DIA7865

Automotive 300 mA, High-Voltage, Ultra-Low Quiescent Current, Low-Dropout Regulator

Description

The DIA7865 is a low-dropout linear regulator designed to function with an input voltage range from 3 V to 40 V. With a minimum operation of 3 V, the DIA7865 can function normally during cold-crank and start and stop conditions. The DIA7865 provides an ideal solution for powering microcontrollers (MCUs) and CAN/LIN transceivers in standby systems for its typical quiescent current at no load is only 4 μA.

In always-on systems, low quiescent current (I_Q) is important for power saving and prolonging battery lifetime, especially in automotive battery-connected applications, which must include ultra-low quiescent current.

To match the needs of automotive applications' power supply, a short-circuit and overcurrent protection is included in the device. In addition, to dissipate the heat, a thermally conductive package is placed to ensure the device can function sustainably.

Features

- AEC-Q100 qualified
- Temperature grade 1: -40°C ≤ T_A ≤ 125°C
- Operating output voltage range:
  – Fixed 1.2 V to 5 V output voltage
  – Adjustable 1.2 V to 16 V output voltage
- Low quiescent current: 4 μA (Typ.)
- Shutdown current: 300 nA
- 3 V to 40 V wide V_{IN} input voltage range with up to 45 V transient
- Maximum output current: 300 mA
- ±2% output voltage accuracy
- Typical dropout voltage: 500 mV at 300 mA load current for fixed 5 V output version
- Stable with low equivalent series resistance (0.001 Ω to 5 Ω) ceramic output-stability capacitor (1 μF to 200 μF)
- Packages: DFN2*2-6, EP-MSOP8

Applications

- Battery powered equipment
- Automotive head units
- Telematics control units
- Headlights
- Body control modules

Ordering Information

Part Number	Top Marking	RoHS	T_A	Package	
DIA7865BaaCD6	F5BX	Green	-40 to +125°C	DFN2*2-6	Tape & Reel, 3000
DIA7865BaaXM8	DF5BX	Green	-40 to +125°C	EP-MSOP8	Tape & Reel, 3000
DIA7865BADJCD6	F5BQ	Green	-40 to +125°C	DFN2*2-6	Tape & Reel, 3000
DIA7865BADJXM8	DF5BQ	Green	-40 to +125°C	EP-MSOP8	Tape & Reel, 3000

Output Voltage Options							
Option Code "**aa**"	**12**	**15**	**18**	**25**	**30**	**33**	**50**
Voltage	1.2 V	1.5 V	1.8 V	2.5 V	3.0 V	3.3 V	5.0 V

Marking Definition	
F5BX	F5B: Product code
DF5BX	DF5B: Product code
F5BQ	F5BQ: Product code
DF5BQ	DF5BQ: Product code

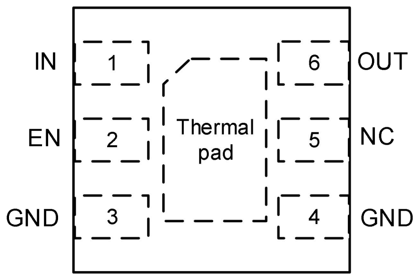
Voltage Code							
Option Code "X"	F	G	H	J	L	M	P
Voltage	1.2 V	1.5 V	1.8 V	2.5 V	3.0 V	3.3 V	5.0 V

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.

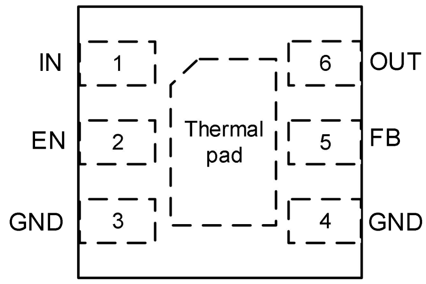
Table of Contents

List of Figures

1. Pin Assignment and Functions

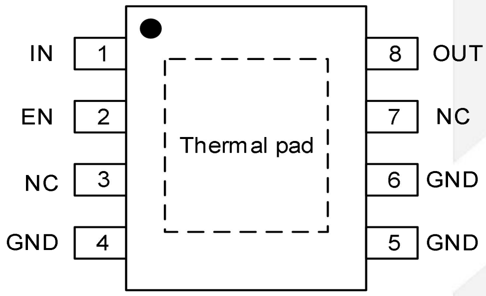


Fixed

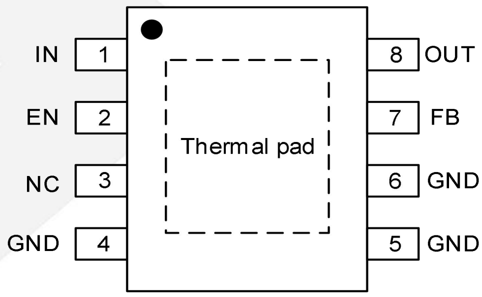


Adjustable

DFN2*2-6 (Top view)



Fixed



Adjustable

EP-MSOP8 (Top view)

Pin Name	Description
OUT	Regulated output voltage. The output should be bypassed with a small 1 µF ceramic capacitor.
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.
EN	Enable pin. This pin has an internal pull-down resistor. A logic low reduces the supply current to less than 1 µA. Connect to logic “High” for normal operation.
GND	Power supply ground.
IN	Input voltage supply pin.
PAD	Connect the thermal pad to a large-area GND plane to improve the thermal performance.
NC	Not internally connected.

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}	Unregulated input[1]	-0.3 to 45	V
V_{EN}	Enable input[1]	-0.3 to V_{IN}	V
V_{OUT}	Regulated output voltage for fixed version	-0.3 to 6	V
	Output voltage for adjustable version	-0.3 to 20	
T_J	Junction temperature	-40 to 150	°C
T_{STG}	Storage temperature	150	°C

Note:

(1) Absolute maximum voltage, withstand 45 V for 200 ms.

3. Recommended Operating Condition

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}	Unregulated input voltage	3 to 40	V
V_{EN}	Enable input voltage	0 to V_{IN}	V
C_{OUT}	Output capacitor requirements[1]	1 to 200	μF
ESR	Output capacitor equivalent series resistance requirements[2]	0.001 to 5	Ω
T_A	Ambient temperature	-40 to 125	°C

Note:

(1) All voltage values are with respect to GND.

(2) Absolute maximum voltage, withstand 45 V for 200 ms.

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.

Model	Condition	Value	Unit
HBM	ESDA/JEDEC JS-001	±2000	V

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	Metric		Value	Unit
$R_{\theta JA}$	Junction-to-ambient thermal resistance	DFN2*2-6	72.8	°C/W
		EP-MSOP8	63.9	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	DFN2*2-6	85.8	°C/W
		EP-MSOP8	50.2	°C/W

6. Electrical Characteristics

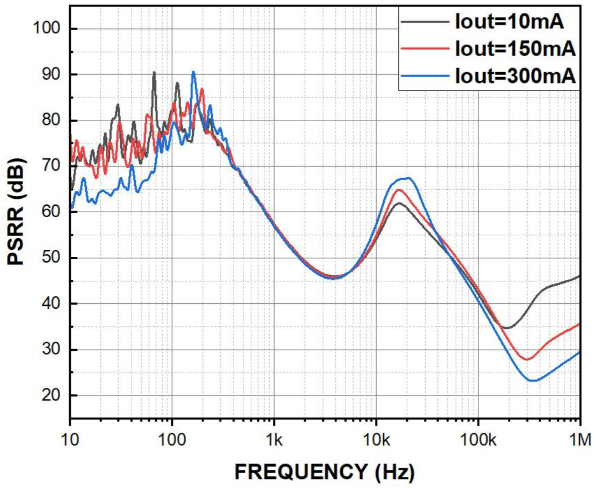
V_{IN} = 14 V, 10 μF ceramic output capacitor, T_A = -40°C to +125°C, unless otherwise noted.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}	Input voltage		3		40	V
I_{SD}	Shutdown current	EN = 0 V		0.3	1	μA
I_Q	Quiescent current	V_{IN} = 6 V to 40 V, EN ≥ 2 V, I_{OUT} = 0 mA		4	8	μA
$V_{IN, UVLO}$	V_{IN} undervoltage detection	Ramp V_{IN} down until the output turns ON			2.9	V
		Hysteresis		200		mV
V_{IL}	Logic-input low level				0.6	V
V_{IH}	Logic-input high level		1.2			V
V_{OUT}	Regulated output	I_{OUT} = 10 mA	–2		2	%
V_{FB}	Reference voltage (adjustable voltage version)		0.64	0.65	0.66	V
$V_{Line\text{-}Reg}$	Line regulation	V_{IN} = 6 V to 40 V, I_{OUT} = 10 mA			10	mV
$V_{Load\text{-}Reg}$	Load regulation	V_{IN} = 14 V, I_{OUT} =1 mA to 300 mA			10	mV
$V_{Dropout}$	Dropout voltage	I_{OUT} = 300 mA, V_{OUT} = 5 V	280	500	950	mV
		I_{OUT} = 200 mA, V_{OUT} = 5 V	180	310	630	
		I_{OUT} = 100 mA, V_{OUT} = 5 V	100	160	315	
		I_{OUT} = 300 mA, V_{OUT} = 3.3 V	300	525	1030	
		I_{OUT} = 200 mA, V_{OUT} = 3.3 V	210	350	715	
		I_{OUT} = 100 mA, V_{OUT} = 3.3 V	100	175	350	
I_{OUT}	Output current	V_{OUT} in regulation	0		300	mA
I_{CL}	Output current limit	V_{OUT} short to 90% × V_{OUT}	310		800	mA
PSRR	Power-supply ripple rejection	$V_{(Ripple)}$ = 0.2 V_{PP}, I_{OUT} = 10 mA, frequency = 100 Hz, C_{OUT} = 2.2 μF		60		dB
$T_{(SD)}$	Junction shutdown temperature			160		°C
$T_{(HYST)}$	Hysteresis of thermal shutdown			40		°C

Note:

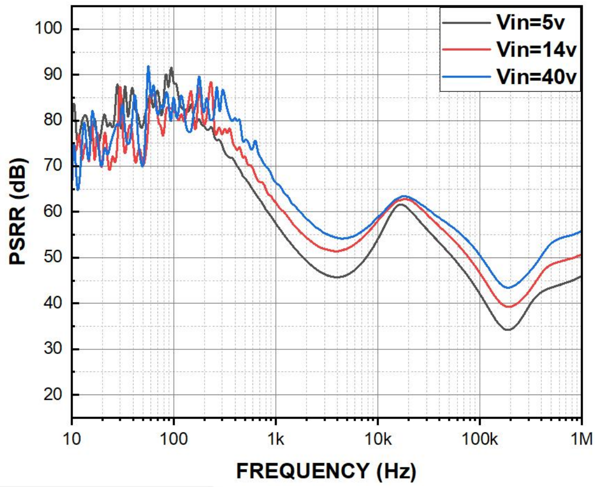
(1) Specifications subject to change without notice.

7. Typical Characteristics



V_{IN} = 5 V, V_{OUT} = 3.3 V, C_{OUT} = 1 μF

Figure 1. PSRR vs. Output and I_L



V_{OUT} = 3.3 V, I_L = 10 mA, C_{OUT} = 1 μF

Figure 2. PSRR vs. Frequency

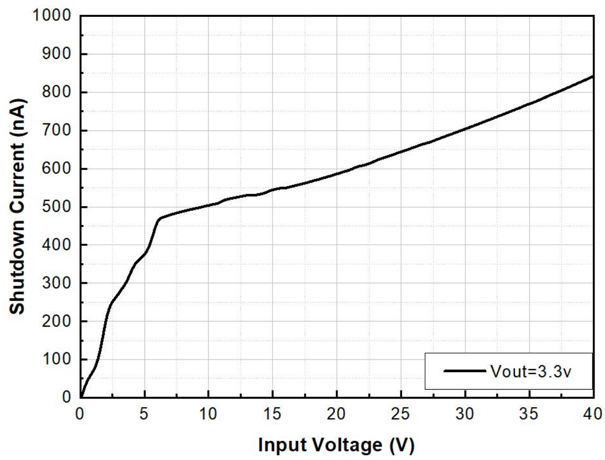


Figure 3. Shutdown current vs. Input voltage

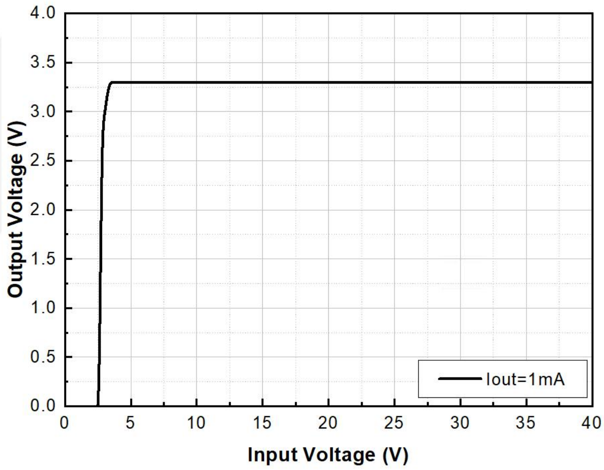


Figure 4. Output voltage vs. Input voltage at V_{OUT} = 3.3 V

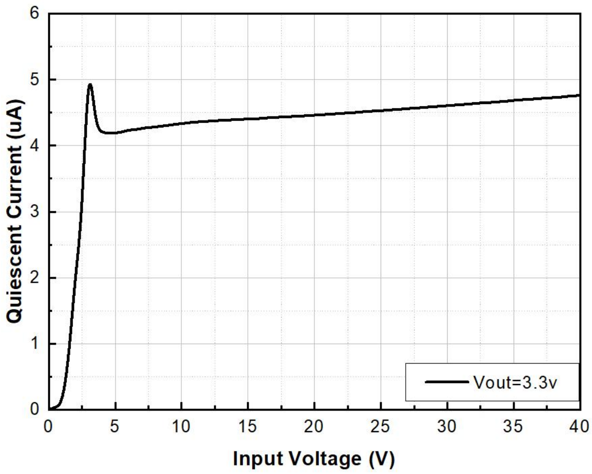


Figure 5. Quiescent current vs. Input voltage

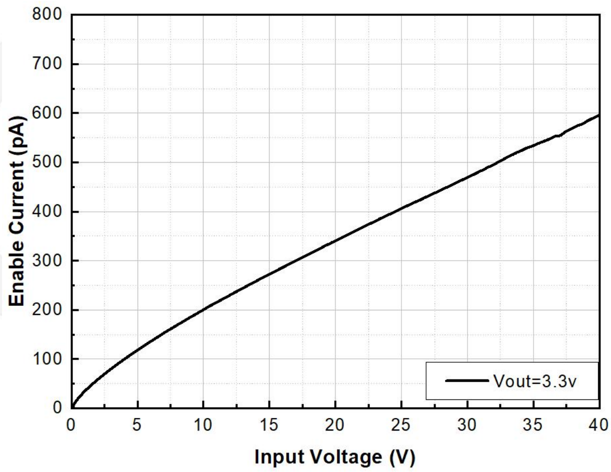
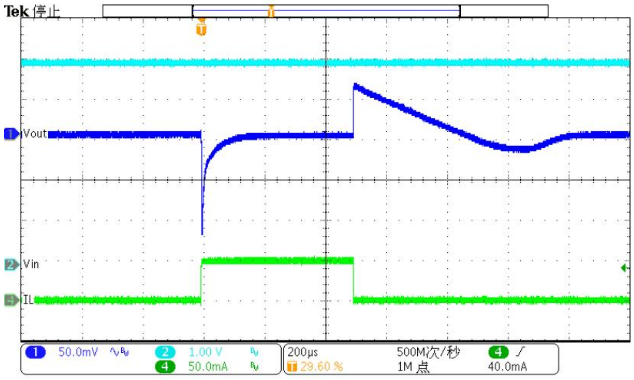


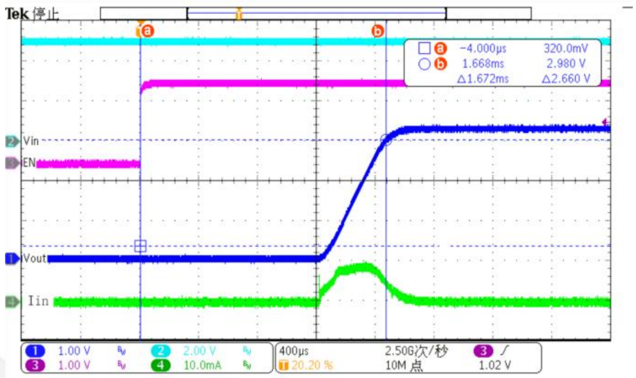
Figure 6. Enable current vs. Input voltage



$V_{IN} = V_{EN} = 5$ V, $V_{OUT} = 3.3$ V, $C_{OUT} = 1$ μF,

0.1 mA to 50 mA, edge speed at 1 μs

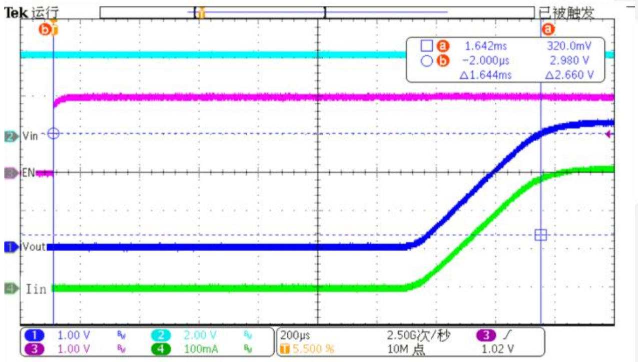
Figure 7. Load transient



$V_{IN} = 4.3$ V, $V_{EN} = 2$ V, $V_{OUT} = 3.3$ V,

$C_{IN} = C_{OUT} = 1$ μF, $I_L = 0$ mA

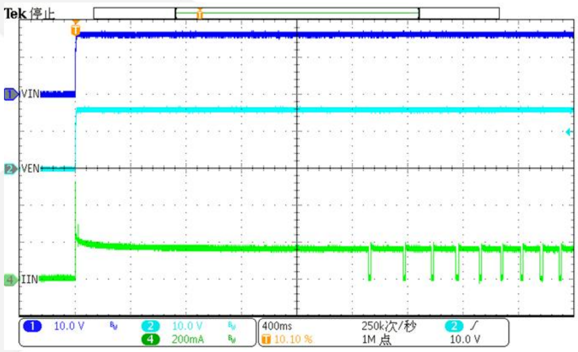
Figure 8. Turn-on time



$V_{IN} = 4.3$ V, $V_{EN} = 2$ V, $V_{OUT} = 3.3$ V,

$C_{IN} = C_{OUT} = 1$ μF, $I_L = 300$ mA

Figure 9. Turn-on time



$V_{IN} = V_{EN} = 16$ V

Figure 10. Short circuit start

8. Block Diagram

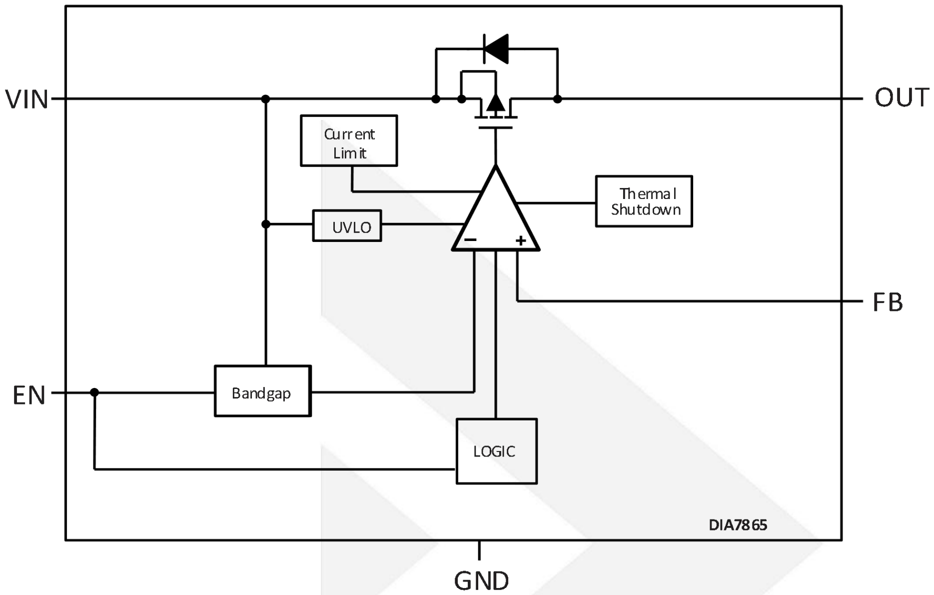


Figure 11. Block diagram - adjustable version

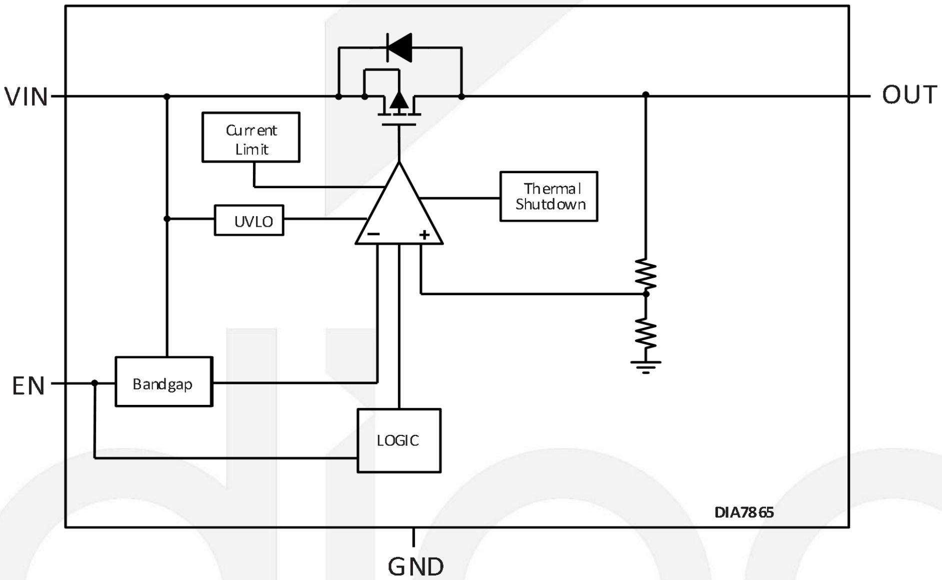


Figure 12. Block diagram - fixed version

9. Function Description

The DIA7865 is a low-dropout linear regulator designed to function with an input voltage range from 3 V to 40 V and provides 45 V load dump protection. The typical quiescent current of the standby system at no load is only 4 μA, which is designed for the automotive always-on application.

9.1. Device enable (EN)

The device can be enabled and disabled by the EN pin. The EN pin is a high-voltage tolerant pin. A high input turns the regulation on and activates the device. To enable and disable the device, connect this pin to an external microcontroller or a digital circuit, or connect to the IN pin for self-bias applications.

9.2. Undervoltage shutdown

The DIA7865 will be shut down if the input voltage (V_{IN}) falls below an internal UVLO threshold (V_{UVLO}). In the event that the input voltage drops below UVLO threshold and recovers, as soon as the voltage returns to the proper range, the regulator shuts down and powers up with a normal power-up sequence. Ensure that the regulator does not latch into an unknown state during low-input-voltage conditions. The regulator shuts down and powers up with a normal power-up sequence when the input voltage is above the required level.

9.3. Thermal shutdown

The DIA7865 is protected by a thermal shutdown (TSD) circuit from overheating. The junction temperature exceeding the TSD trip point causes the output to turn off, and the output will turn on again when the junction temperature falls below the TSD trip point.

9.4. Operation with V_{IN} lower than 3 V

The DIA7865 can operate with input voltages above 3 V and at lower input voltages, the maximum UVLO voltage is 2.9 V, and the device does not operate at input voltages below the actual UVLO voltage.

9.5. Operation with V_{IN} higher than 3 V

When V_{IN} is higher than the output set value plus the device dropout voltage and higher than 3 V, V_{OUT} is equal to the set value. Otherwise, V_{OUT} is equal to V_{IN} minus the dropout voltage.

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

The DIA7865 is a low-dropout linear regulator designed to function with an input-voltage range from 3 V to 40 V with a 45 V load dump protection.

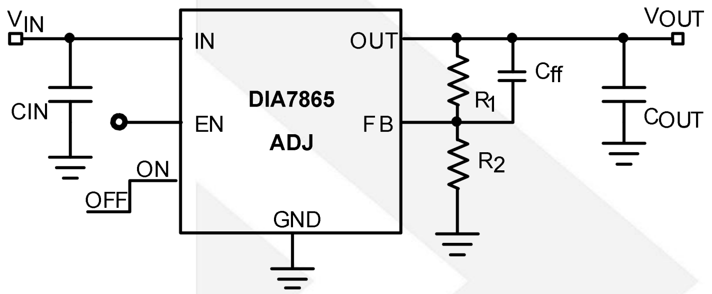


Figure 13. Typical application - adjustable version

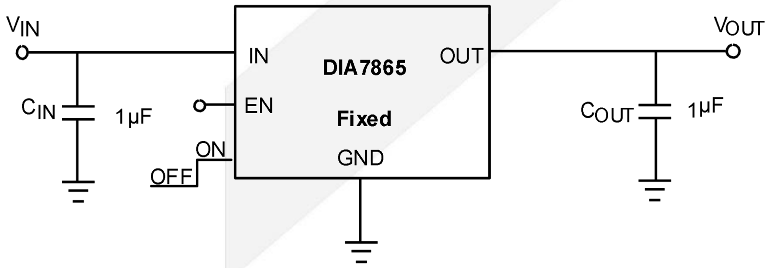


Figure 14. Typical application - fixed version

10.2. Detailed design procedure

To begin the design process, determine the input and output voltage range and output current.

10.3. Input capacitor

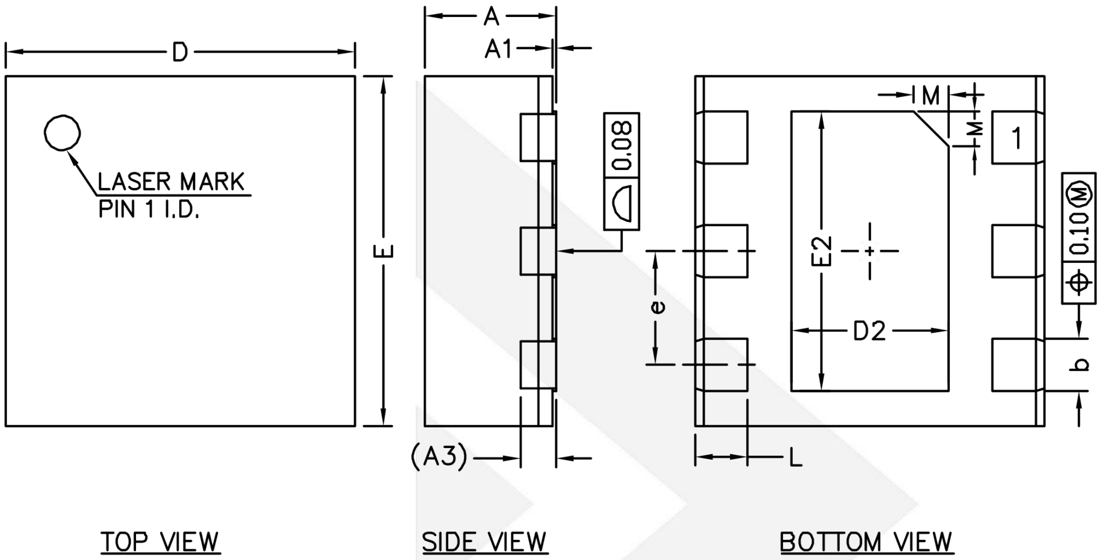
The voltage rating of the input capacitor must be greater than the maximum input voltage. An input capacitor is not required for stability. A good analog design practice is to connect a 10 μF to 22 μF capacitor from IN to GND.

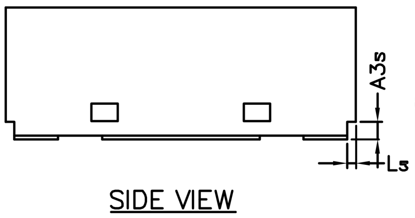
10.4. Output capacitor

The voltage rating of the output capacitor must be greater than the maximum output voltage. To better endure the stability of the DIA7865, an output capacitor with a value in the range from 1 μF to 200 μF and with an equivalent series resistance range between 0.001 Ω and 5 Ω is required. To improve the load transient response, select a ceramic capacitor with low equivalent series resistance.

11. Physical Dimensions

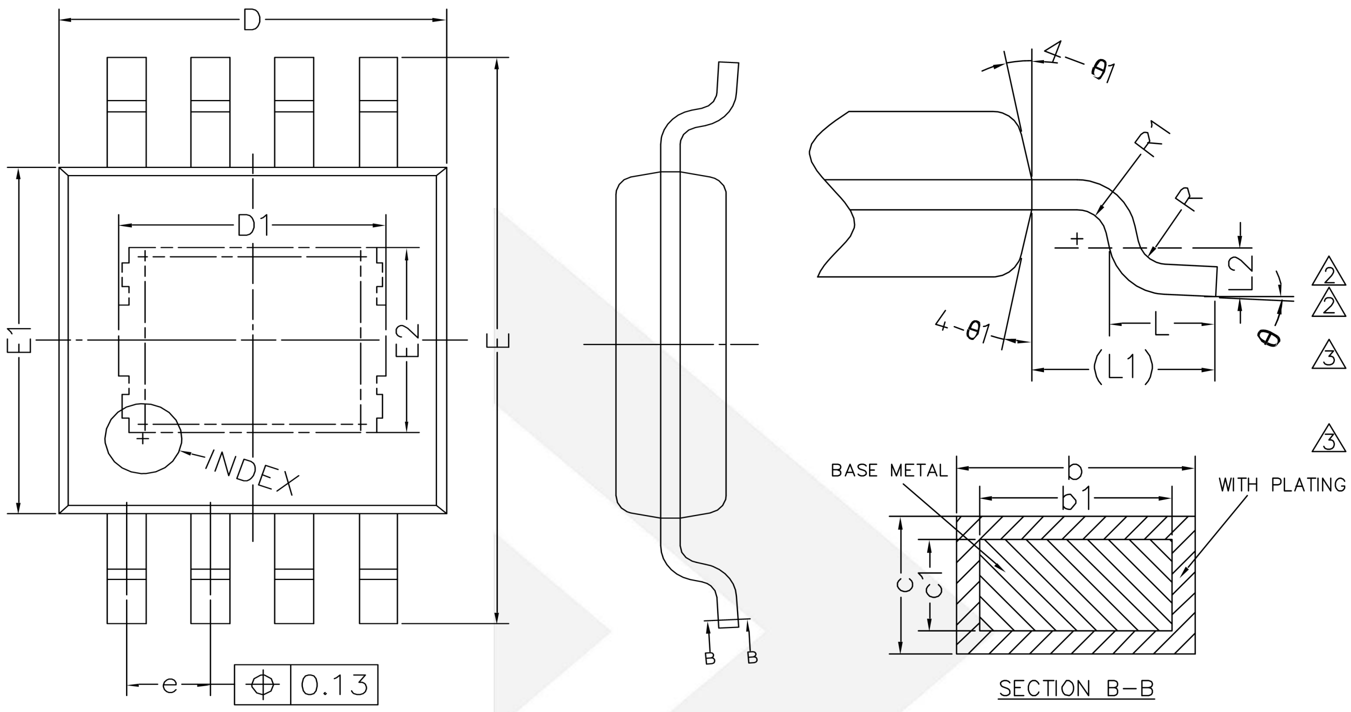
11.1. Physical Dimensions: DFN2*2-6

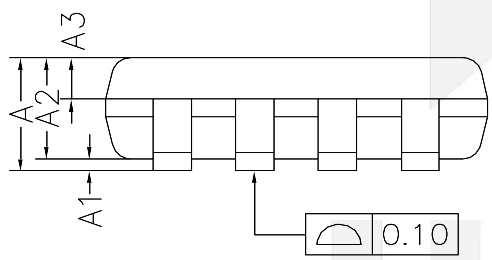




Common Dimensions (Units of Measure = Millimeter)			
Symbol	Min	Nom	Max
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3	0.203 REF		
A3s	0.10	-	-
b	0.25	0.30	0.35
D	1.90	2.00	2.10
E	1.90	2.00	2.10
D2	0.80	0.90	1.00
E2	1.50	1.60	1.70
e	0.55	0.65	0.75
L	0.25	0.30	0.35
Ls	0.05 REF		
M	0.20 REF		

11.2. Physical Dimensions: EP-MSOP8





Common Dimensions (Units of Measure = Millimeter)			
Symbol	Min	Nom	Max
A	-	-	1.10
A1	0.05	0.10	0.15
A2	0.75	0.85	0.95
A3	0.30	0.35	0.40
b	0.25	-	0.38
b1	0.24	0.30	0.33
c	0.13	-	0.20
c1	0.13	0.15	0.16
D	2.90	3.00	3.10
D1	1.92	2.07	2.22
E	4.75	4.90	5.05
E1	2.90	3.00	3.10
E2	1.45	1.60	1.75
e	0.55	0.65	0.75
L	0.40	0.55	0.70
L1	0.95 REF		
L2	0.25 BSC		
R	0.07	-	-
R1	0.07	-	-
Θ	0°	-	8°
Θ1	9°	12°	15°

Disclaimer

This specification and information contained herein are provided on an "AS IS" basis and WITH ALL FAULTS. All product specifications, statements, information, and data (collectively, the "Information") in this datasheet or made available on the website of www.dioo.com are subject to change without notice. The customer is responsible for checking and verifying the extent to which the Information contained in this publication is applicable to his/her application. All Information given herein is believed to be accurate and reliable, but it is presented without guarantee, warranty, or responsibility of any kind, express or implied.