

Summary

The ZABG6004 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 ZABG6004 provides drain voltage and current control for up to 6 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 ZABG6004 uses two resistors and drain current control is split between the six FETs in a group of two and a group of four. This allows the operating current of input FETs to be adjusted to minimize noise, whilst the following FET stages can be adjusted for maximum gain.

Features

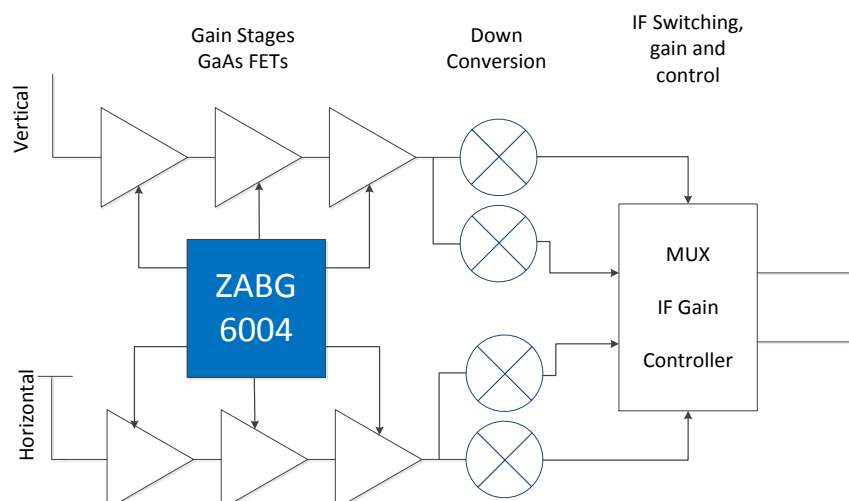
- Provides Bias for up to 6 GaAs and HEMT FETs
- Operating Range of 2.1V to 5V
- Ultra-low Operating Current of 1.1mA
- Dynamic FET Protection
- Amplifier FET Drain Current Selectable (4mA to 15mA)
- Regulated Negative Rail Generator Requires only 1 External Capacitor
- Extended Temperature Range of -40°C to +105°C
- U-QFN3030-16 (Type B) and QSOP-20 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 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 ZABG6004 has six 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 and the later stages for optimum gain. All FET groups can be operated at currents in the range 4mA to 15mA, R_{CAL1} sets the drain current for D1 and D4 and R_{CAL2} sets the drain current for D2, D3, D5 and D6. It is not recommended to connect R_{CAL1} and R_{CAL2} together.

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 ZABG6004 includes an integrated switched capacitor DC-DC converter generating a regulated output of -2V to allow single supply operation. The ZABG6004 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.

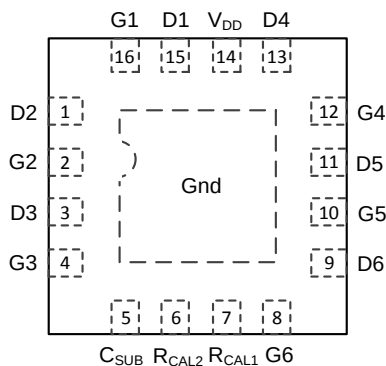
To protect the external FETs the circuits have been designed to ensure that, under any conditions including power up/down transients, the gate drive from the bias circuits cannot exceed -2.5V. Additionally each stage has its own individual current limiter. Furthermore if the negative rail experiences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

The ZABG6004 is available in the U-QFN3030-16 (Type B) and the QSOP-20 packages.

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

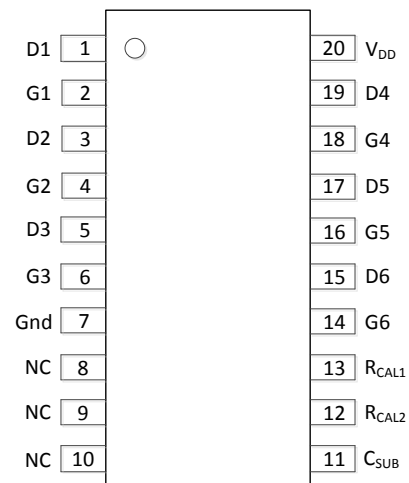
Pin Assignments and Descriptions

(Top View)



U-QFN3030-16 (Type B)

(Top View)



QSOP-20

Pin Number		Pin Name	Description
U-QFN3030-16 (Type B)	QSOP-20		
	3	D2	Drain GaAs FET 2
2	4	G2	Gate GaAs FET 2
3	5	D3	Drain GaAs FET 3
4	6	G3	Gate GaAs FET 3
5	11	CSUB	Negative rail reservoir capacitor
6	12	R _{CAL2}	Drain current setting for D1 and D4
7	13	R _{CAL1}	Drain current setting for D2, D3, D5 and D6
8	14	G6	Gate GaAs FET 6
9	15	D6	Drain GaAs FET 6
10	16	G5	Gate GaAs FET 5
11	17	D5	Drain GaAs FET 5
12	18	G4	Gate GaAs FET 4
13	19	D4	Drain GaAs FET 4
14	20	V _{DD}	Supply voltage
15	1	D1	Drain GaAs FET 1
16	2	G1	Gate GaAs FET 1
Pad	—	Gnd	Must be connected to Ground

Maximum Ratings

Symbol	Parameter	Rating	Unit
V_{DD}	Supply Voltage	-0.6 to +6	V
I_{DD}	Supply Current	100	mA
—	Power Dissipation U-QFN3030-16 (Type B)	650	mW
—	Power Dissipation QSOP-20	600	mW
T_J	Junction Temperature	+135	°C
T_{STG}	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	$I_{D1-6} = 0$	—	1.1	2.5	mA
$I_{DD(L)}$		$I_{D1-6} = 10\text{mA}$	—	—	65	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)	$C_{GATE-GND} = 10\text{nF}$ $C_{DRAIN-GND} = 10\text{nF}$	—	—	0.02	V_{PK-PK}
$V_{G(NOISE)}$	Gate Voltage (Note 6)	$C_{GATE-GND} = 10\text{nF}$ $C_{DRAIN-GND} = 10\text{nF}$	—	—	0.005	V_{PK-PK}

Gate Characteristics

Gate (G1 to G6)

I_G	Current Range	—	-50	—	60	μA
$V_{G(L)}$	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

Drain Characteristics

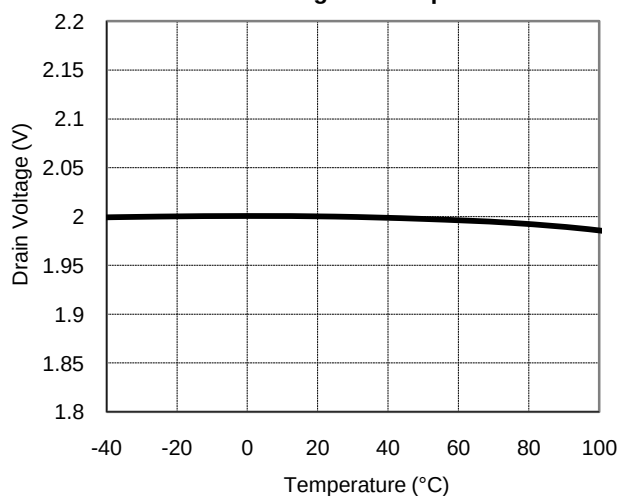
Drain (D1 to D6)

I_D	Current Range	D1 and D6	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 5.5V	—	0.075	—	%/V
dI_D/dV_{DD}	delta I_D vs V_{DD}	$V_{DD} = 2.3\text{V}$ to 5.5V	—	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

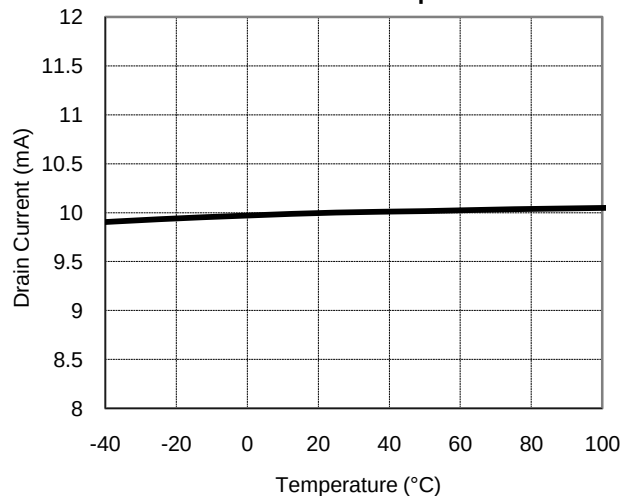
- Notes:
4. Characteristics are measured using up to two external reference resistors, R_{CAL1} and R_{CAL2} .
 5. The negative bias voltages are generated on-chip using an internal oscillator. An external 47nF capacitor is required for this purpose.
 6. Noise voltage measurements are made with FETs and gate and drain capacitors of value 10nF in place. Noise voltages are not measured in production.
 7. The maximum operating drain voltage is equal to V_{DD} or $V_{D(OP)}$ max whichever is lower.
 8. 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.)

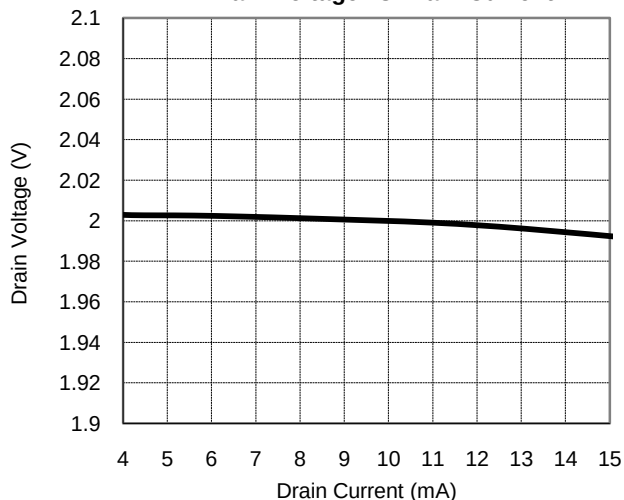
Drain Voltage vs Temperature



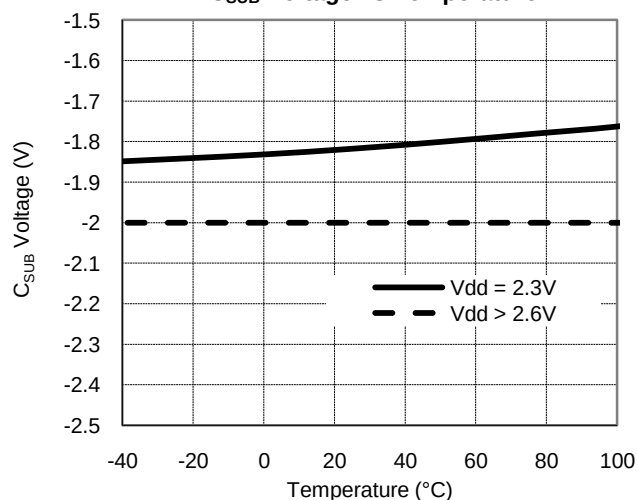
Drain Current vs Temperature



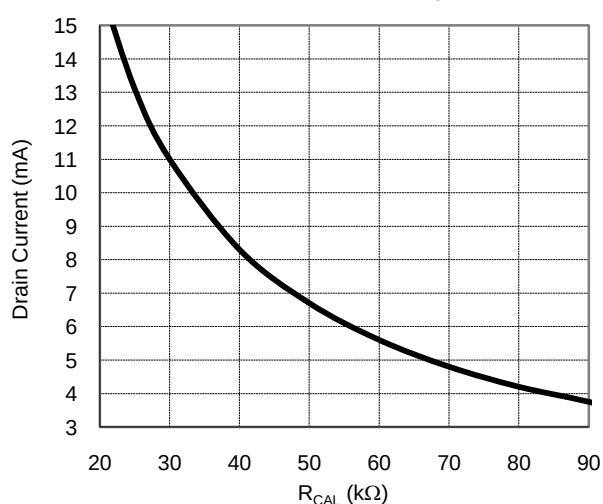
Drain Voltage vs Drain Current



C_{SUB} Voltage vs Temperature



Drain Current vs R_{CAL}



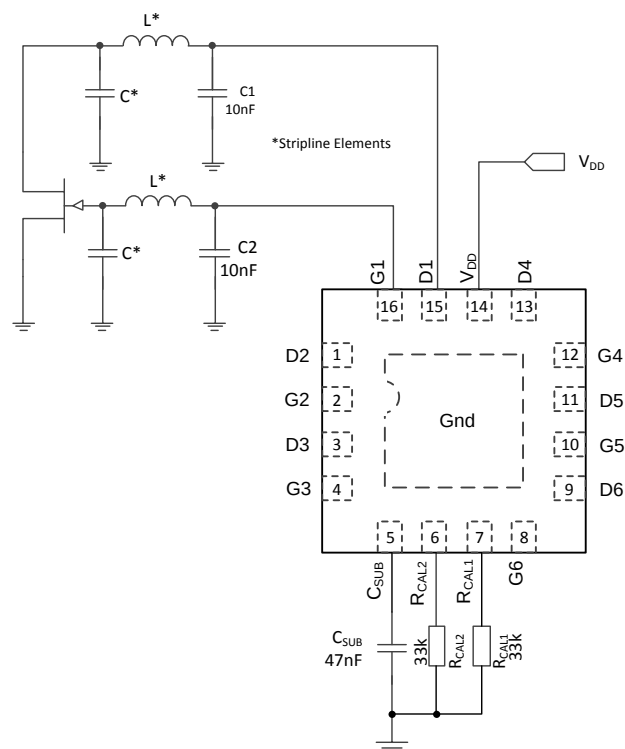
Application Information

Below are partial applications circuits for the ZABG6004 showing all external components needed for biasing one of the six 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 4, whilst R_{CAL2} sets the drain currents of stages 2, 3, 5 and 6.

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.

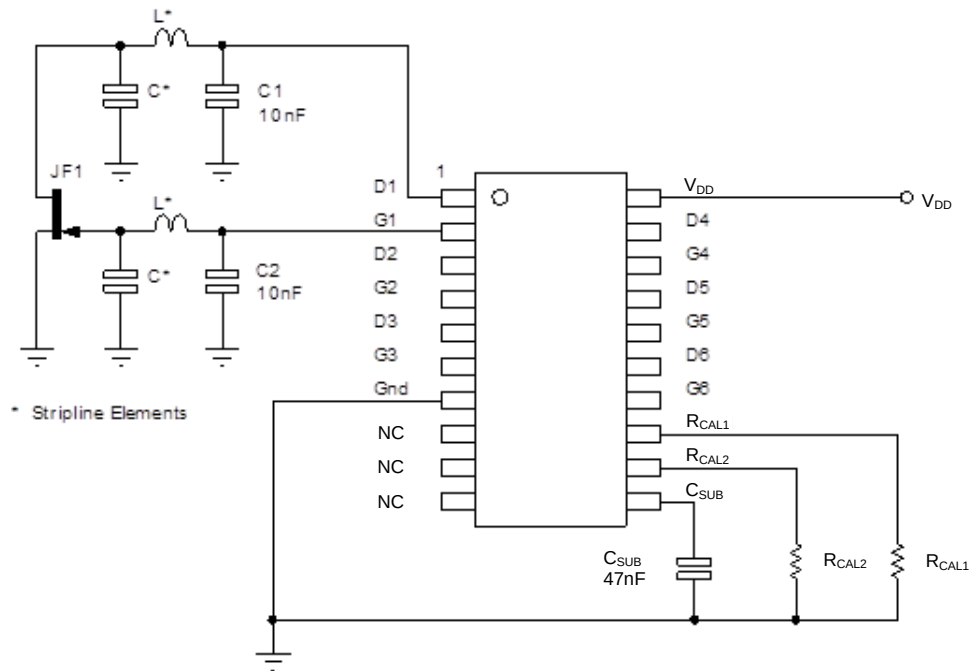
ZABG6004JA16TC



The Gnd flag on the underside ZABG6004JA16 must be connected to ground.

Application Information (Cont.)

ZABG6004Q20TC



The ZABG6004 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.

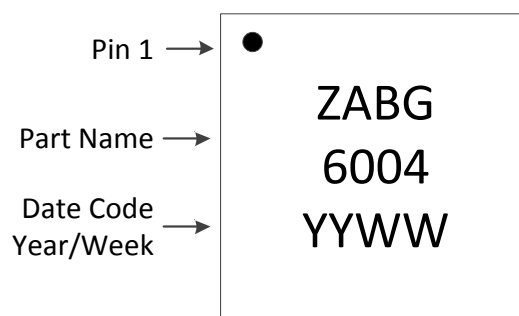
Ordering Information

Part Number	Package	Reel Size (inches)	Tape Width (mm)	Quantity Per Reel
ZABG6004JA16TC	U-QFN3030-16 (Type B)	13	12	3,000
ZABG6004Q20TC	QSOP-20	13	16	2,500

Marking Information

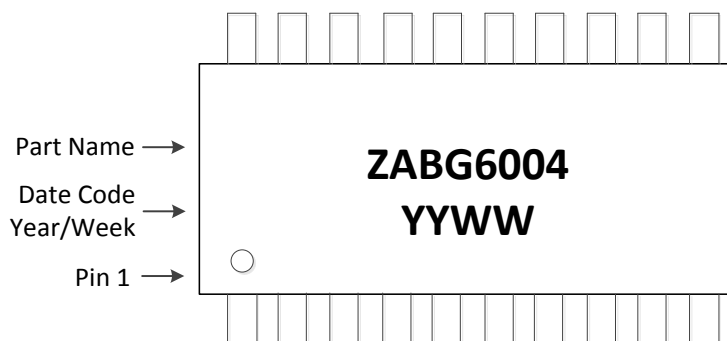
(1) U-QFN3030-16 (Type B)

(Top View)



(2) QSOP-20

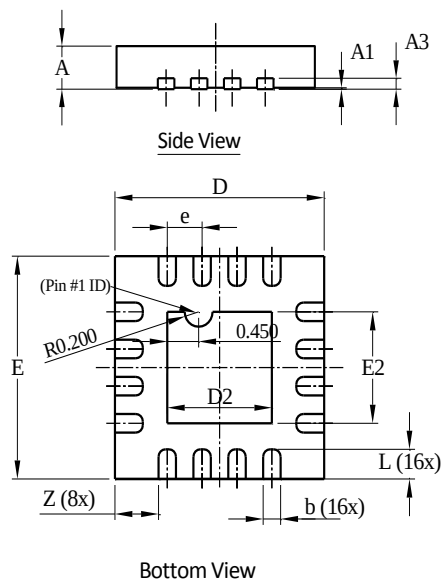
(Top View)



Package Outline Dimensions

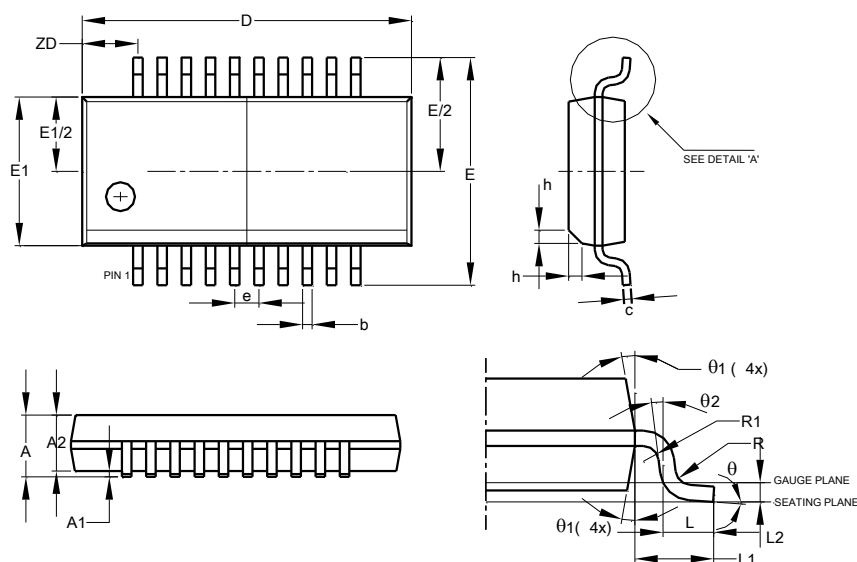
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

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



U-QFN3030-16 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			

(2) QSOP-20

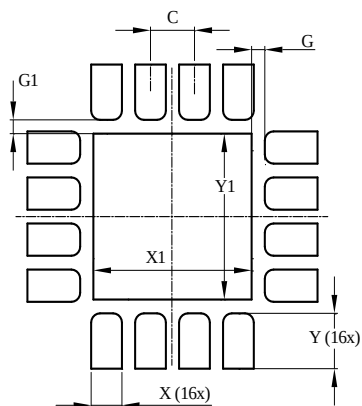


QSOP-20			
Dim	Min	Max	Typ
A	1.55	1.73	-
A1	0.10	0.25	-
A2	1.40	1.50	-
b	0.20	0.30	-
c	0.18	0.25	-
D	8.56	8.74	-
E	5.79	6.20	-
E1	3.81	3.99	-
e	0.635 BSC		
h	0.254	0.508	-
L	0.41	1.27	-
L1	1.03 REF		
L2	0.254 BSC		
R	0.0762	-	-
R1	0.0762	-	-
ZD	1.47 REF		
θ	0°	8°	-
θ1	5°	15°	-
θ2	0°	-	-
All Dimensions in mm			

Suggested Pad Layout

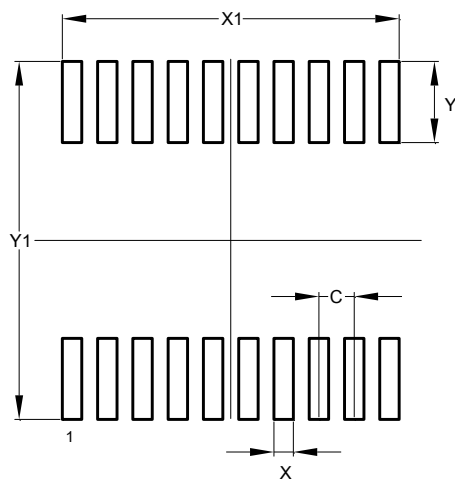
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

(1) 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

(2) QSOP-20



Dimensions	Value (in mm)
C	0.635
X	0.350
X1	6.065
Y	1.450
Y1	6.400

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