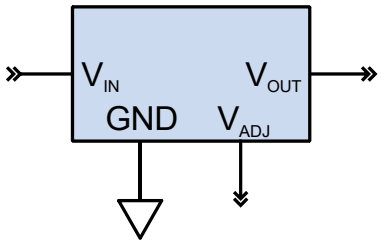
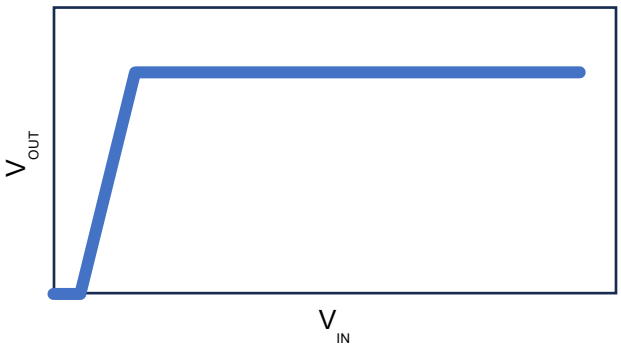
DC00x-Series High Temperature High Input Voltage Regulators

Block Diagram



Transfer Function



Features

- 3.3 V and 5 V regulated output versions
- Input voltage to 36 V (maximum rating 45 V)
- 175°C operating temperature
- Low quiescent current (0.9 mA)
- Reverse input voltage protection
- Excellent immunity to load transients and ESD
- 1.1 x 1.8 mm WLCSP and 2.5 x 2.5 mm DFN6 versions
- 22.5 FIT per billion device hours

Applications

- Industrial sensors and controls
- Instrumentation
- Powering high-temperature analog circuitry
- High-temperature voltage references

Description

DC-Series voltage regulators are designed for harsh, noisy environments where immunity to large voltage transients and high input voltages are required.

These fixed-output regulators protect sensitive electronic components while providing a stable regulated supply. They are rated for high temperature operation (up to 175°C), and high input operating voltage (up to 36 V).

No external components—not even bypass capacitors—are required for full operation.

The low-profile DFN6 package features an exposed die-attach pad for direct heat sinking to the circuit board. Ultraminiature wafer-level, chip-scale package (WLCSP) versions have a dense network of solder bumps for optimal heatsinking and miniaturization.

Absolute Maximum Ratings*

Parameter	Symbol	Min.	Typical	Max.	Units
Operating supply voltage	V_{CC}	0		45	Volts
Supply voltage	V_{CC}	−60		45	Volts
Output current				25	mA
Operating temperature	T_{min}, T_{max}		−40	175	°C
Junction temperature			−65	175	°C
ESD (Human Body Model)[1]				2000	Volts
Voltage from sensor connections to center pad				63	Volts DC

*Stresses beyond those listed under "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 under "Electrical characteristics" is not implied.

Electrical Characteristics

(V_{out} + 1.2 < V_{in} <36 V; −40°C to 175°C, unless otherwise noted)

Parameter	Symbol	Min.	Typical	Max.	Units	Test Conditions
Input voltage	V_{in}	V_{out} + 1.2		36	V	
Dropout voltage	$V_{in} - V_{out}$		1.2		V	
Output voltage DC001 DC002 DC003 DC004	V_{out}	 3.0 4.5 4.5 4.75	 3.3 5 5 5	 3.6 5.5 5.25 5.25	V	
Output current	I_{out}			20	mA	
Quiescent current	I_Q		500	900	µA	V_{in} = 36 V
Line regulation	$\Delta V_{out} / \Delta V_{in}$		75	100	mV	7 ≤ V_{in} ≤ 36 V
Load regulation	$\Delta V_{out} / \Delta I_{out}$		20	30	mV	0 ≤ I_{out} ≤ 20 mA
Ripple rejection DC001 DC002 DC003 DC004	$\Delta V_{in} / \Delta V_{out}$	 50 47 47 47	 52 49 49 49		dB	 V_{in} = 10 VDC + 800 mV_{PP} 120 Hz

Thermal Specifications

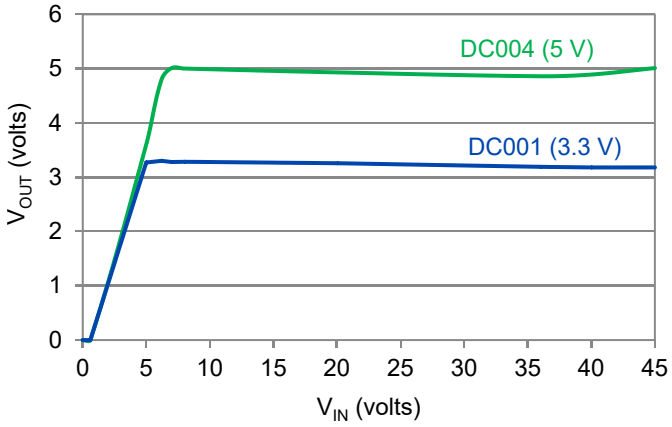
Parameter	Symbol	Min.	Typical	Max.	Units
Junction–ambient thermal resistance[2] DFN6	θ_{JA}		 320		°C/W
Power dissipation DFN6	P_D		 500		mW

Notes to all specifications:

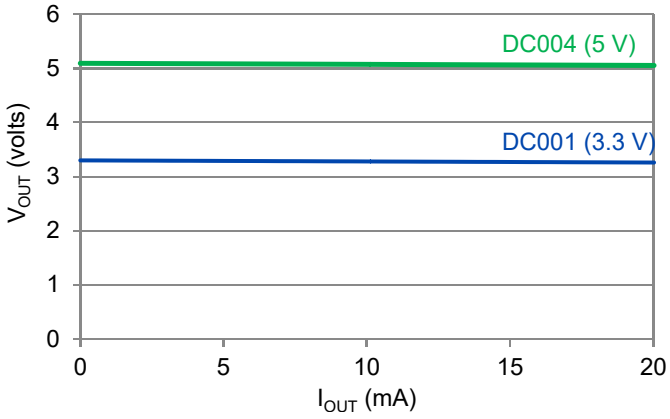
1. Human Body Model (HBM) per JESD22-A114.
2. Measured per JESD51 with ground pad not connected to circuit board. Soldering the package to a PCB, including the die attach paddle, improves temperature performance substantially. The input voltage and output current are limited by thermal power dissipation at the package.

Typical Performance Data

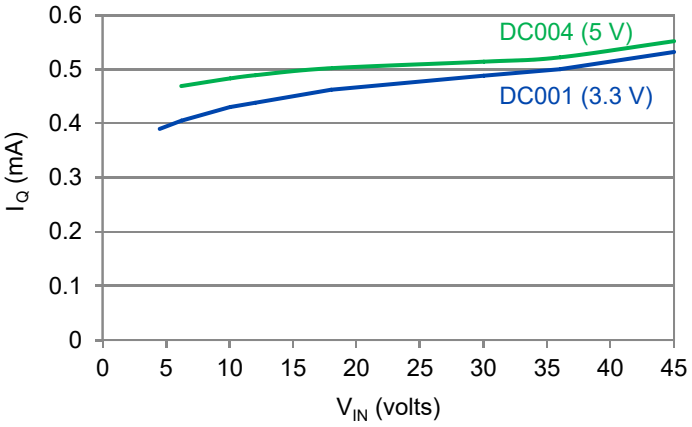
DC00x Line Regulation
(25ºC; I_{OUT} = 20 mA)



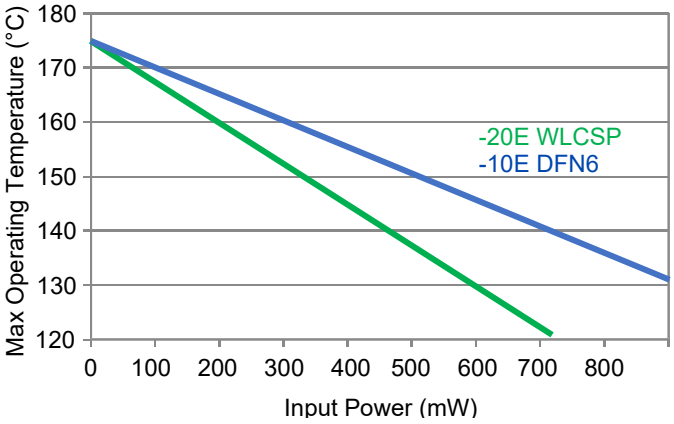
DC00x Load Regulation
(25ºC; V_{IN} = 10 V)



DC00x Quiescent Current



DC00x Operating Temperature Derating



Application Circuits

Variable Output Voltage with Resistors

A single resistor on the V_{ADJ} connection (available in WLCSP versions) can be used to set the output voltage or create a variable output:

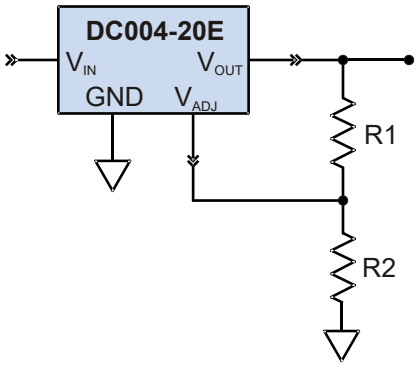


Fig. 1. Variable output voltage with external resistors.

R1 decreases the output voltage and R2 increases the output voltage.

The output voltage is: $V_{OUT} = 1.25 (R_{OUT}/R_{GND} + 1)$

Where:

1.25 V is the DC00x internal bandgap reference voltage;
For the DC004, R_{OUT} = R1 || 14.85 kΩ; R_{GND}= R2 || 4.95 kΩ

The output must be in the range of 2.2 to 8.5 volts.

Recommended resistor values for common voltages other than the fixed voltages are listed in the following table:

Output Voltage	Regulator Part	R1	R2
3.3 V	DC004-20E	18.1 kΩ	-
6 V	DC004-20E	-	18.7 kΩ
6.2 V	DC004-20E	-	15.4 kΩ
8 V	DC004-20E	-	6.34 kΩ

Table 1. External resistor values for various output voltages.

Increased Output Voltage with a Zener Diode

A Zener diode can be placed in series with the ground pin to increase the output voltage. This approach works beyond the 8-volt maximum with external resistor does not require parts with a V_{ADJ} pads:

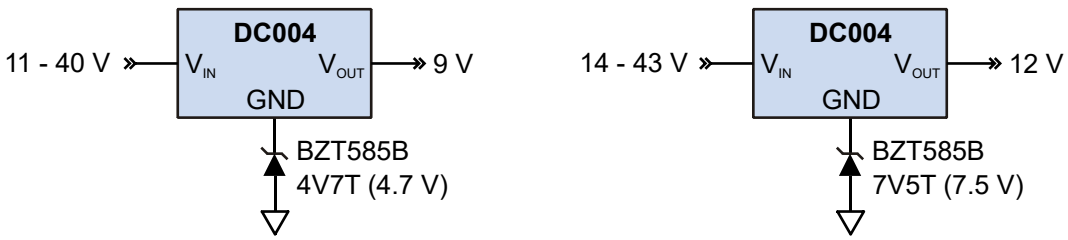


Fig. 2. Increased output voltage with a Zener diode.

4.7 V and 7.5 V Zener diodes are used in the examples above rather than 4 V and 7 V because the diode is biased by the regulator's quiescent current, which is significantly less than the diode's test current.

Trimming the Output Voltage

The WLCSP versions can be trimmed with a potentiometer. The fixed resistors keep the output centered around its nominal voltage:

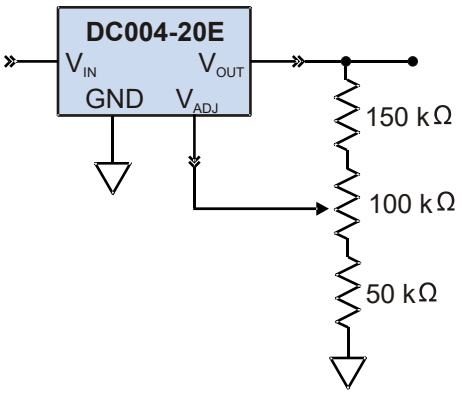


Fig. 3. Trimmed output voltages.

Constant Current Source

A DC00x regulator can be configured as a constant current source with a single external resistor. In this example, powering the AAH00x bridge sensor with constant current provides better temperature stability than powering with constant voltage:

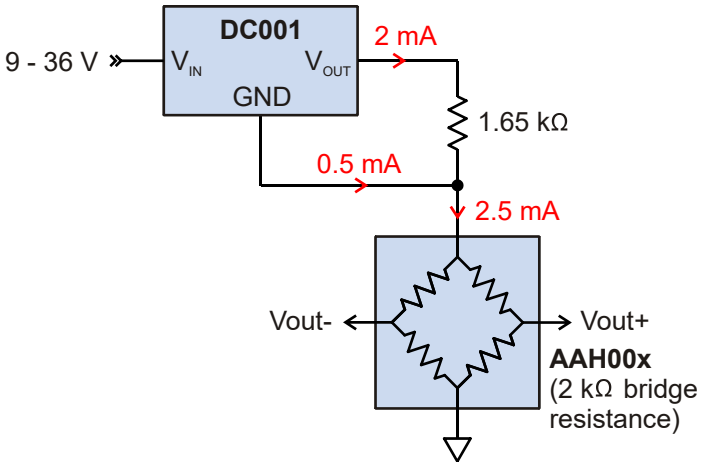


Fig. 4. Current source for driving a bridge sensor.

As shown above in red, the current through the external resistor is the regulator output divided by the resistor value. The regulator's quiescent current (typically 0.5 mA) adds to the current. The total source current of 2.5 mA provides approximately five volts to the sensor, but the voltage varies as the bridge resistance changes to provide constant current and compensate for bridge resistance changes with temperature.

The high temperature rating of the DC001 regulator complements the sensor's extended temperature range.

Two-Wire Sensor Module

Two-wire switch sensors are common in industrial controls to simplify wiring. A DC001 regulator allows operation over a wide power supply range, and its low quiescent current allows the circuit to draw less than one milliamp when the sensor is off:

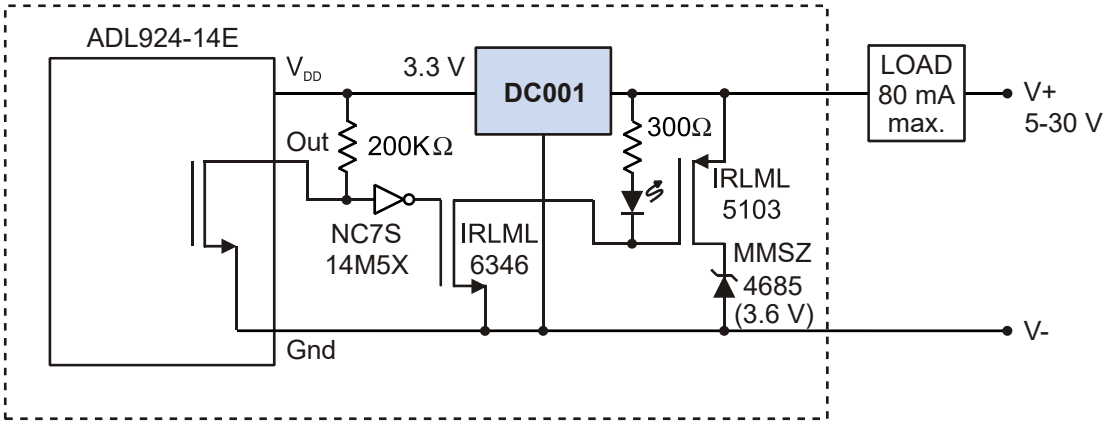
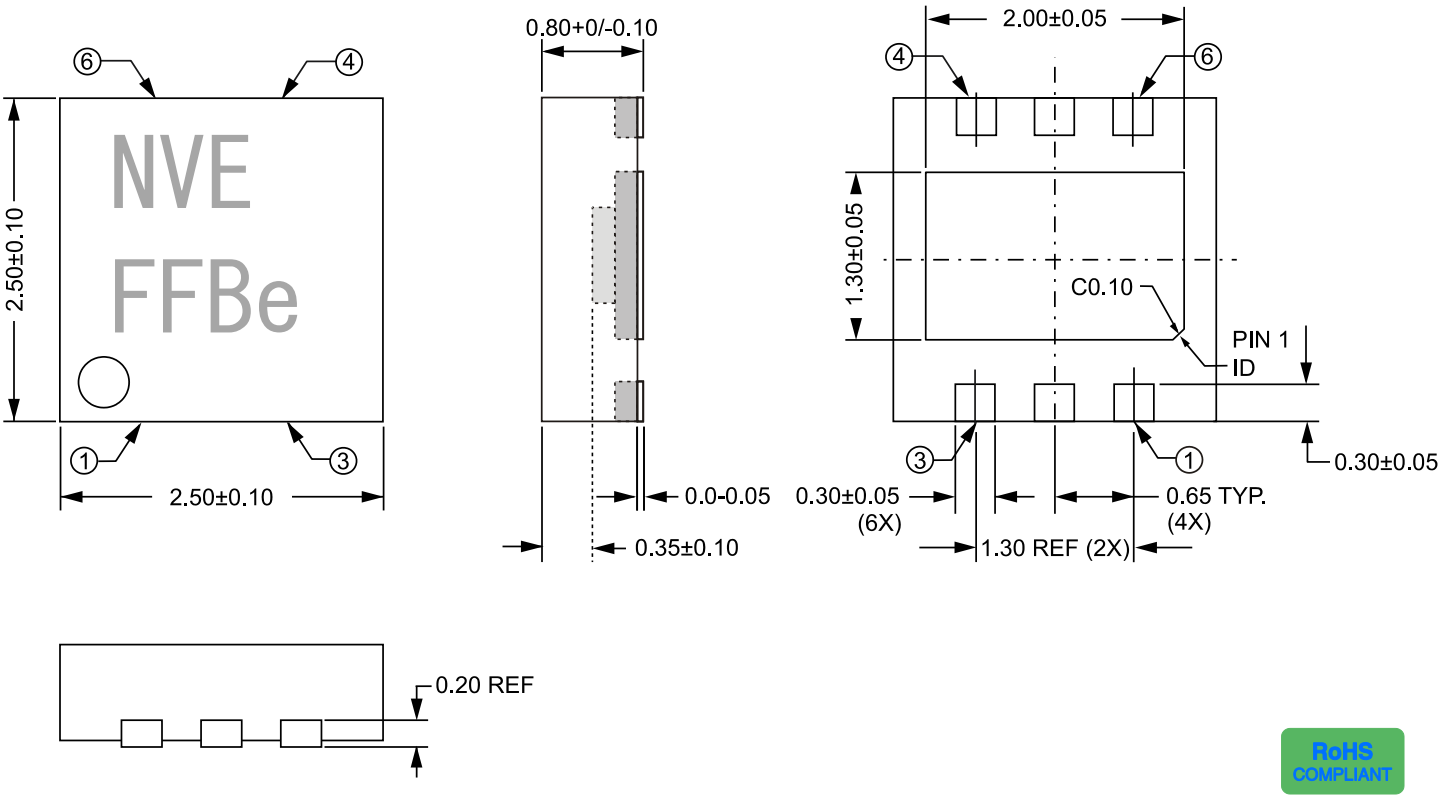


Fig. 5. Two-wire sensor assembly.

When the sensor is activated, its output goes low, the invertor output goes low driving the N-channel MOSFET on, which turns on the LED. That turns on the P-channel MOSFET, powering the load.

2.5 mm x 2.5 mm DFN6 Package (-10 suffix)

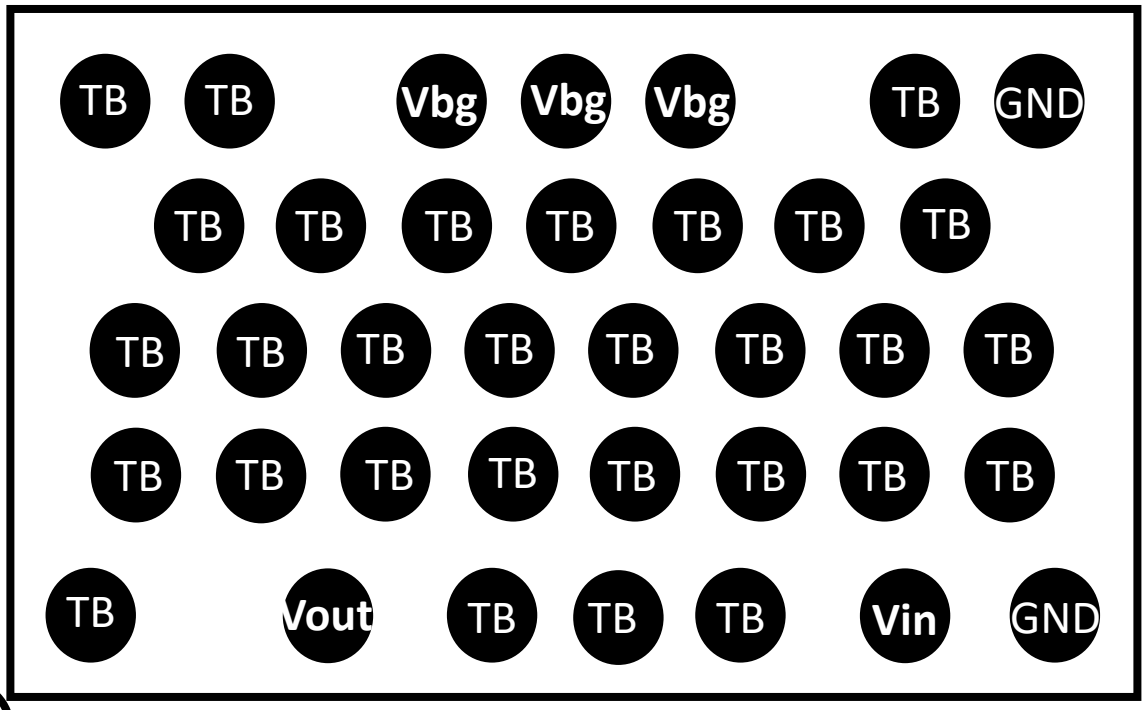


RoHS COMPLIANT

Notes:

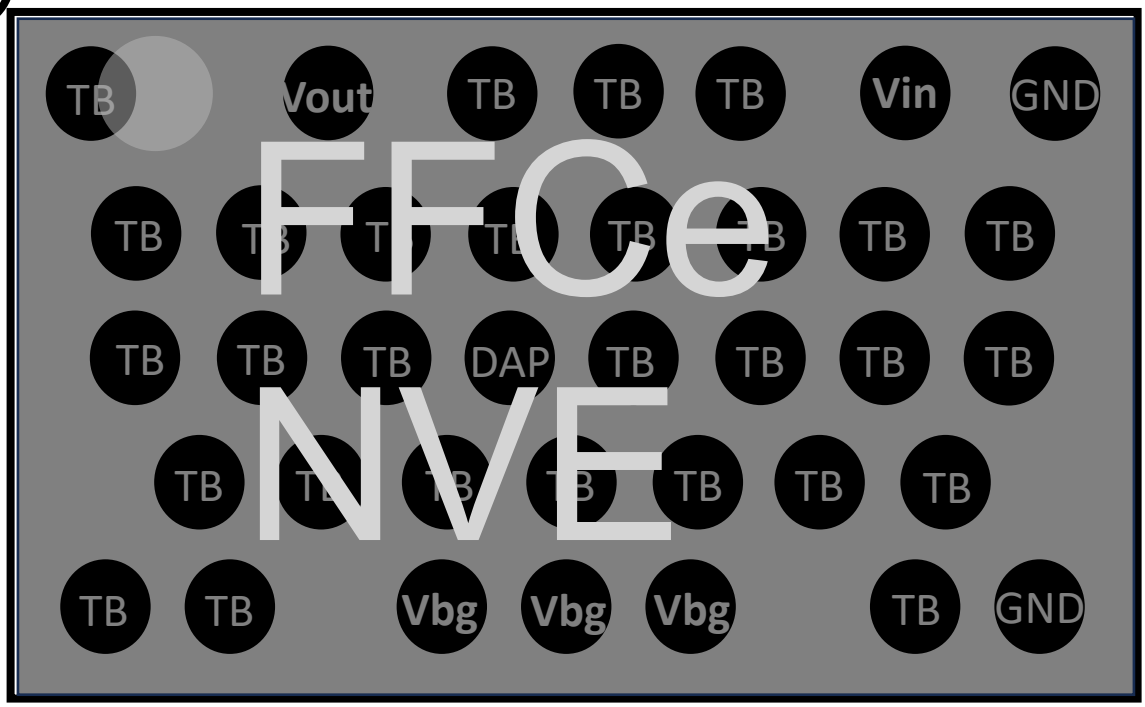
- Dimensions in millimeters.
- Soldering profile per JEDEC J-STD-020C, MSL 1.
- The die attach pad is exposed on the back of the package.
  NVE recommends that it be connected to the ground pin and the PCB to improve thermal performance.

DC004-20E: 1.8 x 1.1 mm x 0.2 mm WLCSP Package



Bottom view

Top view

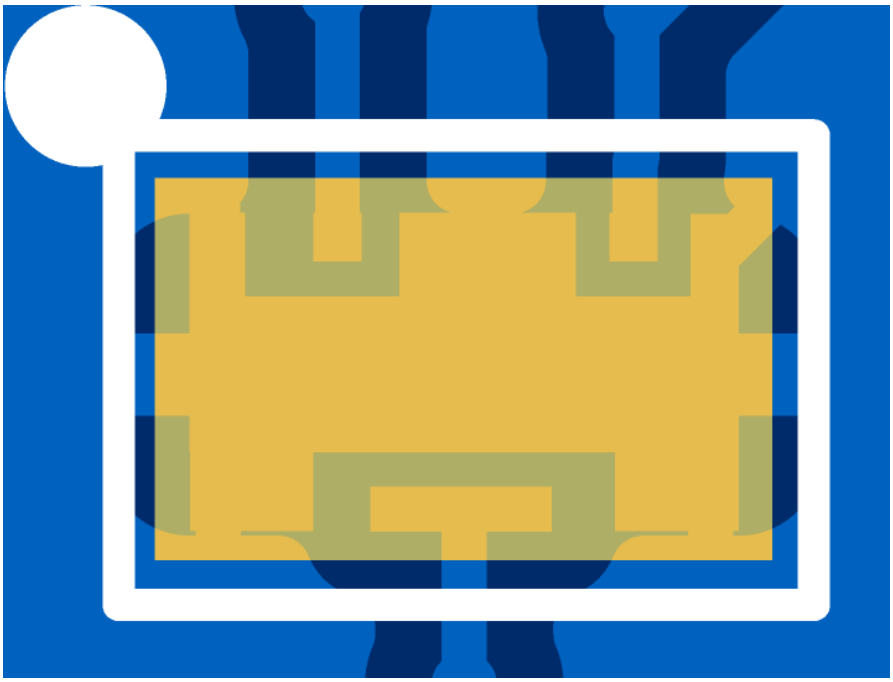


RoHS COMPLIANT

Notes:

- Soldering profile per JEDEC J-STD-020C, MSL 1.
- NVE recommends connecting thermal balls (marked "TB") to PCB ground for optimal thermal performance.

Example Layout for DC004-20E



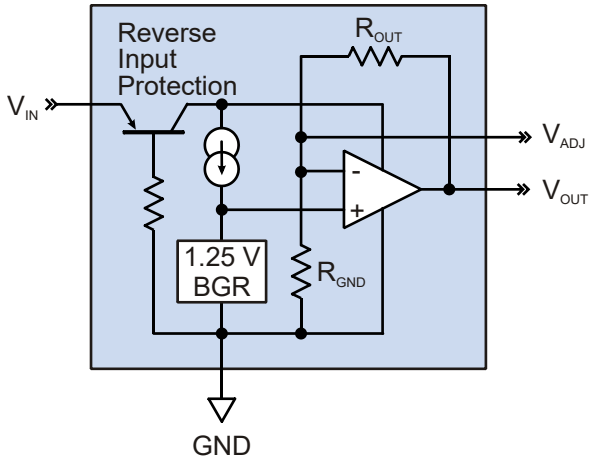
The PCB footprint and 3D STEP files are hosted on our website: https://www.nve.com/webstore/voltage-regulator

Available Parts

Part Number	Nominal Output Voltage	Output Tolerance	Package	WLCSP / DFN6 Marking
DC001-10E	3.3 V	±0.3 V	DFN6	FFBe
DC002-10E	5 V	±0.5 V	DFN6	FFCe
DC003-10E	5 V	−0.5 / +0.25 V	DFN6	FFCe
DC004-10E	5 V	±0.25 V	DFN6	FFCe
DC004-20E	5 V	±0.25 V	WLCSP	FFCe

Functional Diagram

DC00x regulators consist of a precision band-gap voltage reference, a high-temperature operational amplifier, and reverse input voltage protection circuitry. Two internal resistors set the output voltage:



Regulator	Nominal Output	R_{GND}	R_{OUT}
DC001	3.3 V	7.5 kΩ	12.3 kΩ
DC002/DC003/DC004	5 V	4.95 kΩ	14.85 kΩ

External resistors in parallel with the internal resistors can be used to modify the output voltage.

Pinout

Symbol	Description	DFN6 Pinout	WLCSP Pinout
V_{in}	Voltage regulator input (45 V max.)	3	See recommended layout; Connect thermal balls marked "TB" to GND
V_{out}	Regulated output	1	
V_{ADJ}	(WLCSP only) Connect to external resistors to adjust V_{out} from 2.2 V to 8.5 V (see Fig. 1)	NA	
GND	Ground	5	
NC	No electrical connection; leave floating or connect to ground	2, 4, 6	
DAP	Die attach paddle; connect to ground and use for heatsinking	Center pad	

Breakout Boards

Breakout boards are available for DC004-20E:

Part number DC004-20E-EVB01
(1.1" x 0.38" / 28.2 mm x 9.7 mm; actual size).

Bare Circuit Boards

NVE offers bare circuit boards for easy connections to DC00x-10E DFN6 regulators:

AG035-06: DFN6 connection board for -10E suffix voltage regulators.
(1.57" x 0.25" / 40 mm x 6 mm; actual size).

Revision History

SB-00-033 – Rev. A July 2025	**Change** • Consolidated legacy DC001-10E and DC002-10E datasheets. • Initial release of WLCSP versions. • Added typical performance graphs. • Added application circuits. • Added functional diagram. • Added boards. • Other significant additions throughout.

Datasheet Limitations
The information and data provided in datasheets shall define the specification of the product as agreed between NVE and its customer, unless NVE and customer have explicitly agreed otherwise in writing. All specifications are based on NVE test protocols. In no event however, shall an agreement be valid in which the NVE product is deemed to offer functions and qualities beyond those described in the datasheet.

Limited Warranty and Liability
Information in this document is believed to be accurate and reliable. However, NVE does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information.

In no event shall NVE be liable for any indirect, incidental, punitive, special or consequential damages (including, without limitation, lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Right to Make Changes
NVE reserves the right to make changes to information published in this document including, without limitation, specifications and product descriptions at any time and without notice. This document supersedes and replaces all information supplied prior to its publication.

Use in Life-Critical or Safety-Critical Applications
Unless NVE and a customer explicitly agree otherwise in writing, NVE products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical devices or equipment. NVE accepts no liability for inclusion or use of NVE products in such applications and such inclusion or use is at the customer's own risk. Should the customer use NVE products for such application whether authorized by NVE or not, the customer shall indemnify and hold NVE harmless against all claims and damages.

Applications
Applications described in this datasheet are illustrative only. NVE makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NVE products, and NVE accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NVE product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customers. Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NVE does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customers. The customer is responsible for all necessary testing for the customer's applications and products using NVE products in order to avoid a default of the applications and the products or of the application or use by customer's third party customers. NVE accepts no liability in this respect.

Limiting Values
Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and operation of the device at these or any other conditions above those given in the recommended operating conditions of the datasheet is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

Terms and Conditions of Sale
In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NVE hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NVE products by customer.

No Offer to Sell or License
Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

Export Control
This document as well as the items described herein may be subject to export control regulations. Export might require a prior authorization from national authorities.

Automotive Qualified Products
Unless the datasheet expressly states that a specific NVE product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NVE accepts no liability for inclusion or use of non-automotive qualified products in automotive equipment or applications.

In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NVE's warranty of the product for such automotive applications, use and specifications, and (b) whenever customer uses the product for automotive applications beyond NVE's specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NVE for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NVE's standard warranty and NVE's product specifications.

An ISO 9001 Certified Company

NVE Corporation
11409 Valley View Road
Eden Prairie, MN 55344-3617 USA
Telephone: (952) 829-9217
www.nve.com
www.youtube.com/NveCorporation

e-mail: power-apps@nve.com