500 mA, High-Accuracy LDO with Power-Good for Automotive Application

Features

- AEC-Q100 qualified:
  - Device ambient temperature: -40°C ≤ T_A ≤ 125°C
  - Device junction temperature: -40°C ≤ T_J ≤ 150°C
- Operating input voltage range: 1.7 V to 6.0 V
- Operating output voltage range:
  - Fixed options: 0.65 V to 5.0 V
  - Adjustable option: 0.55 V to 5.5 V
- High PSRR: 64 dB at 1 kHz
- Power-good output options:
  - Open-drain:DIA7976AO and DIA7976BO
  - Push-pull: DIA7976AP and DIA7976BP
- Output accuracy:
  - ±1% at T_A = 25°C
  - ±1.5% at -40°C ≤ T_A ≤ 85°C
  - ±2% at -40°C ≤ T_A ≤ 125°C
- Ultra-low dropout:
  - 150 mV at 500 mA, V_{OUT} = 3.3 V
- Low quiescent current:
  - 27 μA typical at no load
  - 100 nA shutdown mode typical current
- Active output discharge: DIA7976A
- Stable with a 1 μF or larger capacitor

Applications

- Automotive head units
- Front and rear cameras
- Automotive cluster displays
- Telematics control units
- Medium, short range radar

Package Information

Part Number	Package	Body Size
DIA7976	DFN6	2 mm × 2 mm
	DFN8	3 mm × 3 mm
	SOT23-5	2.9 mm × 1.6 mm

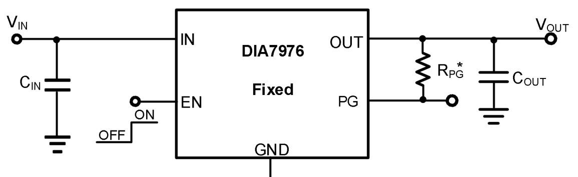
Description

The DIA7976 is a 500 mA ultra-low-dropout regulator with power-good function. The DIA7976 is designed for applications requiring low quiescent current and provides fast line and load transient performance. Additionally, DIA7976 features high Power Supply Ripple Rejection (PSRR) at up to 500 mA.

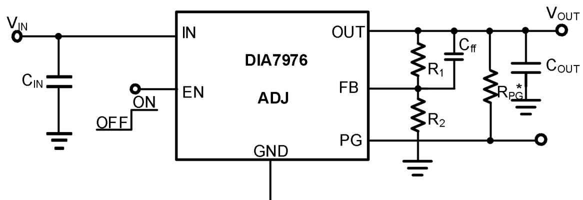
The DIA7976 operates with an input voltage range from 1.7 V to 6.0 V and the output voltage is adjustable from 0.55 V to 5.5 V.

The DIA7976 is stable with small ceramic output capacitors, allowing for a small overall solution size. An error amplifier and precision band-gap provide an accuracy of ±2% over temperature. The DIA7976 helps reduce the thermal dissipation during short-circuit events with internal short-current limit. The device also contains integrated thermal shutdown, current limit, and undervoltage lockout (UVLO) features.

Simplified Schematic



*Pull-up resistor not required for push-pull option



*Pull-up resistor not required for push-pull option

Ordering Information

Ordering Part No.	Top Marking	MSL	Description	RoHS	T_A	Package	
DIA7976AOaaCD6	YWXZ GF5XO	1	Active Discharge	Green	-40 to 125°C	DFN2*2-6	Tape & Reel, 3000
DIA7976APaaCD6	YWXZ GF5XP	1		Green	-40 to 125°C	DFN2*2-6	Tape & Reel, 3000
DIA7976AOaaCD8	YWXZ GF5XO	1		Green	-40 to 125°C	DFN3*3-8	Tape & Reel, 3000
DIA7976APaaCD8	YWXZ GF5XP	1		Green	-40 to 125°C	DFN3*3-8	Tape & Reel, 3000
DIA7976AaaST5	A5XYW	1		Green	-40 to 125°C	SOT23-5	Tape & Reel, 3000
DIA7976AOADJCD6	YWXZ GF5XO	1		Green	-40 to 125°C	DFN2*2-6	Tape & Reel, 3000
DIA7976APADJCD6	YWXZ GF5XP	1		Green	-40 to 125°C	DFN2*2-6	Tape & Reel, 3000
DIA7976AOADJCD8	YWXZ GF5XO	1		Green	-40 to 125°C	DFN3*3-8	Tape & Reel, 3000
DIA7976APADJCD8	YWXZ GF5XP	1		Green	-40 to 125°C	DFN3*3-8	Tape & Reel, 3000
DIA7976AADJST5	A5XYW	1		Green	-40 to 125°C	SOT23-5	Tape & Reel, 3000
DIA7976BOaaCD6	YWXZ GF7XO	1	Non-Active Discharge	Green	-40 to 125°C	DFN2*2-6	Tape & Reel, 3000
DIA7976BPaaCD6	YWXZ GF7XP	1		Green	-40 to 125°C	DFN2*2-6	Tape & Reel, 3000
DIA7976BOaaCD8	YWXZ GF7XO	1		Green	-40 to 125°C	DFN3*3-8	Tape & Reel, 3000
DIA7976BPaaCD8	YWXZ GF7XP	1		Green	-40 to 125°C	DFN3*3-8	Tape & Reel, 3000
DIA7976BaaST5	A7XYW	1		Green	-40 to 125°C	SOT23-5	Tape & Reel, 3000
DIA7976BOADJCD6	YWXZ GF7XO	1		Green	-40 to 125°C	DFN2*2-6	Tape & Reel, 3000
DIA7976BPADJCD6	YWXZ GF7XP	1		Green	-40 to 125°C	DFN2*2-6	Tape & Reel, 3000
DIA7976BOADJCD8	YWXZ GF7XO	1		Green	-40 to 125°C	DFN3*3-8	Tape & Reel, 3000
DIA7976BPADJCD8	YWXZ GF7XP	1		Green	-40 to 125°C	DFN3*3-8	Tape & Reel, 3000
DIA7976BADJST5	A7XYW	1		Green	-40 to 125°C	SOT23-5	Tape & Reel, 3000

Output Voltage Options											
Option Code "**aa**"	**08**	**10**	**11**	**12**	**15**	**18**	**25**	**28**	**30**	**33**	**50**
Voltage	0.8 V	1.0 V	1.1 V	1.2 V	1.5 V	1.8 V	2.5 V	2.8 V	3 V	3.3 V	5.0 V

Marking Definition: GF5XO/GF5XP/A5XYW/GF7XO/GF7XP/A7XYW	
YWXZ	YWXZ: Year code; Week code; Factory code; Internal code
GF5XO	GF: Product code; 5: Product code; X: Voltage code; O: Open-drain version.
GF5XP	GF: Product code; 5: Product code; X: Voltage code; P: Push-pull version.
A5XYW	A: Product code; 5: Product code; X: Voltage code; Y: Year code; W: Week code.
GF7XO	GF: Product code; 7: Product code; X: Voltage code; O: Open-drain version.
GF7XP	GF: Product code; 7: Product code; X: Voltage code; P: Push-pull version.
A7XYW	A: Product code; 7: Product code; X: Voltage code; Y: Year code; W: Week code.

Voltage Code												
Option Code "X"	C	D	E	F	G	H	J	K	L	M	P	Q
Voltage	0.8 V	1.0 V	1.1 V	1.2 V	1.5 V	1.8 V	2.5 V	2.8 V	3 V	3.3 V	5.0 V	ADJ

If you encounter any issue in the process of using the device, please contact our customer service at marketing@dioo.com or phone us at (+86)-21-62116882. If you have any improvement suggestions regarding the datasheet, we encourage you to contact our technical writing team at docs@dioo.com. Your feedback is invaluable for us to provide a better user experience.

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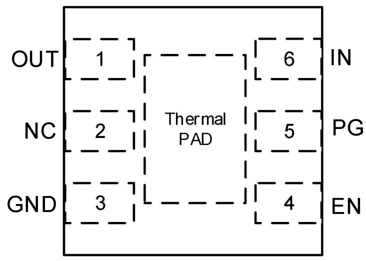

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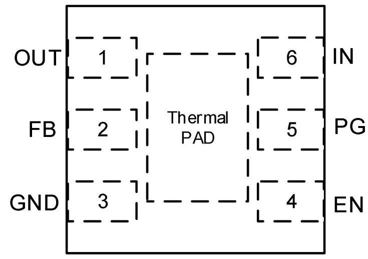
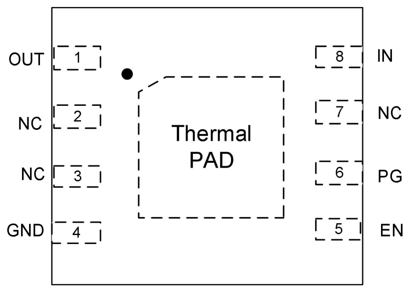


Adjustable

DFN2*2-6

Top view



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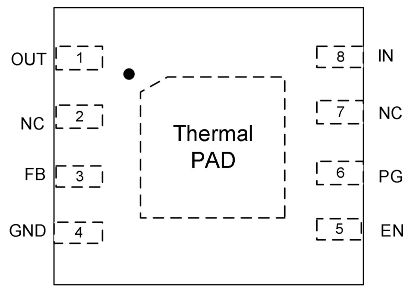
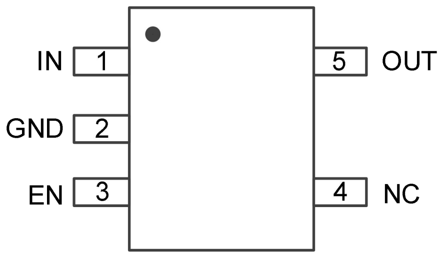


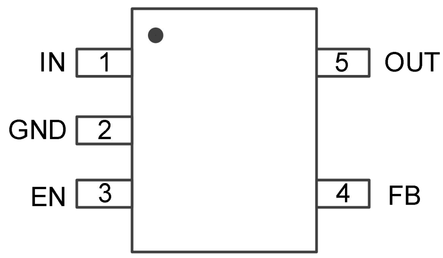
Adjustable

DFN3*3-8

Top view



Fixed



Adjustable

SOT23-5

Top view

Pin Name	Description
EN	Enable pin. Drive EN greater than $V_{EN(HI)}$ to turn on the regulator. Drive EN less than $V_{EN(LO)}$ to put the low-dropout regulator (LDO) into shutdown mode.
FB	This pin is used as an input to the control loop error amplifier and is used to set the output voltage of the LDO.
GND	Ground pin.
IN	Input pin. For best transient response and to minimize input impedance, use the recommended value or larger ceramic capacitor from IN to ground as listed in the Recommended Operating Conditions table. Place the input capacitor as close to the output of the device as possible.
NC	No internal connection. Ground this pin for better thermal performance.
OUT	Regulated output voltage pin. A capacitor is required from OUT to ground for stability. For best transient response, use the nominal recommended value or larger ceramic capacitor from OUT to ground; Place the output capacitor as close to the output of the device as possible.
PG	Power-good output. Available in open-drain and push-pull topologies. A pull-up resistor is only required for the open-drain type. For the open-drain version (DIA7976AO and DIA7976BO), if the power-good functionality is not being used, ground this pin or leave floating. For the push-pull version (DIA7976AP and DIA7976BP), if the power-good functionality is not being used, leave this pin floating.
Thermal Pad	The thermal pad is left floating. Connect to the GND plane for improved thermal performance.

2. Absolute Maximum Ratings

Exceeding the maximum ratings listed under Absolute Maximum Ratings when designing is likely to damage the device permanently. Do not design to the maximum limits because long-time exposure to them might impact the device's reliability. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter	Rating	Unit
V_{IN}	Supply voltage	-0.3 to 6.6	V
V_{EN}	Enable voltage	-0.3 to 6.6	
V_{FB}	Feedback voltage	-0.3 to 2	
V_{PG}	Power-good voltage	-0.3 to 6.6	
V_{OUT}	Output voltage	-0.3 to V_{IN} + 0.3 (1)	
I_{OUT}	Output current	Internally limited	
I_{PG}	Power-good current	-10 to 10	mA
T_J	Operating junction temperature	-40 to 150	°C
T_{STG}	Storage temperature	-65 to 150	

Note:

(1) The absolute maximum rating is V_{IN} + 0.3 V or 6.0 V, whichever is smaller.

3. Recommended Operating Conditions

Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. The ratings are obtained over an operating free-air temperature range unless otherwise specified.

Symbol	Parameter		Rating	Unit
V_{IN}	Input voltage		1.7 to 6.0	V
V_{OUT}	Output voltage	Adjustable only	0.55 to 5.5	V
		Fixed only	0.65 to 5.0	V
I_{OUT}	Output current		0 to 500	mA
C_{IN}	Input capacitor		≥ 1	μF
C_{OUT}	Output capacitor(1)		1 to 22	μF
C_{FF}	Feed-forward capacitor		10	nF
V_{EN}	Enable voltage		0 to 6	V
V_{PG}	PG voltage		0 to 6	V
T_J	Junction operating temperature		-40 to 125	°C

Note:

(1) Minimum derated capacitance of 0.47 μF is required for stability.

4. ESD Ratings

When a statically-charged person or object touches an electrostatic discharge sensitive device, the electrostatic charge might be drained through sensitive circuitry in the device. If the electrostatic discharge possesses sufficient energy, damage might occur to the device due to localized overheating.

Symbol	Condition	Value	Unit
HBM	JEDEC JS-001	±4000	V
CDM	JEDEC JS-002	±2000	

5. Thermal Considerations

The thermal resistance determines the heat insulation property of a material. The higher the thermal resistance is, the lower the heat loss. Accumulation of heat energy degrades the performance of semiconductor components.

Symbol	Thermal Metric	DFN6	DFN8	SOT23-5	Unit
$R_{\theta JA}$	Junction-to-ambient thermal resistance	96.6	82.43	150	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	36.03	32.11	93.1	°C/W

6. Electrical Characteristics

At operating temperature range (T_A = -40°C to 125°C), V_{IN} = $V_{OUT(NOM)}$ + V_{DO} or 1.7 V (whichever is greater), I_{OUT} = 1 mA, V_{EN} = V_{IN}, and C_{IN} = C_{OUT} = 1 μF, unless otherwise noted; all typical values are at T_A = 25°C.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{FB}	Feedback voltage	Adjustable only	0.539	0.55	0.561	V
V_{OUT}	Output accuracy[1]	T_A = 25°C	-1		1	%
		-40°C ≤ T_A ≤ 85°C	-1.5		1.5	%
		-40°C ≤ T_A ≤ 125°C	-2.0		2.0	%
$Line_{Reg}$	Line regulation	$V_{OUT(NOM)}$ + V_{DO} ≤ V_{IN}[2] ≤ 6.0 V		0.1	0.3	%/V
$Load_{Reg}$	Load regulation	0.1 mA ≤ I_{OUT} ≤ 500 mA, V_{IN} ≥ 2.0 V		0.04		V/A
I_Q	Quiescent current	I_{OUT} = 0 mA, T_A = 25°C		27	45	μA
		I_{OUT} = 0 mA, -40°C ≤ T_A ≤ 125°C		27	50	μA
I_{SHDN}	Shutdown current	V_{EN} ≤ 0.3 V, 1.7 V ≤ V_{IN} ≤ 6.0 V, -40°C ≤ T_A ≤ 125°C		0.1	1	μA
I_{FB}	Feedback pin current	Adjustable only		0.01	0.1	μA
I_{CL}	Output current limit	$V_{OUT(NOM)}$ < 1.0 V, V_{OUT} = $V_{OUT(NOM)}$ - 0.2 V, V_{IN} = 2.0 V $V_{OUT(NOM)}$ ≥ 1.0 V, V_{OUT} = $V_{OUT(NOM)}$ × 0.85, V_{IN} = $V_{OUT(NOM)}$ + 1.0 V	515	720	1000	mA
I_{SC}	Short-circuit current limit	V_{OUT} = 0 V: $V_{OUT(NOM)}$ < 1.0 V, V_{IN} = 2.0 V $V_{OUT(NOM)}$ ≥ 1.0 V, V_{IN} = $V_{OUT(NOM)}$ + 1.0 V	200	300	400	mA
V_{DO}	Dropout voltage	I_{OUT} = 500 mA, V_{OUT} = 0.95 × $V_{OUT(NOM)}$, V_{OUT} = 1 V		830		mV
		V_{OUT} = 1.2 V		650		mV
		V_{OUT} = 1.5 V		400		mV
		V_{OUT} = 1.8 V		270		mV
		V_{OUT} = 2.5 V		185		mV
		V_{OUT} = 3.3 V		150	200	mV
		V_{OUT} = 5.5 V		115		mV
PSRR	Power-supply rejection ratio	V_{OUT} = 0.55 V, V_{IN} = 2.0 V, I_{OUT} = 10 mA, C_{OUT} = 2.2 μF, f = 1 kHz		64		dB
		f = 100 kHz		50		dB
		f = 1 MHz		75		dB
V_N	Output noise voltage	BW = 10 Hz to 100 kHz, V_{OUT} = 0.55 V, V_{IN} = 2.0 V		40		μVRMS

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{UVLO}	Undervoltage lockout	V_{IN} falling	1.17	1.27	1.48	V
		V_{IN} rising	1.21	1.32	1.55	
$V_{UVLO, HYST}$	Undervoltage lockout hysteresis	V_{IN} hysteresis		50		mV
t_{STR}	Startup time	From EN low-to-high transition to $V_{OUT} = V_{OUT(NOM)} \times 0.95$	200	450	800	µs
$V_{EN(HI)}$	EN pin high voltage	enabled	1			V
$V_{EN(LO)}$	EN pin low voltage	disabled			0.3	V
I_{EN}	Enable pin current	$V_{IN} = V_{EN} = 6.0$ V		10		nA
$R_{PULLDOWN}$	Pulldown resistance (only for DIA7976A)	$V_{IN} = 6.0$ V		100		Ω
PG_{HTH}	PG high threshold	V_{OUT} increasing	89	92	96	$\%V_{OUT}$
PG_{LTH}	PG low threshold	V_{OUT} decreasing	86	90	93	$\%V_{OUT}$
PG_{HYST}	PG hysteresis			2		$\%V_{OUT}$
$V_{OL(PG)}$	PG pin low-level output voltage	$V_{IN} \geq 1.7$ V, $I_{SINK} = 1.0$ mA			400	mV
		$V_{IN} \geq 2.75$ V, $I_{SINK} = 2.0$ mA				
$V_{OH(PG)}$	PG pin high-level output voltage(3)	$V_{OUT} \geq 1.0$ V, $I_{SOURCE} = 0.04$ mA	$0.8 \times V_{OUT}$			V
		$V_{OUT} \geq 1.4$ V, $I_{SOURCE} = 0.2$ mA				
		$V_{OUT} \geq 2.5$ V, $I_{SOURCE} = 0.5$ mA				
		$V_{OUT} \geq 4.5$ V, $I_{SOURCE} = 1.0$ mA				
$I_{kg(PG)}$	PG pin leakage current(4)	$V_{OUT} > PG_{HTH}$, $V_{PG} = 6.0$ V		7	50	nA
T_{SD}	Thermal shutdown	Shutdown, temperature increasing		165		°C
		Reset, temperature decreasing		150		
t_{PGDH}	PG delay time rising	time from 92% V_{OUT} to 20% of PG(5)		165		µs
t_{PGDL}	PG delay time falling	time from 90% V_{OUT} to 80% of PG(5)		12		

Note:

(1) When the device is connected to external feedback resistors at the FB pin, external resistor tolerances are not included.

(2) $V_{IN} = 1.7$ V for $V_{OUT(NOM)} + V_{DO} < 1.7$ V.

(3) Push-pull version only. The push-pull option is supported only for $V_{OUT} \geq 1.0$ V.

(4) Open-drain version only.

(5) Output overdrive = 10%.

(6) Specifications subject to change without notice.

7. Typical Characteristics

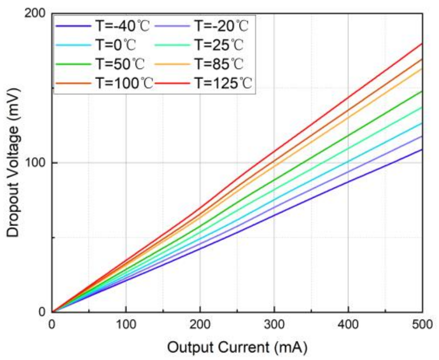


Figure 1. Dropout voltage vs. I_{OUT} at V_{OUT} = 3.3 V

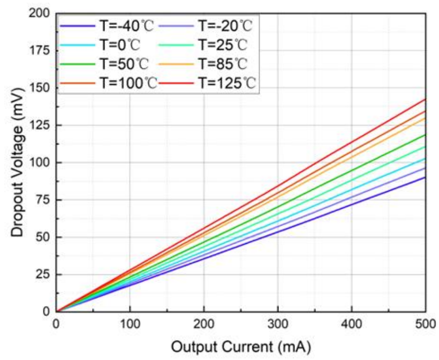
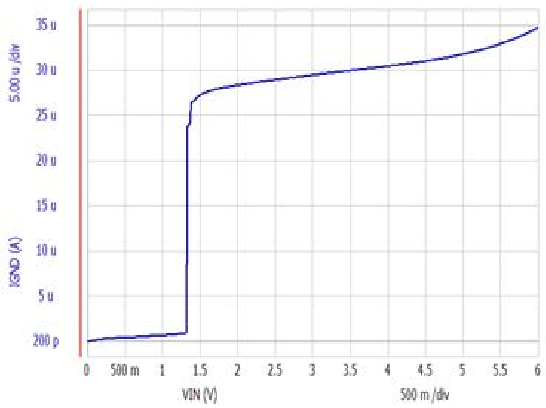
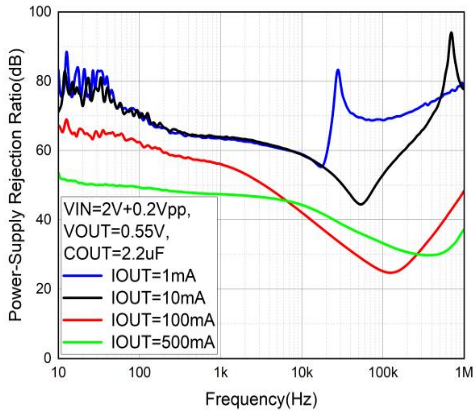


Figure 2. Dropout voltage vs. I_{OUT} at V_{OUT} = 5.5 V



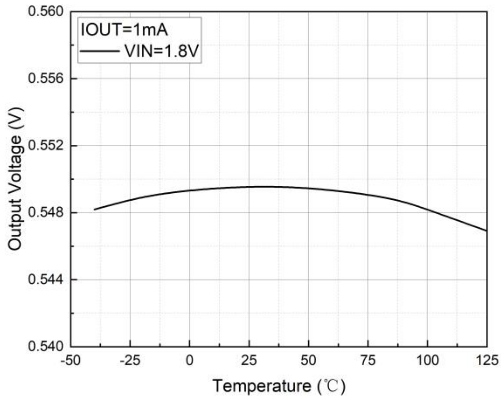
V_{OUT} = 0.55 V, I_{OUT} = 0 mA

Figure 3. I_{GND} vs. V_{IN}



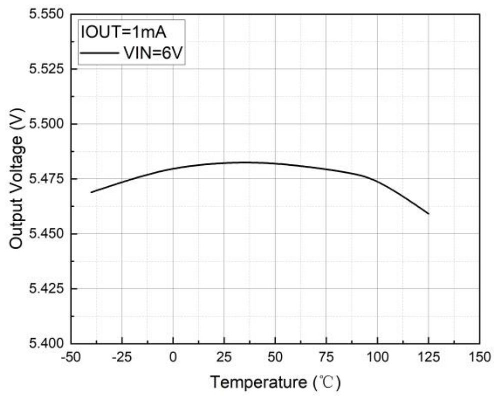
V_{IN} = 2 V, V_{OUT} = 0.55 V, C_{OUT} = 2.2 μF

Figure 4. PSRR vs. Frequency and I_{OUT}



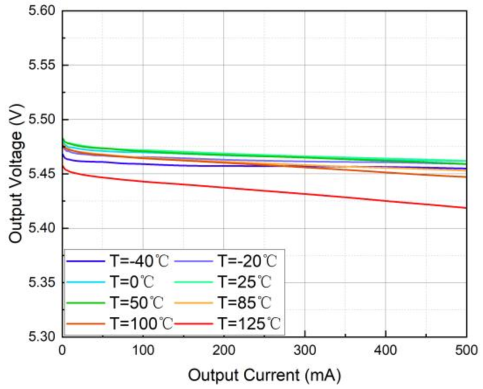
V_{OUT} = 0.55 V, I_{OUT} = 1 mA

Figure 5. Output voltage vs. Temperature



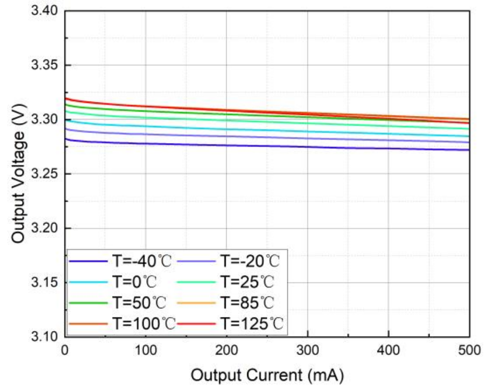
V_{OUT} = 5.5 V, I_{OUT} = 1 mA

Figure 6. Output voltage vs. Temperature



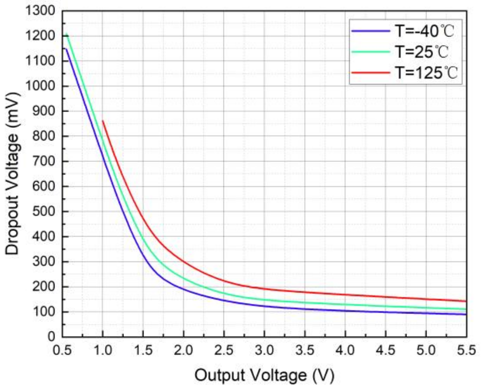
V_{IN} = 6 V

Figure 7. Output voltage vs. Output current



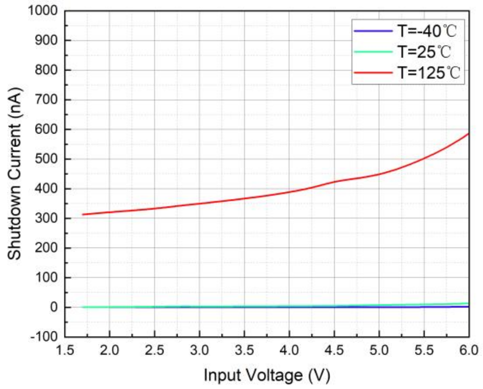
V_{IN} = 3.8 V

Figure 8. Output voltage vs. Output current



I_{OUT} = 500 mA

Figure 9. Dropout voltage vs. Output voltage



V_{EN} = 0 V

Figure 10. Shutdown current vs. Input voltage

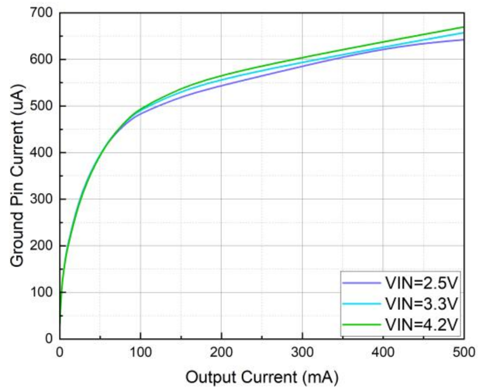
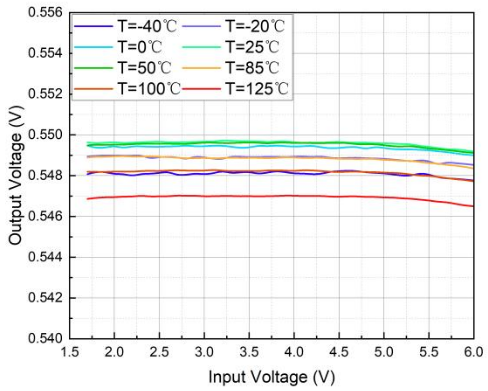
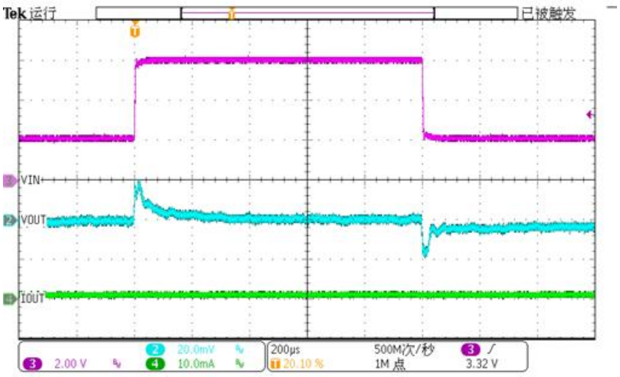


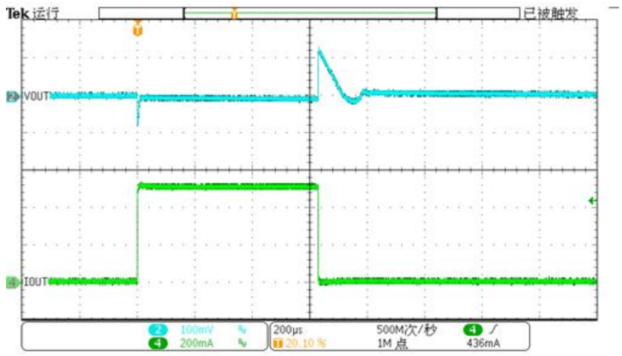
Figure 11. Ground pin current vs. Output current



V_{OUT} = 0.55 V, I_{OUT} = 1 mA

Figure 12. Output voltage vs. Input voltage





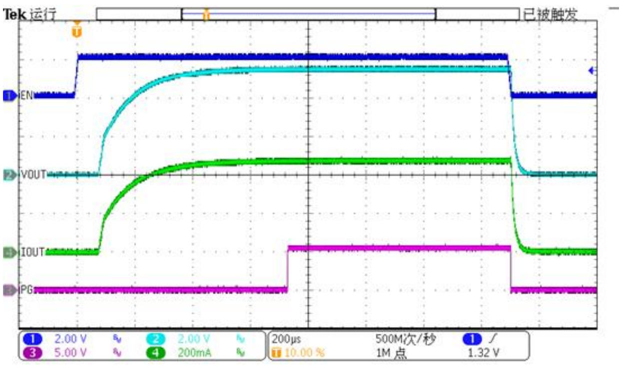
V_{OUT} = 0.55 V, V_{IN} = 2 V <-> 6 V at 1 V/µs,

I_{OUT} = 1 mA

Figure 13. Line transient

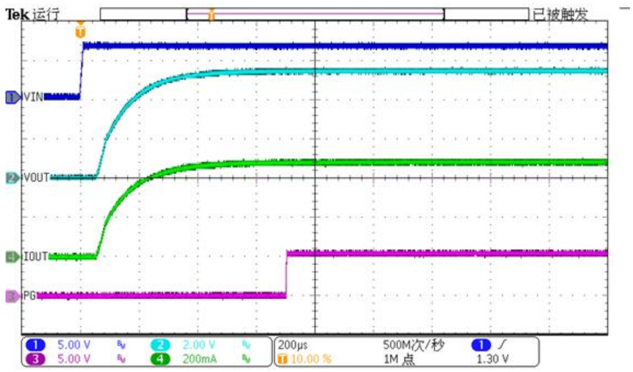
V_{IN} = 6 V, V_{OUT} = 5.5 V, 1 mA <->500 mA at 1 µs

Figure 14. Load transient



V_{IN} = 6 V, V_{OUT} = 5.5 V, I_{OUT} = 500 mA

Figure 15. Start up with EN



V_{IN} = 6 V, V_{OUT} = 5.5 V, I_{OUT} = 500 mA

Figure 16. Power up with VIN

8. Block Diagram

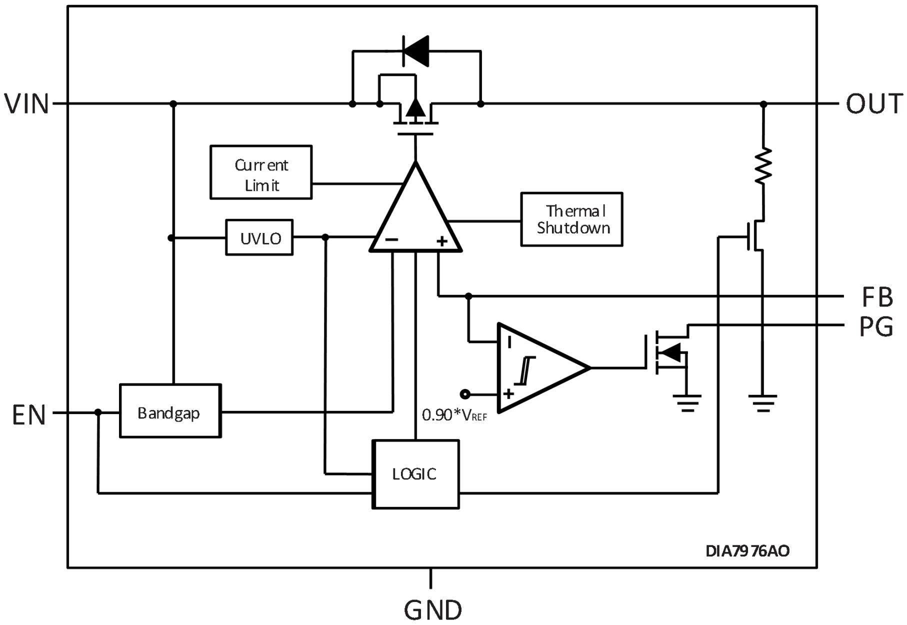


Figure 17. Adjustable version with open-drain power-good

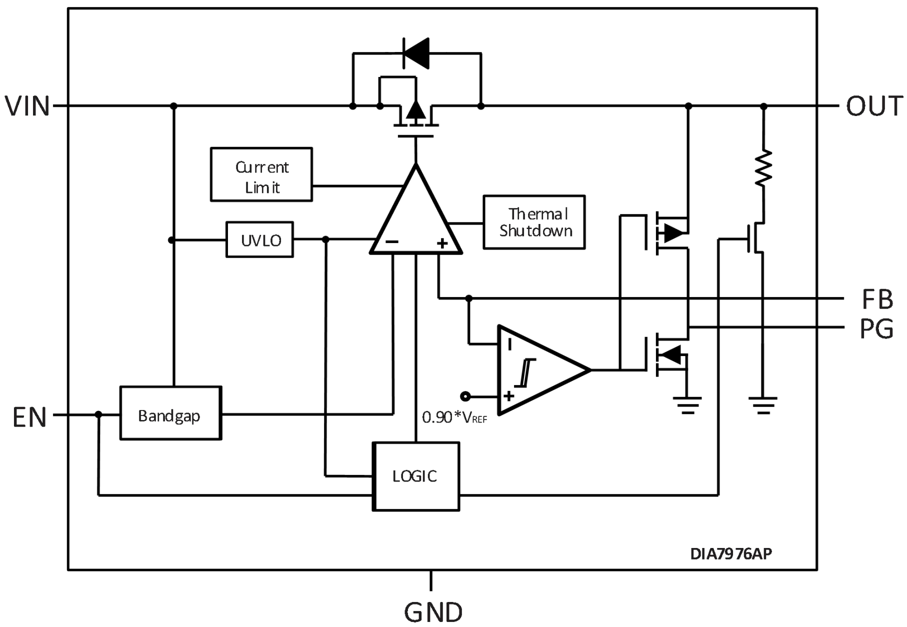


Figure 18. Adjustable version with push-pull power-good

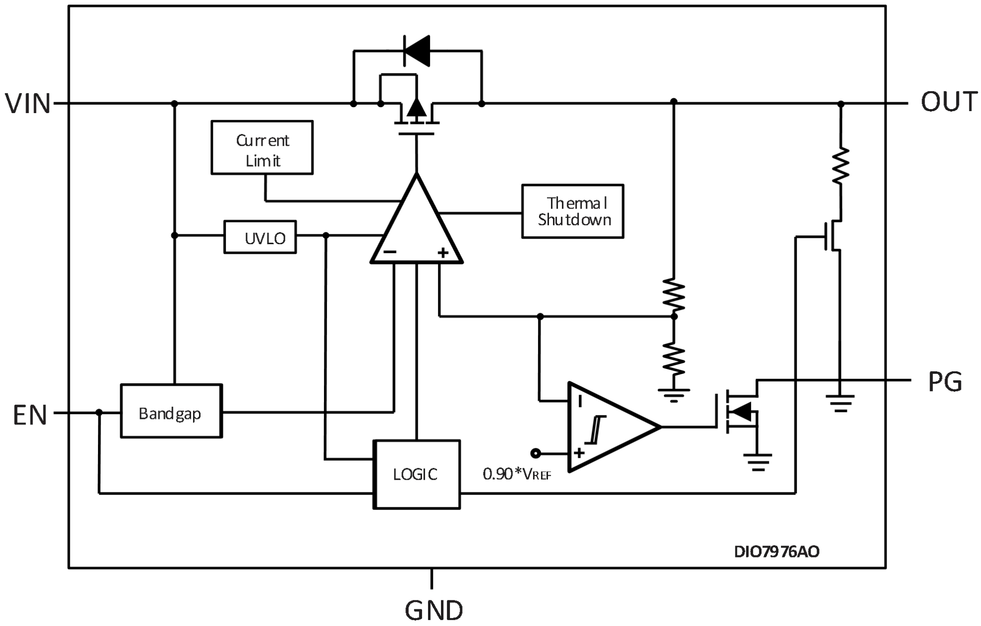


Figure 19. Fixed voltage version with open-drain power-good

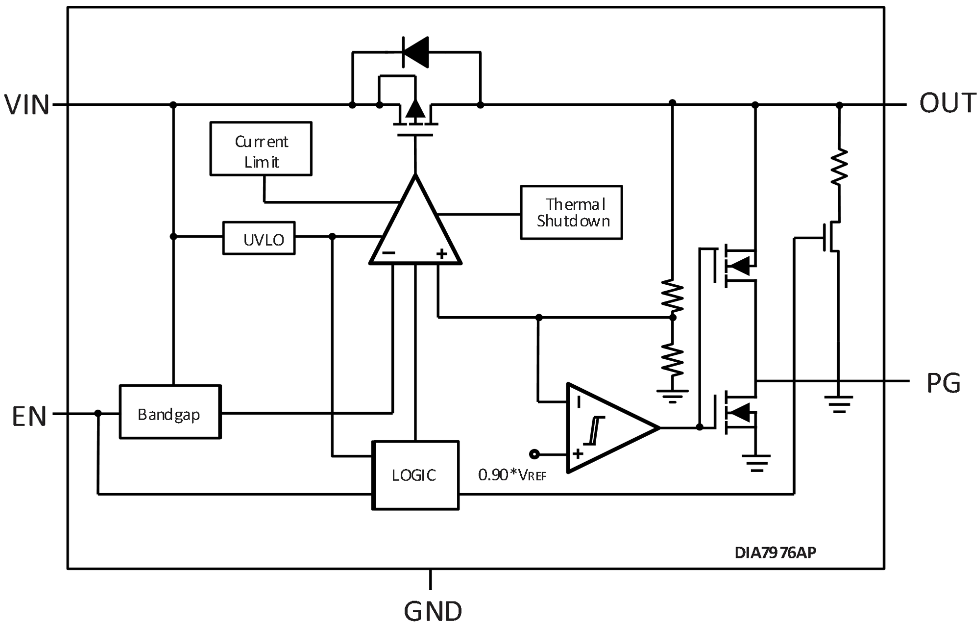


Figure 20. Fixed voltage version with push-pull power-good

9. Function Description

9.1. Overview

The DIA7976 is a low-dropout regulator (LDO) that consumes a low quiescent current and delivers an excellent line and load transient performance. These characteristics, combined with low noise and high PSRR with low dropout voltage, make this device ideal for automotive applications.

This regulator offers short-current limit, shutdown, and thermal protection. The operating junction temperature for this device is -40°C to 150°C.

9.2. Undervoltage lockout (UVLO)

The DIA7976 contains an undervoltage lockout (UVLO) circuit that ensures that the device is functional when the supply voltage is lower than the operational range of the internal circuitry, which disables the output until the input voltage is greater than the rising UVLO voltage (V_{UVLO}). When V_{IN} is less than V_{UVLO}, the output is connected to the ground with a pulldown resistor ($R_{PULLDOWN}$). When the device enters UVLO, the PG output is pulled low.

9.3. Shutdown

The enable pin (EN) is active high. Forcing the EN pin to exceed $V_{EN(HI)}$ will enable the device forcing the EN pin to drop below $V_{EN(LO)}$ will turn off the device. Connect EN to IN when shutdown capability is not required. The PG output pin is pulled low when the device is disabled. The DIA7976 has an internal pulldown MOSFET that connects an $R_{PULLDOWN}$ resistor to the ground when the device is disabled. Output capacitance (C_{OUT}) and the load resistance (R_L) in parallel with the pulldown resistor ($R_{PULLDOWN}$) decide the discharge time after disabling. The equation below calculates the time constant:

$$T = (R_{PULLDOWN} \times R_L)/(R_{PULLDOWN} + R_L) \times C_{OUT} \quad (1)$$

9.4. Current limit

The device is protected during transient high-load current faults or shorting events by an internal current limit circuit. The current limit is a hybrid scheme that transitions from a current-limit scheme to a short-limit scheme at the voltage about 0.3 V. When the output is shorted, the device supplies a typical current called the short-circuit current limit (I_{SC}). In a high-load current fault with the output voltage above 0.3 V, the current-limit scheme limits the output current to I_{CL}. When the voltage drops below 0.3 V, a short-current limit activates that scales back the current as the output voltage approaches GND.

When the device is within the current limit, the output voltage is not regulated. The device begins to heat up when a current limit event occurs, and if a thermal shutdown is triggered, the device turns off. When the device is in current-limit, the pass transistor dissipates power [(V_{IN} - V_{OUT}) × I_{CL}]. When the device output is shorted and the output is below 0.3 V, the pass transistor dissipates power [(V_{IN} - V_{OUT}) × I_{SC}]. The internal thermal shutdown circuit turns the device back on after the device cools down. The device cycles between the current limit and thermal shutdown if the output current fault condition continues.

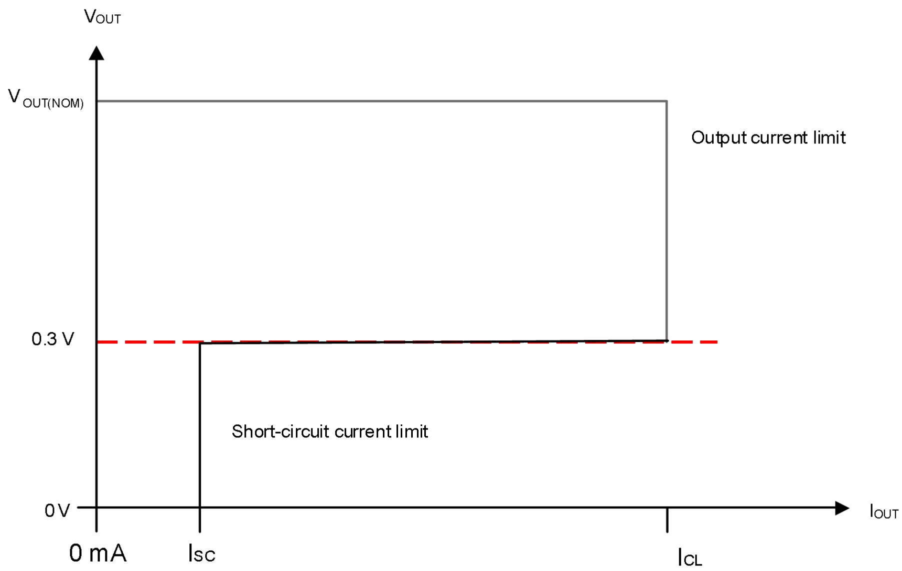


Figure 21. Current limit

9.5. Power-good function (PG)

To indicate the status of the output voltage, the power-good circuit monitors the voltage at the FB pin. If the output voltage is below PG_{LTH} (PG low threshold), the PG pin open-drain output activates and pulls the PG pin close to GND. If the output voltage is higher than PG_{HTH} (PG high threshold), then the PG pin will be high impedance.

A pull-up resistor is needed for the open-drain output. Any downstream device can receive power-good as a logic signal for sequencing through attaching a pull-up resistor to an external supply. Furthermore, the open-drain output may be linked to other open-drain outputs to implement AND logic. Check to see if the external pull-up supply voltage produces a valid logic signal for the receiving device. It is advised to use a pull-up resistor ranging from 10 kΩ to 100 kΩ. While for push-pull PG option, the pull-up resistor is not needed. The push-pull PG option has a high logic signal correlating with the output voltage. The push-pull option is only valid for $V_{OUT} \geq 1$ V and please do not link the push-pull output to other logic outputs.

If C_{FF} (feed-forward capacitor) is used, the time constant for the LDO start-up is increased while the time constant for PG output remains unchanged, which may leading to an invalid PG output. To avoid the situation, DIOO recommend to ensure the time constant of both LDO start-up and PG output match by adding a capacitor in parallel with the power-good pull-up resistor.

To make the PG valid, the device should operate above the minimum V_{IN} and PG is asserted, regardless of the output voltage state when V_{IN} is below V_{UVLO} minus $V_{UVLO,\ HYST}$. When V_{IN} falls below about 0.8 V, power-good device turns on and the power-good output pulls high because of no enough gate drive voltage to keep the open-drain. This effect can be minimized by connecting the PG pull-up resistor to the output voltage.

9.6. Thermal shutdown

The DIA7976 has a thermal shutdown protection feature that disables the device when the junction temperature rises to approximately 165°C. This feature helps to reduce the power dissipated by the device, allowing it to cool down. When the temperature falls to approximately 150°C, the output circuitry is re-enabled. However, depending on various factors like power dissipation, thermal resistance, and ambient temperature, the thermal protection circuit may turn on and off repeatedly. This cycling helps to limit regulator dissipation and protect the regulator from overheating damage. Activating the thermal shutdown feature usually indicates excessive power dissipation as a result of the product of the (V_{IN} - V_{OUT}) voltage and the load current. For reliable operation, limit junction temperature to 150°C maximum. To estimate the margin of safety in a complete design, increase the ambient temperature until the thermal protection is triggered, use worst-case loads and signal conditions.

The DIA7976 has a built-in protection circuit that guards against overload conditions. However, it's not meant to be triggered during regular operation. Running the device continuously into thermal shutdown can harm the device's reliability.

9.7. Device functional modes

The Device functional modes table shows the conditions that lead to the different modes of operation.

Table 1. Device functional modes

Operating Mode	V_{IN}	V_{EN}	I_{OUT}	T_J
Normal operation	$V_{IN} > V_{OUT(nom)} + V_{DO}$ and $V_{IN} > V_{IN(min)}$	$V_{EN} > V_{EN(HI)}$	$I_{OUT} < I_{OUT(max)}$	$T_J < T_{SD(shutdown)}$
Dropout operation	$V_{IN(min)} < V_{IN} < V_{OUT(nom)} + V_{DO}$	$V_{EN} > V_{EN(HI)}$	$I_{OUT} < I_{OUT(max)}$	$T_J < T_{SD(shutdown)}$
Disabled (any true condition disables the device)	$V_{IN} < V_{UVLO}$	$V_{EN} < V_{EN(LOW)}$	Not applicable	$T_J > T_{SD(shutdown)}$

Note:

(1) See the Electrical Characteristics table for parameter values.

9.8. Dropout operation

If all conditions are met for normal operation but the input voltage is lower than the nominal output voltage plus the specified dropout voltage, the device operates in dropout mode. During dropout mode, the output voltage tracks the input voltage and the transient performance of the device becomes significantly degraded and acts as a switch Line or load transients in dropout can result in large output-voltage deviations.

When the device is in dropout, $V_{IN} < V_{OUT(NOM)} + V_{DO}$, directly after being in a normal regulation state, but not during startup, the pass transistor is driven into the ohmic or triode region. The output voltage can overshoot for a short period while the device pulls the pass transistor back into the linear region when the input voltage returns to a value greater than or equal to the nominal output voltage plus the dropout voltage ($V_{OUT(NOM)} + V_{DO}$).

9.9. Disabled

Shutting down the output of the device will require forcing the voltage of the enable pin to less than the maximum EN pin low-level input voltage. The pass transistor is turned off internal circuits are shutdown, and the output voltage is actively discharged to the ground by an internal discharge circuit from the output to the ground, when the device is disabled.

10. Application Information

Important notice: Validation and testing are the most reliable ways to confirm system functionality. The application information is not part of the specification and is for reference purposes only.

10.1. Application examples

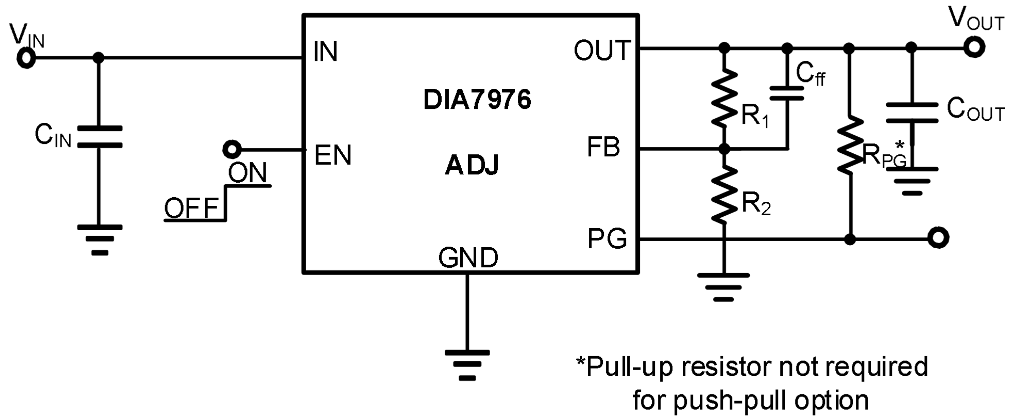


Figure 22. Typical application: adjustable voltage

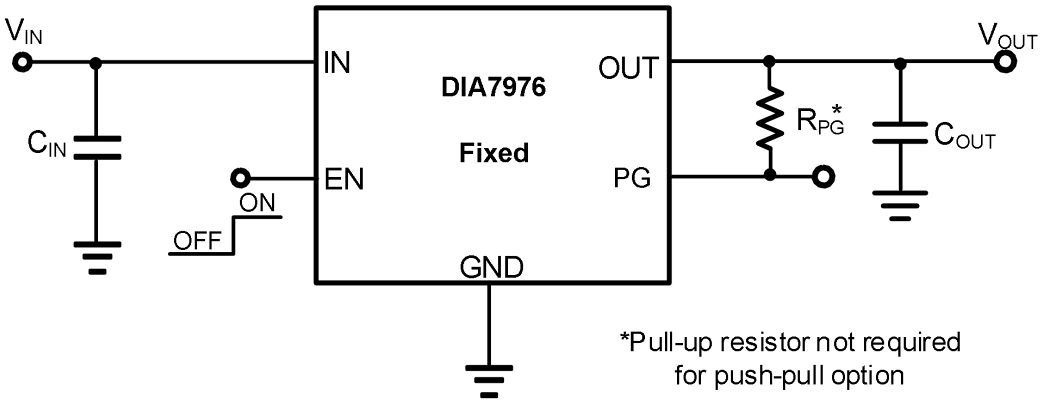


Figure 23. Typical application: fixed voltage

10.2. Adjustable device feedback resistors

Figure 22 shows that the output voltage of the DIA7976 can be adjusted from 0.55 V to 5.5 V by using a resistor divider network.

The adjustable version DIA7976 requires external feedback divider resistors to set the output voltage. The feedback divider resistors, R_1 and R_2 set the V_{OUT}, according to the following equation:

$$V_{OUT} = V_{FB} \times (1 + R_1/R_2) \quad (2)$$

Setting the feedback divider current to 100x the FB pin current listed in the Electrical Characteristics table can ignore the FB pin current error term in the V_{OUT} equation, which provides the maximum feedback divider series resistance, as shown in the following equation:

$$R_1 + R_2 \leq V_{OUT} / (I_{FB} \times 100) \quad (3)$$

Table 2. Recommended resistors for DIA7976 (Adjustable version)

V_{OUT} (V)	R_1 (kΩ)	R_2 (kΩ)
0.55	0	Float
1	8.2	10
1.2	18.2	15.4
1.5	21	12.1
1.8	27.4	12
2.5	39	11
3.3	49.9	10
5.5	18	2

10.3. Dropout voltage

A PMOS pass transistor is used to achieve low dropout. The PMOS pass device is in the linear region of operation and the input-to-output resistance is the $R_{DS(ON)}$ of the PMOS pass element when (V_{IN} - V_{OUT}) is less than the dropout voltage (V_{DO}). The PMOS device behaves like a resistor in dropout mode therefore V_{DO} scales approximately with the output current. PSRR and transient response degrade as (V_{IN} - V_{OUT}) approaches dropout operation with any linear regulator.

10.4. Exiting dropout

A ramping input supply causes an LDO to overshoot on start-up, as shown in Figure 24 when the slew rate and voltage levels are in the correct range. Use an enable signal to avoid this condition.

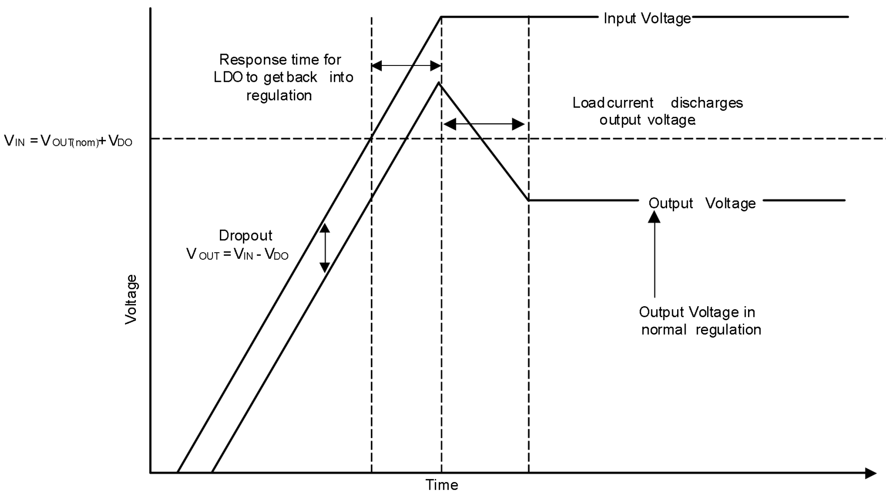
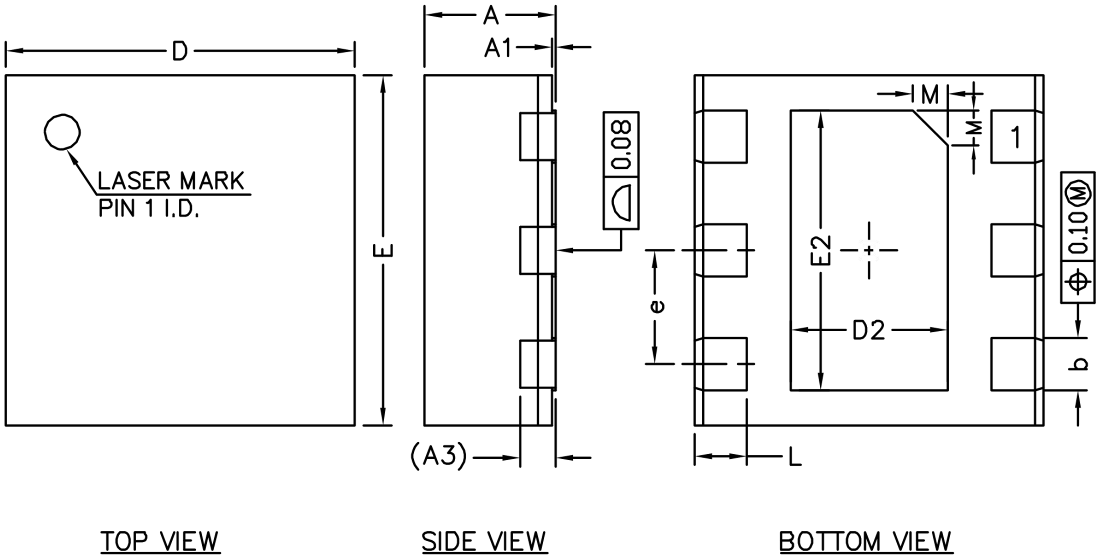


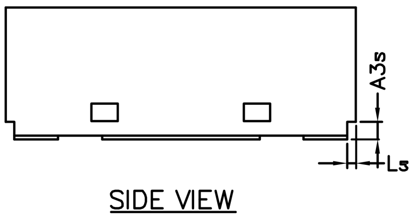
Figure 24. Start-up into dropout

Overshooting on the output of the regulator can be caused by the error amplifier having to drive the gate capacitance of the pass element and bring the gate back to the correct voltage for proper regulation. The gate voltage (V_{GS}) is pulled all the way down to the ground to give the pass device the lowest on-resistance possible when the LDO is placed in dropout. However, the output will overshoot until the loop responds and the output current pulls the output voltage back down into regulation if a line transient occurs when the device is in dropout. Continue to add input capacitance in the system until the transient is slow enough to reduce the overshoot if these transients are not acceptable.

11. Physical Dimensions

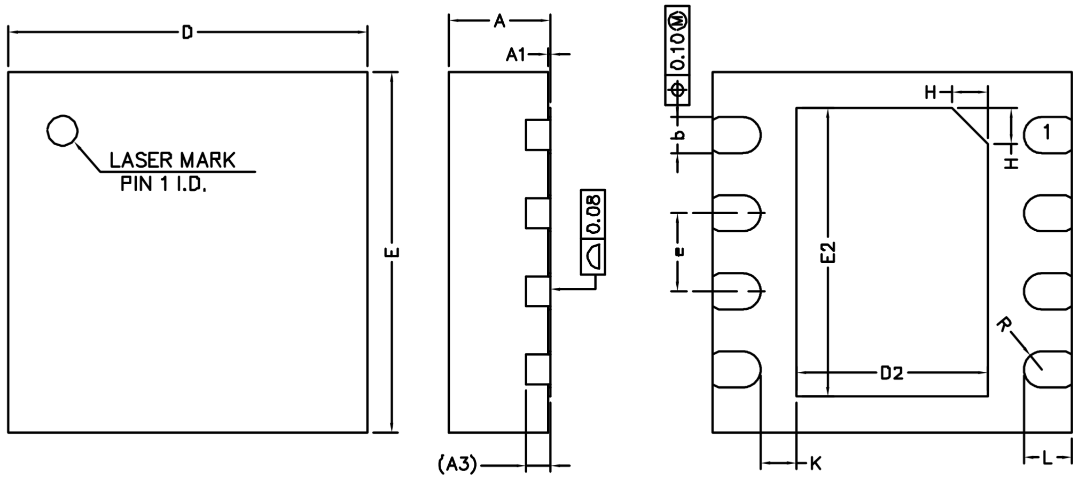
11.1. DFN2*2-6





Common Dimensions (Units of measure = Millimeter)			
Symbol	Min	Nom	Max
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3	0.203 REF		
A3s	0.10	-	-
b	0.25	0.30	0.35
D	1.90	2.00	2.10
E	1.90	2.00	2.10
D2	0.80	0.90	1.00
E2	1.50	1.60	1.70
e	0.55	0.65	0.75
L	0.25	0.30	0.35
Ls	0.05 REF		
M	0.20 REF		

11.2. DFN3*3-8

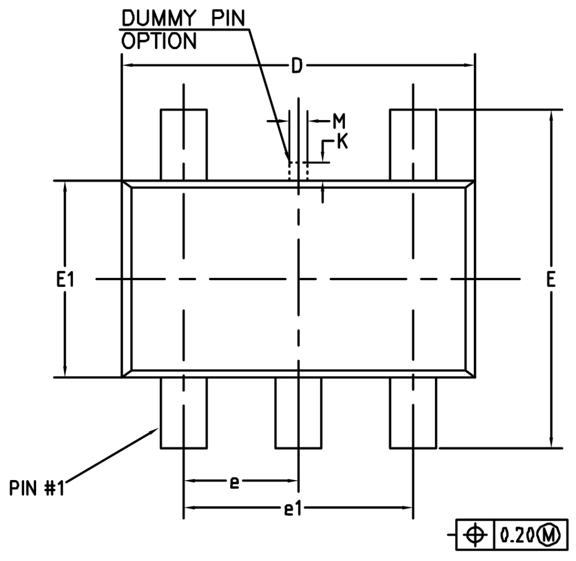


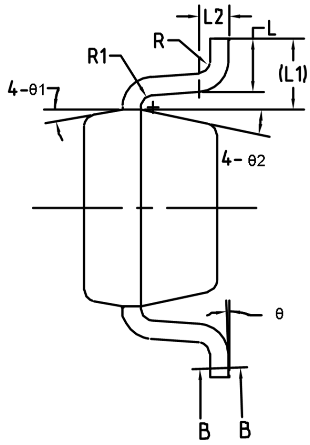
TOP VIEW SIDE VIEW BOTTOM VIEW

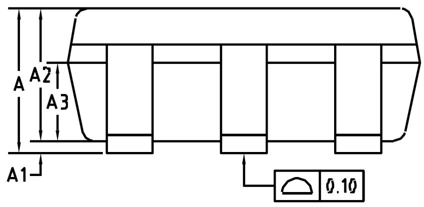
SIDE VIEW

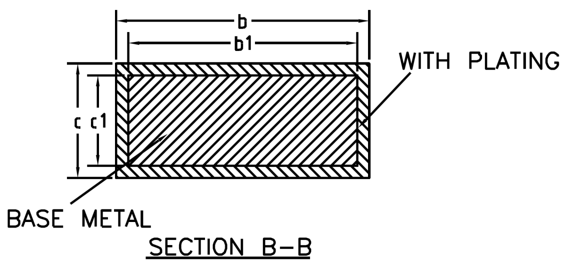
Common Dimensions (Units of measure = Millimeter)			
Symbol	**Min**	**Nom**	**Max**
A	0.80	0.85	0.90
A1	0.00	0.02	0.05
A3	0.203 REF		
b	0.25	0.30	0.35
D	2.90	3.00	3.10
E	2.90	3.00	3.10
D2	1.50	1.60	1.70
E2	2.30	2.40	2.50
e	0.55	0.65	0.75
H	0.30 REF		
K	0.20	0.30	0.40
L	0.30	0.40	0.50
R	0.15 REF		

11.3. SOT23-5









Common Dimensions (Units of measure = Millimeter)			
Symbol	Min	Nom	Max
A	-	-	1.25
A1	0	-	0.15
A2	1.00	1.10	1.20
A3	0.60	0.65	0.70
b	0.36	-	0.45
b1	0.35	0.38	0.41
c	0.14	-	0.20
c1	0.14	0.15	0.16
D	2.826	2.926	3.026
E	2.60	2.80	3.00
E1	1.526	1.626	1.726
e	0.90	0.95	1.00
e1	1.80	1.90	2.00
K	0	-	0.25
L	0.30	0.40	0.60
L1	0.59 REF		
L2	0.25 BSC		
M	0.10	0.15	0.25
R	0.05	-	0.20
R1	0.05	-	0.20
θ	0°	-	8°
θ1	8°	10°	12°
θ2	10°	12°	14°

Disclaimer

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