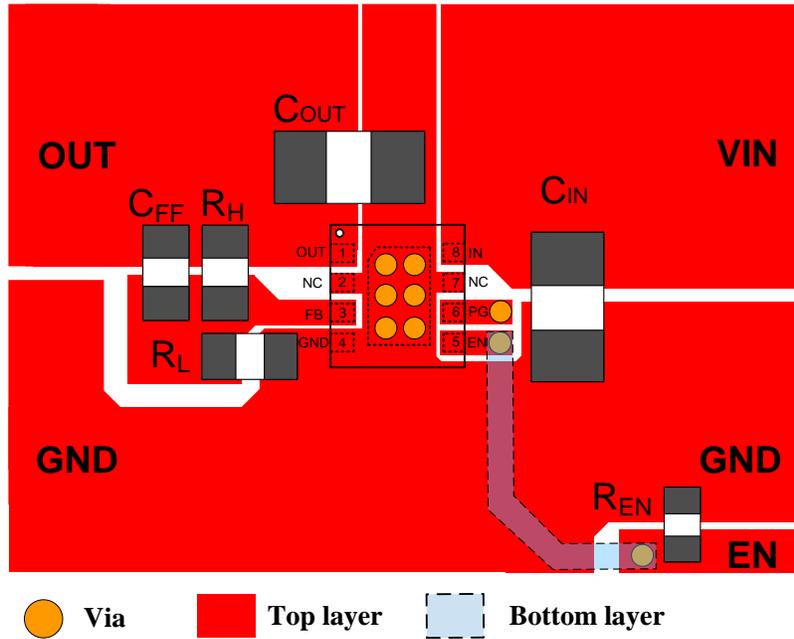
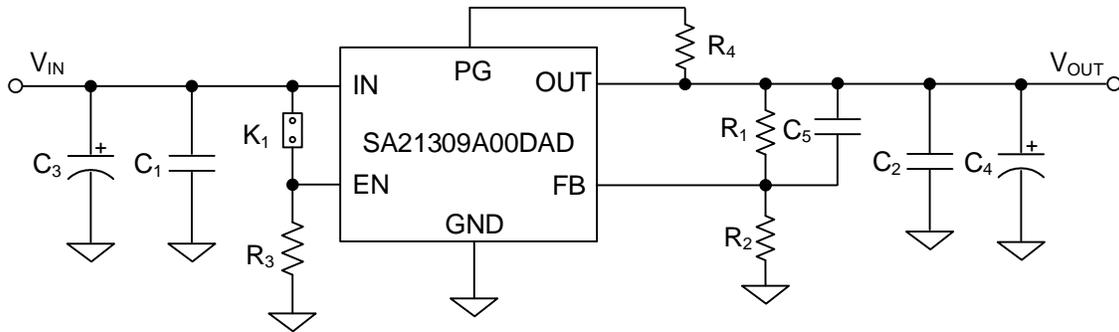


Figure3. PCB Layout Suggestion

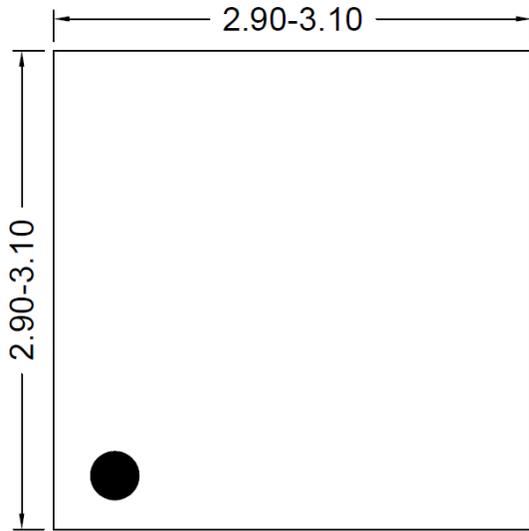
## Schematic



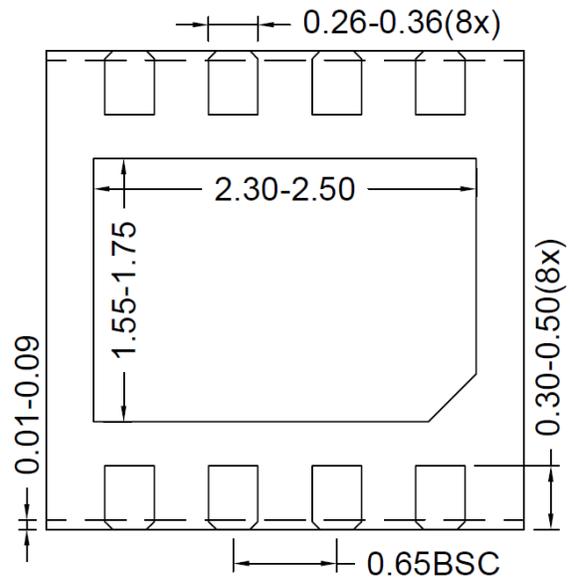
## BOM List

Designator	Description	Part Number	Manufacturer
C <sub>1</sub>	1μF/25V/X7R, 0805	GRM21BR71E105K	muRata
C <sub>2</sub>	2.2μF/25V/X7R, 0805	GRM21BR71E225K	muRata
C <sub>5</sub>	100pF/50V/C0G, 0603	GRM1885C1H101J	muRata
C <sub>3</sub> , C <sub>4</sub>	NC		
R <sub>1</sub>	100kΩ, 1%, 0603		
R <sub>2</sub>	44.2kΩ, 1%, 0603		
R <sub>3</sub>	1MΩ, 1%, 0603		
R <sub>4</sub>	100kΩ, 1%, 0603		

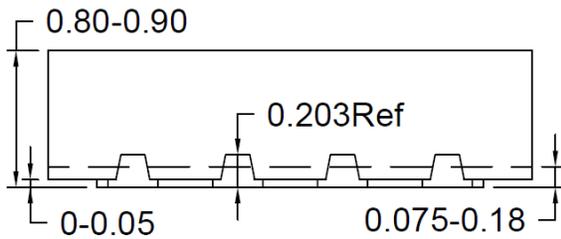
## DFN3x3-8 Package Outline



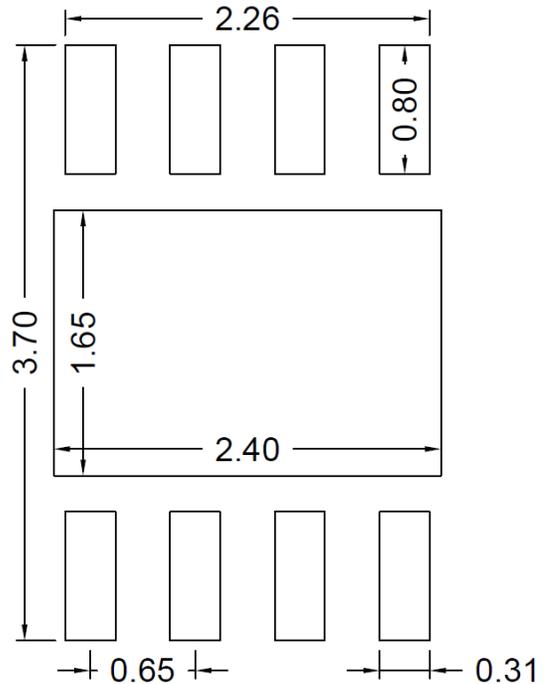
**Top view**



**Bottom view**



**Front view**



**Recommended PCB layout  
(Reference only)**

*Note: All dimension in millimeter and exclude mold flash & metal burr.*





## Revision History

The revision history provided is for informational purposes only and is believed to be accurate; however, not warranted. Please make sure that you have the latest revision.

Date	Revision	Change
Mar. 18, 2025	Revision 1.0	Initial Release



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