

# FET BIAS CONTROLLER

ZNBG4000 ZNBG4001  
ZNBG6000 ZNBG6001

ISSUE 2 - JUNE 1998

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## DEVICE DESCRIPTION

The ZNBG series of devices are designed to meet the bias requirements of GaAs and HEMT FETs commonly used in satellite receiver LNBS, PMR, cellular telephones etc. with a minimum of external components.

With the addition of two capacitors and resistors the devices provide drain voltage and current control for a number of external grounded source FETs, generating the regulated negative rail required for FET gate biasing whilst operating from a single supply. This negative bias, at -3 volts, can also be used to supply other external circuits.

The ZNBG4000/1 and ZNBG6000/1 contain four and six bias stages respectively. In setting drain current the ZNBG4000/1 two resistors allows individual FET pair control to different levels, the ZNBG6000/1 two resistors split control between two and four FETs. This allows the operating current of input FETs to be adjusted to minimise noise, whilst the following FET stages can separately be adjusted for maximum gain. The series also offers the choice of drain voltage to be set for the FETs, the ZNBG4000/6000 gives 2.2 volts drain whilst the ZNBG4001/6001 gives 2 volts.

These devices are unconditionally stable over the full working temperature with the FETs in place, subject to the inclusion of the recommended gate and drain capacitors. These ensure RF stability and minimal injected noise.

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

In order 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 the range -3.5V to 0.7V. Furthermore if the negative rail experiences a fault condition, such as overload or short circuit, the drain supply to the FETs will shut down avoiding excessive current flow.

The ZNBG4000/1 and ZNBG6000/1 are available in QSOP16 and 20 pin packages respectively for the minimum in devices size. Device operating temperature is -40 to 70°C to suit a wide range of environmental conditions.

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## FEATURES

- Provides bias for GaAs and HEMT FETs
- Drives up to four or six FETs
- Dynamic FET protection
- Drain current set by external resistor
- Regulated negative rail generator requires only 2 external capacitors
- Choice in drain voltage
- Wide supply voltage range
- QSOP surface mount package

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## APPLICATIONS

- Satellite receiver LNBS
- Private mobile radio (PMR)
- Cellular telephones

**ZNBG4000 ZNBG4001**  
**ZNBG6000 ZNBG6001**

**ABSOLUTE MAXIMUM RATINGS**

|  |              |  |       |
|--|--------------|--|-------|
| Supply Voltage   | -0.6V to 15V | <b>Power Dissipation (T<sub>amb</sub>= 25°C)</b> |       |
| Supply Current   | 100mA        | QSOP16   | 500mW |
| Drain Current (per FET)<br>(set by R <sub>CAL1</sub> and R <sub>CAL2</sub> ) | 0 to 15mA    | QSOP20   | 650mW |
| Output Current   | 100mA        |  |       |
| Operating Temperature  | -40 to 70°C  |  |       |
| Storage Temperature  | -50 to 85°C  |  |       |

**ELECTRICAL CHARACTERISTICS TEST CONDITIONS (Unless otherwise stated):**  
**T<sub>amb</sub>= 25°C, V<sub>CC</sub>=5V, I<sub>D</sub>=10mA (R<sub>CAL1</sub>=33kΩ; R<sub>CAL2</sub>=33kΩ)**

| SYMBOL                             | PARAMETER                                     | CONDITIONS   | LIMITS |     |               | UNITS          |
|------------------------------------|---|--|--------|-----|---------------|----------------|
|                                    |   |  | Min    | Typ | Max           |                |
| V <sub>CC</sub>                    | Supply Voltage                                |  | 5      |     | 12            | V              |
| I <sub>CC</sub>                    | Supply Current<br>ZNBG4000/1                  | I <sub>D1</sub> to I <sub>D4</sub> =0<br>I <sub>D1</sub> to I <sub>D4</sub> =10mA          |        |     | 10<br>50      | mA<br>mA       |
| I <sub>CC</sub>                    | Supply Current<br>ZNBG6000/1                  | I <sub>D1</sub> to I <sub>D6</sub> =0<br>I <sub>D1</sub> to I <sub>D6</sub> =10mA          |        |     | 15<br>75      | mA<br>mA       |
| V <sub>SUB</sub>                   | Substrate Voltage<br>(Internally generated)   | I <sub>SUB</sub> = 0<br>I <sub>SUB</sub> = -200μA  | -3.5   | -3  | -2<br>-2      | V<br>V         |
| E <sub>ND</sub><br>E <sub>NG</sub> | Output Noise<br>Drain Voltage<br>Gate Voltage | C <sub>G</sub> =4.7nF, C <sub>D</sub> =10nF<br>C <sub>G</sub> =4.7nF, C <sub>D</sub> =10nF |        |     | 0.02<br>0.005 | Vpkpk<br>Vpkpk |
| f <sub>O</sub>                     | Oscillator Freq.                              |  | 200    | 350 | 800           | kHz            |

**DRAIN CHARACTERISTICS**

| I <sub>D</sub>   | Current   |                               | 8        | 10       | 12         | mA     |
|------------------|---|-------------------------------|----------|----------|------------|--------|
| ΔI <sub>DV</sub> | Current Change<br>with V <sub>CC</sub>              | V <sub>CC</sub> =5 to 12V     |          | 0.02     |            | %/V    |
| ΔI <sub>DT</sub> | with T <sub>j</sub>                                 | T <sub>j</sub> = -40 to +70°C |          | 0.05     |            | %/°C   |
| V <sub>D</sub>   | Voltage<br>ZNBG4000, ZNGB6000<br>ZNBG4001, ZNGB6001 |                               | 2<br>1.8 | 2.2<br>2 | 2.4<br>2.2 | V<br>V |
| ΔV <sub>DV</sub> | Voltage Change<br>with V <sub>CC</sub>              | V <sub>CC</sub> = 5 to 12V    |          | 0.5      |            | %/V    |
| ΔV <sub>DT</sub> | with T <sub>j</sub>                                 | T <sub>j</sub> = -40 to +70°C |          | 50       |            | ppm    |

**ZNBG4000 ZNBG4001  
ZNBG6000 ZNBG6001**

| SYMBOL | PARAMETER | CONDITIONS | LIMITS |     |     | UNITS |
|--------|-----------|------------|--------|-----|-----|-------|
|        |           |            | Min    | Typ | Max |       |

**GATE CHARACTERISTICS**

|          |                              |  |      |  |      |         |
|----------|------------------------------|--|------|--|------|---------|
| $I_{GO}$ | Output Current Range         |  | -30  |  | 2000 | $\mu A$ |
| $V_{OL}$ | Output Voltage<br>ZNBG4000/1 |  |      |  |      |         |
|          | Output Low                   | $I_{D1}$ to $I_{D4}=12mA$<br>$I_{G1}$ to $I_{G4}=0$        | -3.5 |  | -2   | V       |
| $V_{OH}$ | Output High                  | $I_{D1}$ to $I_{D4}=12mA$<br>$I_{G1}$ to $I_{G4}=-10\mu A$ | -3.5 |  | -2   | V       |
|          | Output High                  | $I_{D1}$ to $I_{D4}=8mA$<br>$I_{G1}$ to $I_{G4}=0$         | 0    |  | 1    | V       |
| $V_{OL}$ | Output Voltage<br>ZNBG6000/1 |  |      |  |      |         |
|          | Output Low                   | $I_{D1}$ to $I_{D6}=12mA$<br>$I_{G1}$ to $I_{G6}=0$        | -3.5 |  | -2   | V       |
| $V_{OH}$ | Output High                  | $I_{D1}$ to $I_{D6}=12mA$<br>$I_{G1}$ to $I_{G6}=-10\mu A$ | -3.5 |  | -2   | V       |
|          | Output High                  | $I_{D1}$ to $I_{D6}=8mA$<br>$I_{G1}$ to $I_{G6}=0$         | 0    |  | 1    | V       |

Notes:

1. The negative bias voltages specified are generated on-chip using an internal oscillator. Two external capacitors,  $C_{NB}$  and  $C_{SUB}$ , of 47nF are required for this purpose.

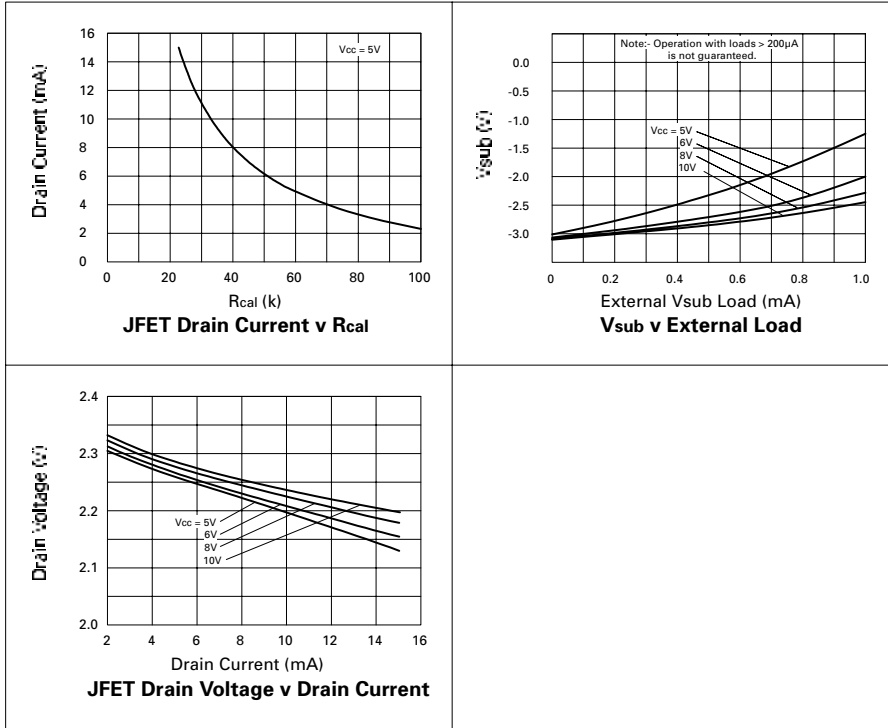
2. The characteristics are measured using two external reference resistors  $R_{CAL1}$  and  $R_{CAL2}$  of value 33k $\Omega$  wired from pins  $R_{CAL1/2}$  to ground. For the ZNBG4000, resistor  $R_{CAL1}$  sets the drain current of FETs 1 and 2, resistor  $R_{CAL2}$  sets the drain current of FETs 3 and 4. For the ZNBG6000, resistor  $R_{CAL1}$  sets the drain current of FETs 1 and 4, resistor  $R_{CAL2}$  sets the drain current of FETs 2, 3, 5 and 6.

3. Noise voltage is not measured in production.

4. Noise voltage measurement is made with FETs and gate and drain capacitors in place on all outputs.  $C_G$ , 4.7nF, are connected between gate outputs and ground,  $C_D$ , 10nF, are connected between drain outputs and ground.

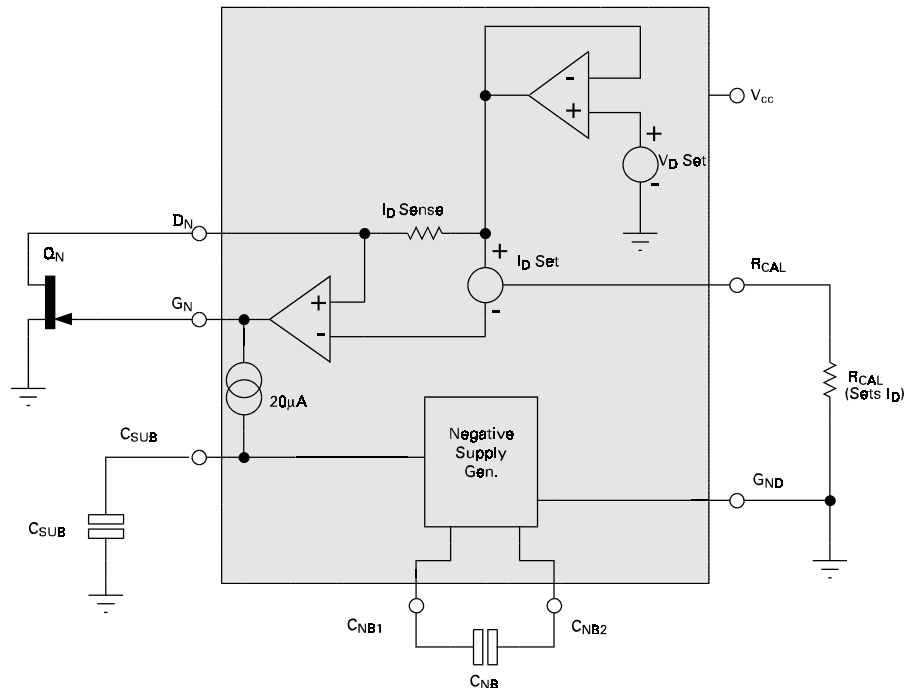
ZNBG4000 ZNBG4001  
 ZNBG6000 ZNBG6001

### TYPICAL CHARACTERISTICS



**ZNBG4000 ZNBG4001  
ZNBG6000 ZNBG6001**

## FUNCTIONAL DIAGRAM



## FUNCTIONAL DESCRIPTION

The ZNBG devices provide all the bias requirements for external FETs, including the generation of the negative supply required for gate biasing, from the single supply voltage.

The diagram above shows a single stage from the ZNBG series. The ZNBG4000/1 contains 4 such stages, the ZNBG6000/1 contains 6. The negative rail generator is common to all devices.

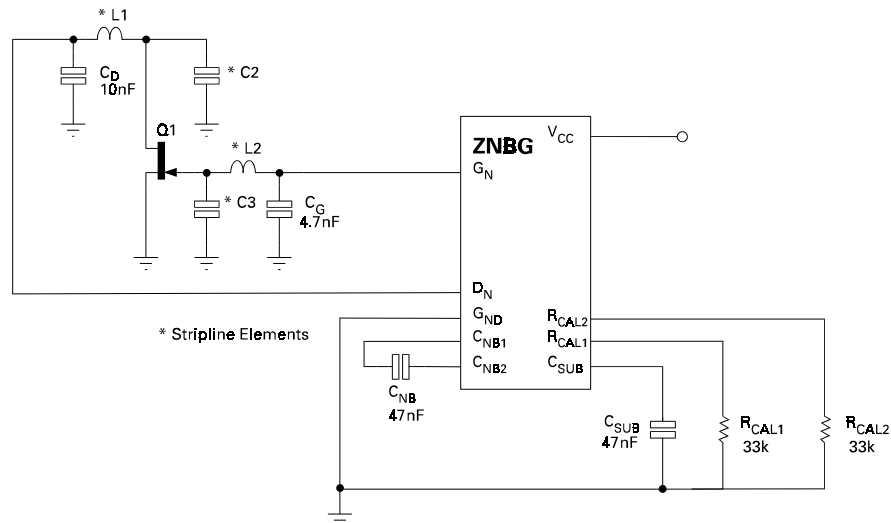
The drain voltage of the external FET  $Q_N$  is set by the ZNBG device to its normal operating voltage. This is determined by the on board  $V_D$  Set reference, for the ZNBG4000/6000 this is nominally 2.2 volts whilst the ZNBG4001/6001 provides nominally 2 volts.

The drain current taken by the FET is monitored by the low value resistor  $I_D$  Sense. The amplifier driving the gate of the FET adjusts the gate voltage of  $Q_N$  so that the drain current taken matches the current called for by an external resistor  $R_{CAL}$ . Both ZNBG devices have the facility to program different drain currents into selected FETs. Two  $R_{CAL}$  inputs are provided. For the ZNBG4000, resistor  $R_{CAL1}$  sets the drain current of FETs 1 and 2, resistor  $R_{CAL2}$  sets the drain current of FETs 3 and 4. For the ZNBG6000, resistor  $R_{CAL1}$  sets the drain current of FETs 1 and 4, resistor  $R_{CAL2}$  sets the drain current of FETs 2, 3, 5 and 6.

Since the FET is a depletion mode transistor, it is usually necessary to drive its gate negative with respect to ground to obtain the required drain current. To provide this capability powered from a single positive supply, the device includes a low current negative supply generator. This generator uses an internal oscillator and two external capacitors,  $C_{NB}$  and  $C_{SUB}$ .

**ZNMG4000 ZNMG4001**  
**ZNMG6000 ZNMG6001**

### TYPICAL APPLICATION CIRCUIT



### APPLICATIONS INFORMATION

The above is a partial application circuit for the ZNMG series showing all external components required for appropriate biasing. The bias circuits are unconditionally stable over the full temperature range with the associated FETs and gate and drain capacitors in circuit.

Capacitors  $C_D$  and  $C_G$  ensure that residual power supply and substrate generator noise is not allowed to affect other external circuits which may be sensitive to RF interference. They also serve to suppress any potential RF feedthrough between stages via the ZNMG device. These capacitors are required for all stages used. Values of 10nF and 4.7nF respectively are recommended however this is design dependent and any value between 1nF and 100nF could be used.

The capacitors  $C_{NB}$  and  $C_{SUB}$  are an integral part of the ZNMGs negative supply generator. The negative bias voltage is generated on-chip using an internal oscillator. The required value of capacitors  $C_{NB}$  and  $C_{SUB}$  is 47nF. This generator produces a low current supply of approximately -3 volts. Although this generator is intended purely to bias the external FETs, it can be used to power other external circuits via the  $C_{SUB}$  pin.

Resistors  $R_{CAL1/2}$  sets the drain current at which all external FETs are operated. Both ZNMG devices have the facility to program different drain currents into selected FETs. Two  $R_{CAL}$  inputs are provided. For the ZNMG4000, resistor  $R_{CAL1}$  sets the drain current of FETs 1 and 2, resistor  $R_{CAL2}$  sets the drain current of FETs 3 and 4. For the ZNMG6000, resistor  $R_{CAL1}$  sets the drain current of FETs 1 and 4, resistor  $R_{CAL2}$  sets the drain current of FETs 2, 3, 5 and 6. If the same drain current is required for all FETs on either device then pins  $R_{CAL1}$  and  $R_{CAL2}$  can be wired together and shunted to ground by a single calibration resistor of half normal value.

If any bias control circuit is not required, its related drain and gate connections may be left open circuit without affecting the operation of the remaining bias circuits. If all FETs associated with a current setting resistor are omitted, the particular  $R_{CAL}$  should still be included. The supply current can be reduced, if required, by using a high value  $R_{CAL}$  resistor (e.g. 470k).

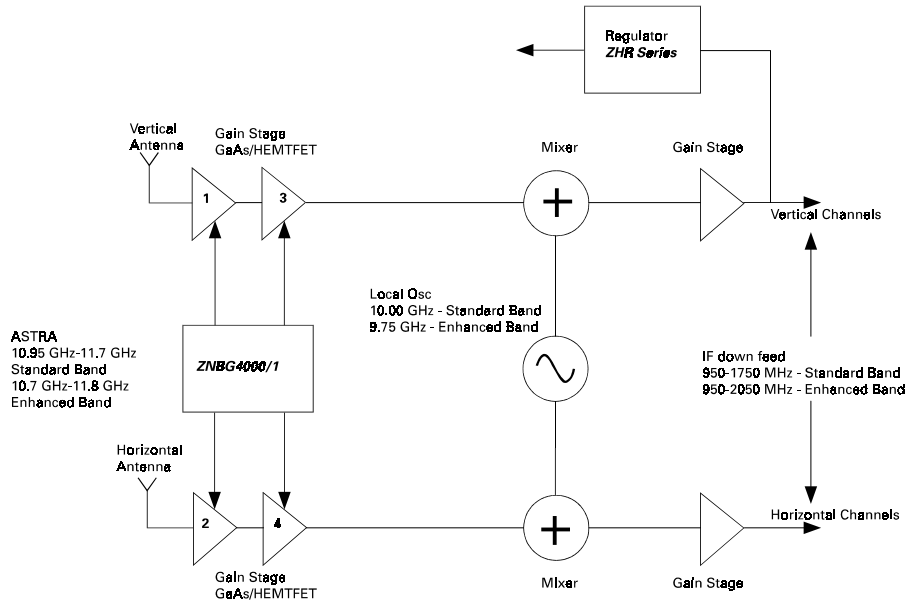
**ZNBG4000 ZNBG4001  
ZNBG6000 ZNBG6001**

**APPLICATIONS INFORMATION (Continued)**

The ZNBG devices have been designed to protect the external FETs from adverse operating conditions. With a JFET connected to any bias circuit, the gate output voltage of the bias circuit can not exceed the range -3.5V to 0.7V, under any conditions including powerup and powerdown transients. Should the negative bias generator be shorted or overloaded so that the drain current of the external FETs can no longer be controlled, the drain supply to FETs is shut down to avoid damage to the FETs by excessive drain current.

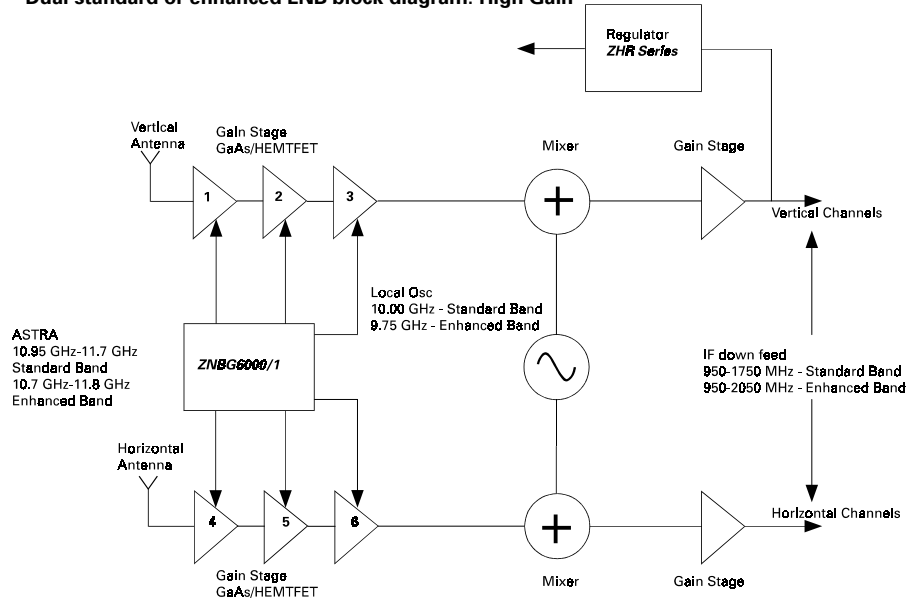
The following diagrams show the ZNBG4000/1 and ZNBG6000/1 in typical LNB applications. Within each FET gain stage the numbering system indicates how the bias stages relate to the application circuits. This is important when RCAL values are used to set differing drain currents.

**Dual standard or enhanced LNB block diagram**



**ZNBG4000 ZNBG4001**  
**ZNBG6000 ZNBG6001**

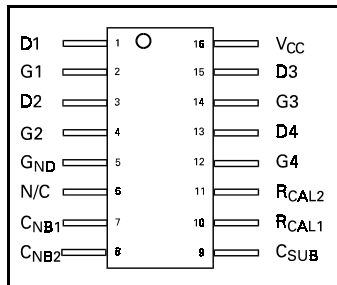
**Dual standard or enhanced LNB block diagram. High Gain**



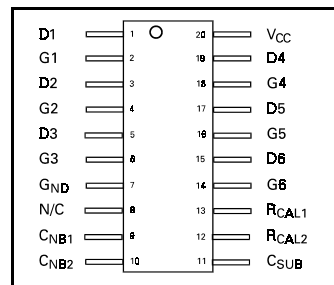


**ZNBG4000 ZNBG4001**  
**ZNBG6000 ZNBG6001**

**CONNECTION DIAGRAMS**



**ZNBG4000**  
**ZNBG4001**



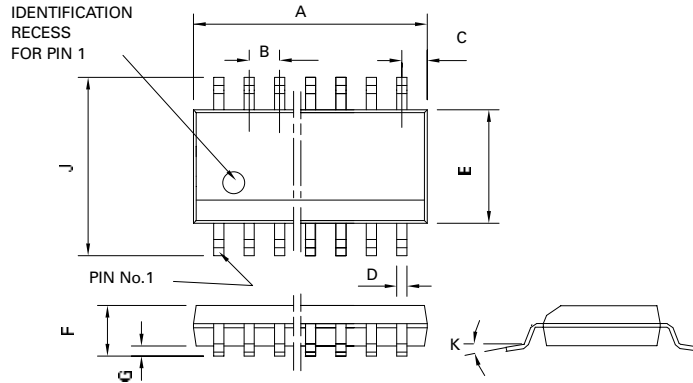
**ZNBG6000**  
**ZNBG6001**

**ORDERING INFORMATION**

| Part Number | Package | Part Mark |
|-------------|---------|-----------|
| ZNBG4000Q16 | QSOP16  | ZNBG4000  |
| ZNBG4001Q16 | QSOP16  | ZNBG4001  |
| ZNBG6000Q20 | QSOP20  | ZNBG6000  |
| ZNBG6001Q20 | QSOP20  | ZNBG6001  |

**ZNBG4000 ZNBG4001**  
**ZNBG6000 ZNBG6001**

**PACKAGE DIMENSIONS**



**QSOP16**

| PIN | Millimetres |       | Inches    |       |
|-----|-------------|-------|-----------|-------|
|     | MIN         | MAX   | MIN       | MAX   |
| A   | 4.80        | 4.90  | 0.033     | 0.039 |
| B   | 0.635       |       | 0.025 NOM |       |
| C   | 0.177       | 0.267 | 0.007     | 0.011 |
| D   | 0.20        | 0.30  | 0.008     | 0.012 |
| E   | 3.81        | 3.99  | 0.15      | 0.157 |
| F   | 1.35        | 1.75  | 0.053     | 0.069 |
| G   | 0.10        | 0.25  | 0.004     | 0.01  |
| J   | 5.79        | 6.20  | 0.228     | 0.244 |
| K   | 0°          | 8°    | 0°        | 8°    |

**QSOP20**

| PIN | Millimetres |      | Inches    |       |
|-----|-------------|------|-----------|-------|
|     | MIN         | MAX  | MIN       | MAX   |
| A   | 8.55        | 8.74 | 0.337     | 0.344 |
| B   | 0.635       |      | 0.025 NOM |       |
| C   | 1.42        | 1.52 | 0.056     | 0.06  |
| D   | 0.20        | 0.30 | 0.008     | 0.012 |
| E   | 3.81        | 3.99 | 0.15      | 0.157 |
| F   | 1.35        | 1.75 | 0.053     | 0.069 |
| G   | 0.10        | 0.25 | 0.004     | 0.01  |
| J   | 5.79        | 6.20 | 0.228     | 0.244 |
| K   | 0°          | 8°   | 0°        | 8°    |



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