

## Summary

The ZABG4003 is an advanced GaAs and HEMT FETs bias controller designed to operate from minimal supply rails and intended primarily for satellite Low Noise Blocks (LNBs). With the addition of one capacitor and two resistors, the ZABG4003 provides drain voltage and current control for up to 4 external grounded source FETs. Generating the regulated negative rail required for FET gate biasing whilst operating from a single supply of 2.1V to 5V. The -2V negative bias can also be used to supply other external circuits. Setting drain currents on the ZABG4003 uses two resistors to split control between two pairs of FETs. This allows the operating current of input FETs to be adjusted to minimize noise, whilst the following FET stages can separately be adjusted for maximum gain.

## Features

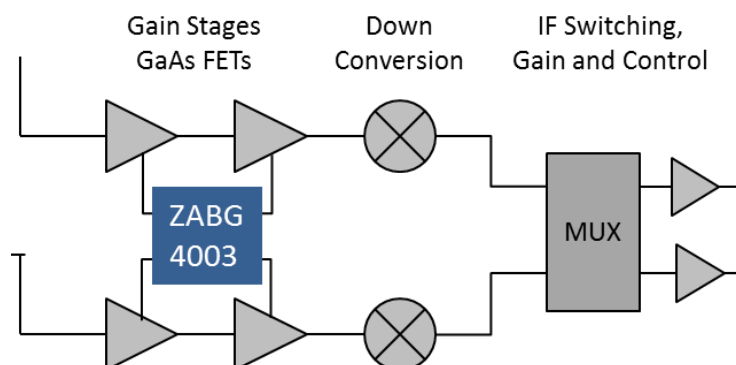
- Provides Bias for up to 4 GaAs and HEMT FETs
- Operating Range of 2.1V to 5V
- Ultra-low Operating Current of 0.95mA
- Dynamic FET Protection
- Amplifier FET Drain Current Selectable (4mA to 15mA)
- Regulated Negative Rail Generator Requires only 1 External Capacitor
- Expanded Temperature Range of -40°C to +105°C
- U-QFN3030-16 (Type B) Surface Mount Package
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

## Applications

- Low Power LNB's
- Digital LNB's
- IP LNB's
- Twin LNB's and Quad LNB's
- General Purpose LNA Bias

- Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
  2. See [http://www.diodes.com/quality/lead\\_free.html](http://www.diodes.com/quality/lead_free.html) for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
  3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

## Twin LNB System Diagrams



## Device Description

The ZABG series of devices are designed to meet the bias requirements of GaAs and HEMT FETs commonly used in satellite receiver LNBs with a minimum of external components whilst operating from a minimal voltage supply and using minimal current.

The ZABG4003 has four FET bias stages that can be programmed to provide a constant drain current. Programming of the FET bias stage arrangement and the operating currents of each FET group is achieved by resistors connected to the  $R_{CAL1}$  and  $R_{CAL2}$  pins, allowing input FETs to be biased for optimum noise, amplifier FETs for optimum gain. Amplifier FETs can be operated at currents in the range 4 to 15mA. D1 and D3 on the ZABG4003 can be programmed with  $R_{CAL1}$  over the range of 4 to 15mA and D2 and D4 are programmed with  $R_{CAL2}$ .

Drain voltages of amplifier stages are set at 2.0V and are current limited to approximately current set by their associated  $R_{CAL}$  resistors.

Depletion mode FETs require a negative voltage bias supply when operated in grounded source circuits. The ZABG4003 includes an integrated switched capacitor DC-DC converter generating a regulated output of -2V to allow single supply operation. The ZABG4003 has been designed to be used with supply rails of 2.1V to 5.0V and the  $V_{DD}$  range has been extended to 5.5V to allow for 10% supply variation.

It is possible to use less than the full complement of FET bias controls, unused drain and gate connections can be left open circuit without affecting operation of the remaining bias circuits.

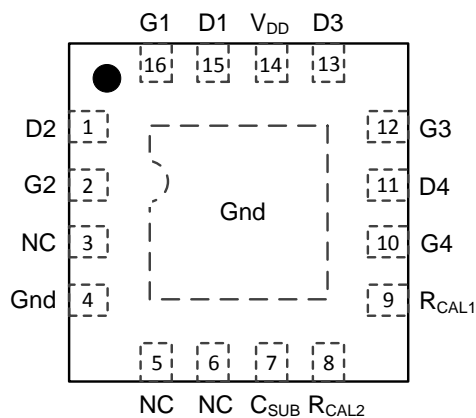
To protect the external FETs the circuits have been designed to ensure that, under any conditions including power up/down transients, the gate drive from the bias circuits cannot exceed -2.5V. Additionally each stage has its own individual current limiter. Furthermore if the negative rail experiences a fault condition, such as overload or short circuit, the drain supply to the FETs will be limited, avoiding excessive current flow.

The ZABG4003 is available in the 16 pin U-QFN3030-16 (Type B) package.

Device operating temperature is -40°C to +105°C to suit a wide range of environmental conditions.

## Pin Assignments and Descriptions

(Top View)



**U-QFN3030-16 (Type B)**

| Pin Number | Pin Name          | Description                                    |
|------------|-------------------|--|
| 1          | D2                | Drain GaAs FET 2                               |
| 2          | G2                | Gate GaAs FET 2                                |
| 3, 5, 6    | NC                | No Connection                                  |
| 4          | Gnd               | Ground   |
| 7          | C <sub>SUB</sub>  | Negative rail reservoir capacitor              |
| 8          | R <sub>CAL2</sub> | Drain current setting for D2 and D4            |
| 9          | R <sub>CAL1</sub> | Drain current setting for D1 and D3            |
| 10         | G4                | Gate GaAs FET 4                                |
| 11         | D4                | Drain GaAs FET 4                               |
| 12         | G3                | Gate GaAs FET 3                                |
| 13         | D3                | Drain GaAs FET 3                               |
| 14         | V <sub>DD</sub>   | Supply voltage                                 |
| 15         | D1                | Drain GaAs FET 1                               |
| 16         | G1                | Gate GaAs FET 1                                |
| Pad        | Gnd               | Ground connection recommended or no connection |

## Maximum Ratings

| Symbol           | Parameter                               | Rating      | Unit |
|------------------|---|-------------|------|
| V <sub>DD</sub>  | Supply Voltage                          | -0.6 to +6  | V    |
| I <sub>DD</sub>  | Supply Current                          | 100         | mA   |
| —                | Power Dissipation U-QFN3030-16 (Type B) | 650         | mW   |
| T <sub>J</sub>   | Junction Temperature                    | +135        | °C   |
| T <sub>STG</sub> | Storage Temperature Range               | -40 to +150 | °C   |

**Recommended Operating Conditions** (Note 8)

| Symbol   | Parameter                   | Min | Max  | Unit |
|----------|-----------------------------|-----|------|------|
| $V_{DD}$ | Operating Voltage Range     | 2.1 | 5.5  | V    |
| $T_A$    | Operating Temperature Range | -40 | +105 | °C   |

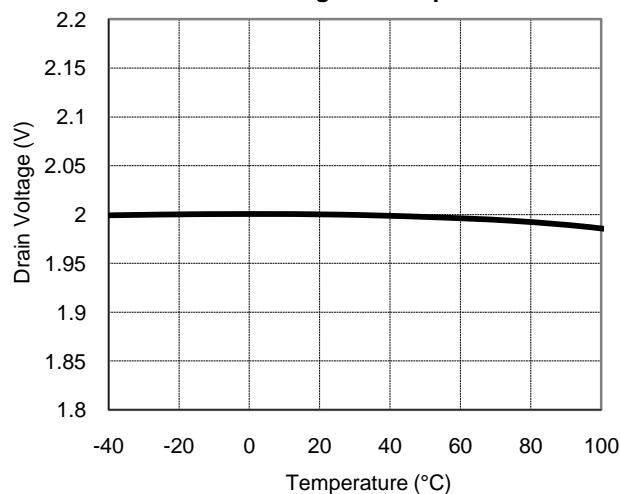
**Electrical Characteristics** (@ $T_A = +25^\circ\text{C}$ ,  $V_{DD} = 2.3\text{V}$ ,  $R_{CAL1} = R_{CAL2} = 33\text{k}\Omega$ , setting  $I_{D1}$  to  $I_{D4}$  set to 10mA.)

| Symbol                       | Parameter                  | Conditions  | Min  | Typ   | Max   | Unit          |
|------------------------------|----------------------------|---|------|-------|-------|---------------|
| $I_{DD}$                     | Supply Current             | $I_{D1-4} = 0$  | —    | 0.95  | 2.0   | mA            |
| $I_{DD(L)}$                  |                            | $I_{D1-4} = 10\text{mA}$                                      | —    | —     | 45    | mA            |
| $V_{CSUB}$                   | Substrate Voltage (Note 5) | $I_{CSUB} = 0$  | -2.5 | -2.0  | -1.5  | V             |
| $V_{CSUB(L)}$                |                            | $I_{CSUB} = -20\mu\text{A}$                                   | —    | —     | -1.5  | V             |
| $f_{OSC}$                    | Oscillator Frequency       | —   | —    | 7.5   | —     | MHz           |
| $V_{D(NOISE)}$               | Drain Voltage (Note 6)     | $C_{GATE-GND} = 10\text{nF}$<br>$C_{DRAIN-GND} = 10\text{nF}$ | —    | —     | 0.02  | $V_{PK-PK}$   |
| $V_{G(NOISE)}$               | Gate Voltage (Note 6)      | $C_{GATE-GND} = 10\text{nF}$<br>$C_{DRAIN-GND} = 10\text{nF}$ | —    | —     | 0.005 | $V_{PK-PK}$   |
| <b>Gate Characteristics</b>  |                            |   |      |       |       |               |
| Gate (G1 to G4)              |                            |   |      |       |       |               |
| $I_G$                        | Current Range              | —   | -50  | —     | 60    | $\mu\text{A}$ |
| $V_{G(L)}$                   | Voltage Low                | $I_D = 12\text{mA}$ , $I_G = -10\mu\text{A}$                  | -2.5 | -2.0  | -1.5  | V             |
| $V_{G(H)}$                   | Voltage High               | $I_D = 8\text{mA}$ , $I_G = 0$                                | 0    | 0.7   | 1.0   | V             |
| <b>Drain Characteristics</b> |                            |   |      |       |       |               |
| Drain (D1 to D4)             |                            |   |      |       |       |               |
| $I_D$                        | Current Range              | D1 and D4   | 4    | —     | 15    | mA            |
| $I_{D(OP)}$                  | Current Operating (Note 4) | Standard Application Circuit                                  | 8    | 10    | 12    | mA            |
| $V_{D(OP)}$                  | Voltage Operating (Note 7) | $I_D = 10\text{mA}$   | 1.8  | 2.0   | 2.2   | V             |
| $dV_D/dV_{DD}$               | delta $V_D$ vs $V_{DD}$    | $V_{DD} = 2.3\text{V}$ to $5.5\text{V}$                       | —    | 0.075 | —     | %/V           |
| $dI_D/dV_{DD}$               | delta $I_D$ vs $V_{DD}$    | $V_{DD} = 2.3\text{V}$ to $5.5\text{V}$                       | —    | 0.7   | —     | %/V           |
| $dV_D/dT_A$                  | delta $V_D$ vs $T_A$       | $T_A = -40^\circ\text{C}$ to $+105^\circ\text{C}$             | —    | 150   | —     | ppm           |

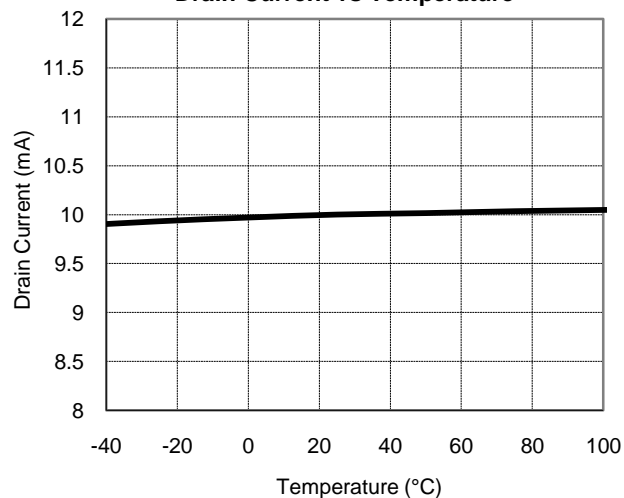
- Notes:
- Characteristics are measured using up to two external reference resistors,  $R_{CAL1}$  and  $R_{CAL2}$ .
  - The negative bias voltages are generated on-chip using an internal oscillator. An external 47nF capacitor is required for this purpose.
  - Noise voltage measurements are made with FETs and gate and drain capacitors of value 10nF in place. Noise voltages are not measured in production.
  - The maximum operating drain voltage is equal to  $V_{DD}$  or  $V_{D(OP)}$  max whichever is lower.
  - ESD sensitive, handling precautions are recommended.

**Typical Characteristics** (@ $T_A = +25^\circ\text{C}$ ,  $V_{DD} = 2.3\text{V}$ ,  $R_{CAL1} = R_{CAL2} = 33\text{k}\Omega$  (setting  $I_D$  to 10mA), unless otherwise stated.)

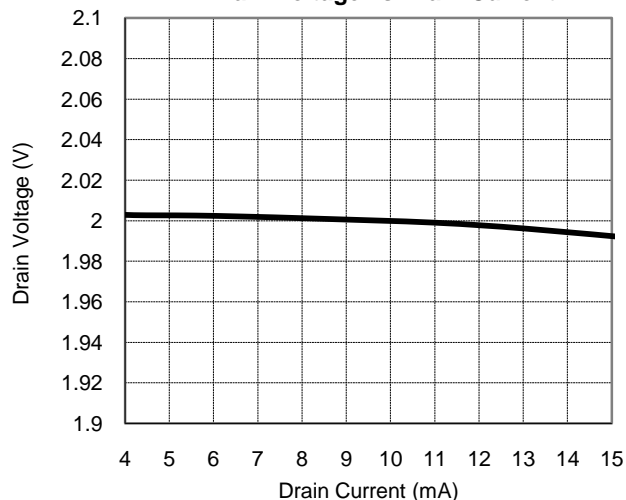
**Drain Voltage vs Temperature**



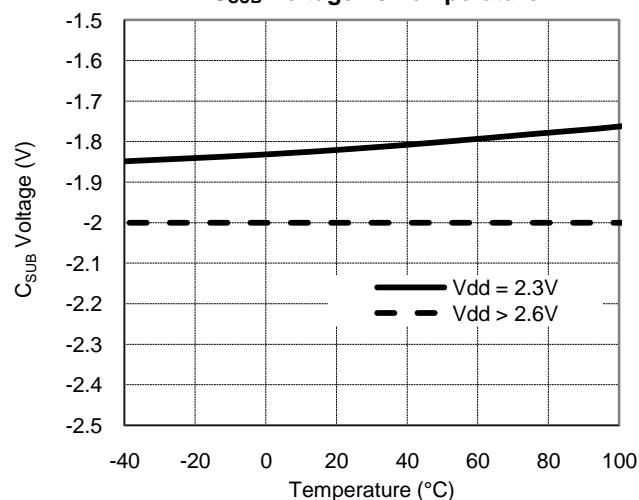
**Drain Current vs Temperature**



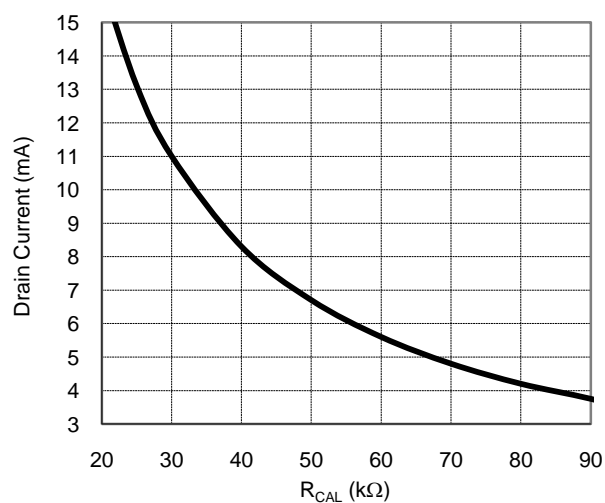
**Drain Voltage vs Drain Current**



**$C_{SUB}$  Voltage vs Temperature**



**Drain Current vs  $R_{CAL}$**

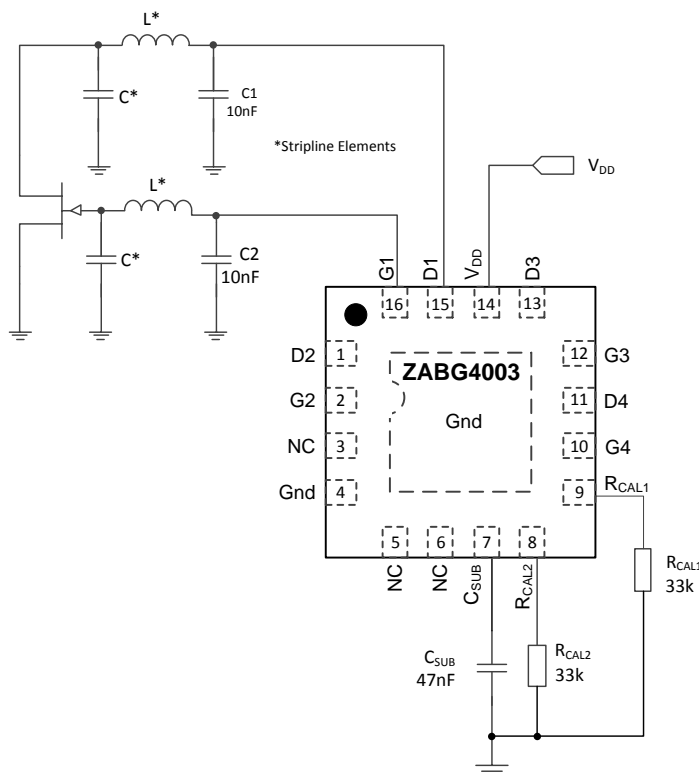


## Application Information

Below are partial applications circuits for the ZABG4003 showing all external components needed for biasing one of the four FET stages available as a typical LNA (Low Noise Amplifier). Each bias stage is provided with a gate and drain pin. The drain pin provides a regulated 2.0V supply that includes a drain current monitor. The drain current taken by the external FET is compared with a user selected level, generating a signal that adjusts the gate voltage of the FET to obtain the required drain current. If for any reason, an attempt is made to draw more than the user set drain current from the drain pin, the drain voltage will be reduced to ensure excess current is not taken. The gate pin drivers are also current limited.

The bias stages are split up into two groups, with the drain current of each group set by an external  $R_{CAL}$  resistor.  $R_{CAL1}$  sets the drain currents of stages 1 and 3, whilst  $R_{CAL2}$  sets the drain currents of stages 2 and 4.

This allows the optimization of drain currents for differing tasks such as input stages where noise can be critical and later amplifier stages where gain may be more important. A graph showing the relationship between the value of  $R_{CAL}$  and  $I_D$  is provided in the Typical Characteristics section of this datasheet.



The Gnd flag on the underside ZABG4003 must be connected to ground or left open circuit.

The ZABG4003 includes a switched capacitor DC-DC converter that is used to generate the negative supply required to bias depletion mode FETs used in common source circuit configuration as shown above. This converter uses an external capacitor  $C_{SUB}$  as the output reservoir capacitor. The circuit provides a regulated -2V supply both for gate driver use and for external use if required (for extra discrete bias stages, mixer bias, local oscillator bias etc.). The -2V supply is available from the  $C_{SUB}$  pin.

If any bias stages are not required, their gate and drain pins may be left open circuit. If all bias stages associated with an  $R_{CAL}$  resistor are not required, then this resistor may be omitted.

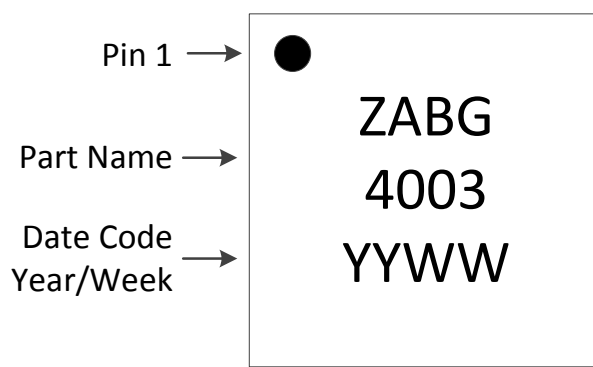
## Ordering Information

| Part Number    | Package               | Reel Size (inches) | Tape Width (mm) | Quantity Per Reel |
|----------------|-----------------------|--------------------|-----------------|-------------------|
| ZABG4003JA16TC | U-QFN3030-16 (Type B) | 13                 | 12              | 3,000             |

## Marking Information

U-QFN3030-16 (Type B)

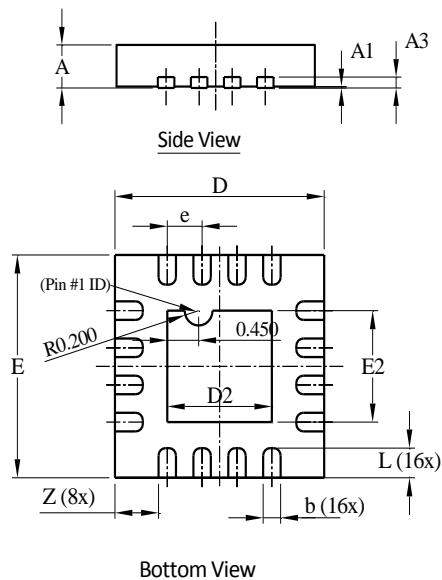
(Top View)



## Package Outline Dimensions

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

**U-QFN3030-16 (Type B)**

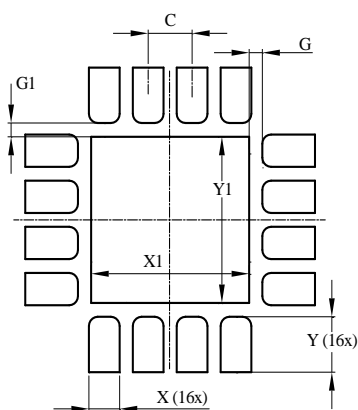


| U-QFN3030-16<br>Type B |      |      |       |
|------------------------|------|------|-------|
| Dim                    | Min  | Max  | Typ   |
| A                      | 0.55 | 0.65 | 0.60  |
| A1                     | 0    | 0.05 | 0.02  |
| A3                     | -    | -    | 0.15  |
| b                      | 0.18 | 0.28 | 0.23  |
| D                      | 2.95 | 3.05 | 3.00  |
| D2                     | 1.40 | 1.60 | 1.50  |
| E                      | 2.95 | 3.05 | 3.00  |
| E2                     | 1.40 | 1.60 | 1.50  |
| e                      | -    | -    | 0.50  |
| L                      | 0.35 | 0.45 | 0.40  |
| Z                      | -    | -    | 0.625 |
| All Dimensions in mm   |      |      |       |

## Suggested Pad Layout

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

**U-QFN3030-16 (Type B)**



| Dimensions | Value (in mm) |
|------------|---------------|
| C          | 0.500         |
| G          | 0.150         |
| G1         | 0.150         |
| X          | 0.350         |
| X1         | 1.800         |
| Y          | 0.600         |
| Y1         | 1.800         |



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