Lead-free Green

ZXBM2004

TWO PHASE VARIABLE SPEED MOTOR CONTROL PRE-DRIVER

Description

The DIODES™ ZXBM2004 is a 2-phase, Brushless Direct Current (BLDC) motor control pre-driver with variable PWM speed control suitable for fan and blower motors.

For system flexibility, motor speed can be controlled by changing SPD pin voltage which can be either from Thermistor network, external voltage or PWM signal.

To help protect the motor coil, the ZXBM2004 provides Rotor Lock Protection which shuts down the output drive if rotor lock is detected. The device automatically re-starts when the rotor lock is removed.
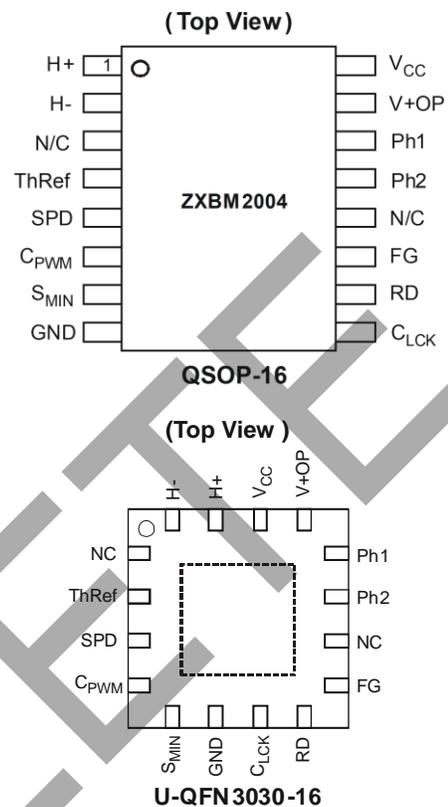
A Tachometer output is provided by open-drain Frequency Generator (FG) pin which allows external interface to monitor motor rotation or speed. The FG output is the magnetic change frequency.

The ZXBM2004 is available in small space saving low profile U-QFN3030-16 and QSOP-16 packages.

Features

- Supports Two-Phase BLDC Motor Control
- Operating Voltage: 4.7V to 18V
  - Can be Extended with External Regulator
- PWM Speed Control via External Thermister, DC Voltage or PWM Signals
- Reference Voltage Output
- Built-in Hall Amplifier Allows Direct Connection of Hall Element
- Rotor Lock Protection (Lock Detection, Output Shutdown and Automatic Restart)
- Rotor Lock Detect (RD) Output
- Minimum Speed Setting
- Frequency Generator (FG) Output for Speed Measurements
- Low Noise
- Space Saving Low Profile U-QFN3030-16 and QSOP-16 Packages
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative. https://www.diodes.com/quality/product-definitions/**

Pin Assignments

(Top View)

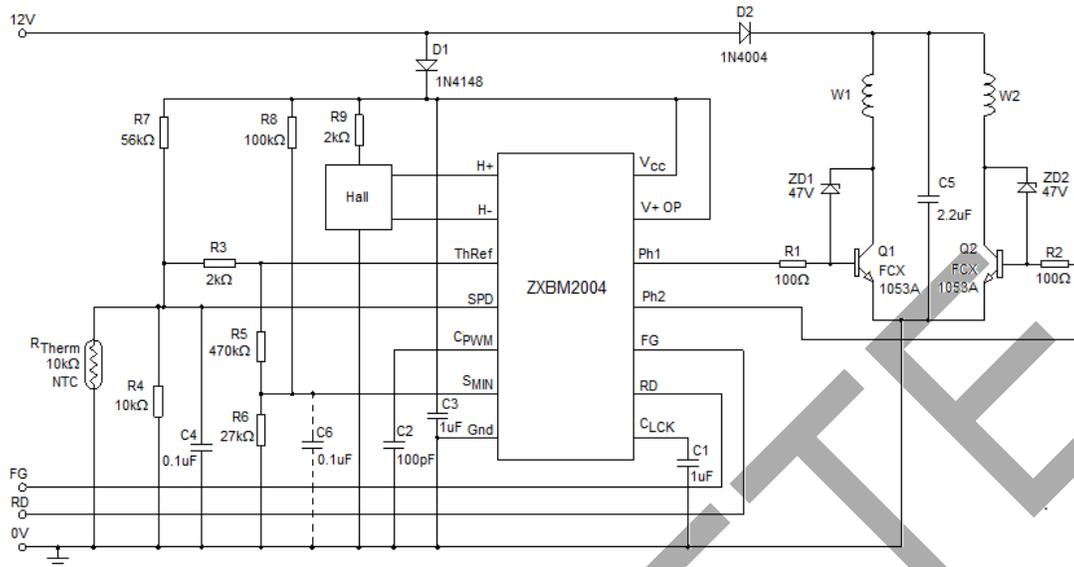

QSOP-16

(Top View)

U-QFN3030-16

Applications

- Desktop PC and servers fans and blowers
- Instrumentation fans
- Central heating blowers
- Automotive instrument cooling and climate controls
- Extractor fans
- General motors and pumps

Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ 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.
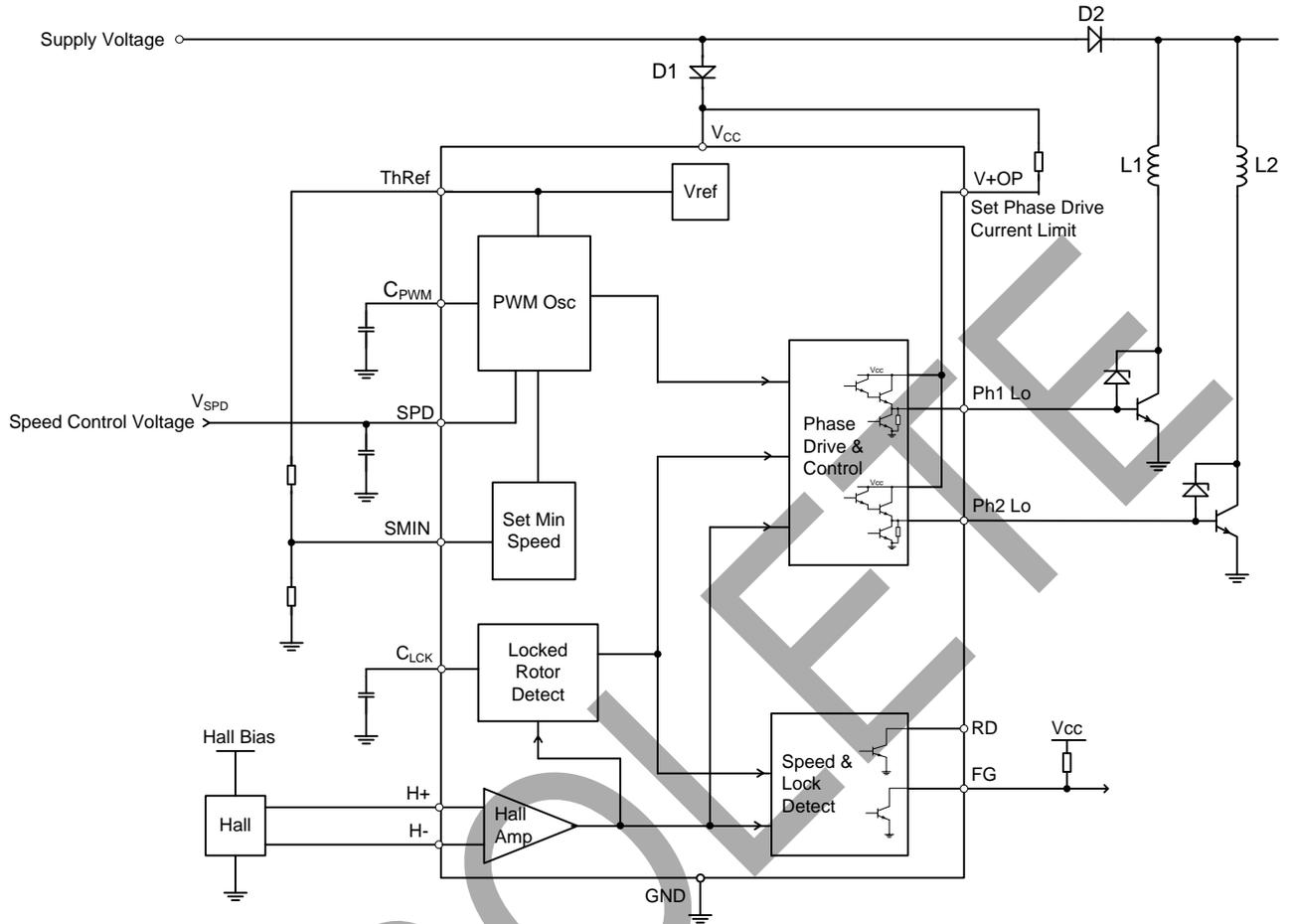
ZXBM2004
Document number: DS33433 Rev. 7 - 4
1 of 19
www.diodes.com
August 2022
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Typical Application Circuit

Pin Descriptions

Pin Name	Description
H+	Hall input to non-inverting input of internal operational amplifier
H-	Hall input to inverting input of internal operational amplifier
ThRef	Reference output voltage
SPD	Speed control pin; The control signal voltage should be between 3V to 1V for 0% to 100% (full speed) speed control.
C_{PWM}	PWM frequency setting pin: Connect a capacitor from this pin to ground (0V) to set PWM frequency. Capacitor of 0.1nF will give PWM frequency of 24kHz typical.
S_{MIN}	Minimum speed setting pin: Voltage between 3V to 1V on this pin sets the minimum speed between 0% to full speed. Lowest minimum speed achieved depends on the motor coil design.
GND	Supply return ground pin
C_{LCK}	Rotor lock detect and auto restart timing pin: Connect a capacitor from this pin to ground to set the lock detect and restart timing.
RD	Rotor lock detect pin: Open collector output to indicate rotor lock detection. Connect a pull-up resistor from the pin to the pull-up supply rail.
FG	Frequency Generator output to provide a tachometer signal
Ph1	Phase-1 low-side external power switch drive output pin: Darlington emitter follower output with active pull down to give source/sink current of 80mA/16mA
Ph2	Phase-2 low-side external power switch drive output pin: Darlington emitter follower output with active pull down to give source/sink current of 80mA/16mA
V+OP	Phase output supply voltage pin: The pin allows to optimize the supply to output drive depending on whether external power switch is Bipolar switch or MOSFET.
V_{CC}	Power supply pin

Functional Block Diagram (Note 4)

Note: 4. The ZXBM2004 has an open-collector FG and RD. Typically a pull-up resistor of 10kΩ is recommended from FG or RD pin to the supply voltage.

ZXBM2004
Document number: DS33433 Rev. 7 - 4

3 of 19
www.diodes.com

August 2022
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Absolute Maximum Ratings (T$_A$ = +25°C, unless otherwise noted.) (Note 5)

Symbol	Characteristics		Values	Unit
V$_{CCMAX}$	Supply Voltage		-0.6 to +20	V
I$_{CCMAX}$	IC Input Current		100	mA
P$_{DMAX}$	Power Dissipation (Note 7)	QSOP-16	500	mW
		U-QFN3030-16 (Note 6)	1500	
T$_A$	Operating Ambient Temperature Range		-40 to +110	°C
T$_{STG}$	Storage Temperature Range		-55 to +150	°C

Recommended Operating Conditions (T$_A$ = +25°C)

Symbol	Parameter	Conditions	Min	Max	Unit
V$_{CC}$	Supply Voltage	Operating	4.7	18.0	V
T$_A$	Operating Temperature Range	Operating	-40	+110	°C

Electrical Characteristics (T$_A$ = +25°C, V$_{CC}$ = 12V)

Symbol	Characteristics	Conditions	Min	Typ.	Max	Unit
I$_{CC}$	Supply Current	No Load (Note 7)	—	5.5	7.5	mA
V$_{IN}$	Hall Amplifier Input Voltage	Diff Peak to Peak	40	—	—	mV
V$_{CM}$	Hall Amplifier Common Mode Voltage	—	0.5	—	V$_{CC}$ -1.5	V
V$_{OFS}$	Hall Amplifier Input Offset Voltage	—	—	±7	—	mV
I$_{BS}$	Hall Amplifier Bias Current	—	—	400	700	nA
V$_{OH}$	Ph1 and Ph2 Output High Voltage	I$_{OH}$ = 80mA	V$_{CC}$ -2.2	V$_{cc}$ -1.8	—	V
V$_{OLA}$	Ph1 and Ph2 Output Low Voltage	I$_{OH}$ = 16mA (Note 8)	—	0.4	0.6	V
V$_{OLB}$	Ph1 and Ph2 Output Low Voltage	I$_{OH}$ = 50uA (Note 9)	—	0.4	0.6	V
I$_{OH}$	Ph1 and Ph2 Output Source Current	—	—	—	80	mA
I$_{OL}$	Ph1 and Ph2 Output Sink Current	—	—	—	16	mA
I$_{PWMC}$	C$_{PWM}$ Charge Current	—	4.5	—	7.85	μA
I$_{PWMD}$	C$_{PWM}$ Discharge Current	—	38	—	65	μA
V$_{THH}$	C$_{PWM}$ High Threshold Voltage	—	—	3	—	V
V$_{THL}$	C$_{PWM}$ Low Threshold Voltage	—	—	1	—	V
f$_{PWM}$	PWM Frequency	C$_{PWM}$ = 0.1nF	—	24	—	kHz

Notes: 5. Stresses greater than those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to *Absolute Maximum Ratings* for extended periods can affect device reliability.
6. U-QFN3030-16 dissipation is based on a two-layer 2oz. copper 2" x 2" FR4 substrate PCB with thermal vias to the bottom layer.
7. Measure with pins H+, H-, C$_{LCK}$ and C$_{PWM}$ and all other signal pins open circuit.
8. Measured when opposing Phase Output is Low.
9. Measured when opposing Phase Output is High.

Electrical Characteristics (T$_A$ = +25°C, V$_{CC}$ = 12V) (continued)

Symbol	Characteristics	Conditions	Min	Typ.	Max	Unit
V$_{ThRef}$	ThRef Reference Output Voltgae	I$_{OThRef}$ = 100µA	2.88	2.96	3.10	V
I$_{OThRef}$	ThRef Output Current	—	—	—	1	mA
I$_{ISMIN}$	S$_{MIN}$ Input Current	V$_{IN}$ = 2V, SPD = Open	—	-0.25	-0.3	µA
V$_{SPDL}$	SPD Voltage Minimum	100% PWM Drive	—	1	—	V
V$_{SPDH}$	SPD Voltage Maximum	0% PWM Drive	—	3	—	V
I$_{ISPD}$	SPD Voltage Maximum	V$_{IN}$ = 2V	—	0.8	2	uA
I$_{LCKC}$	C$_{LCK}$ Charge Current	—	2.8	3.8	—	uA
I$_{LCKD}$	C$_{LCK}$ Discharge Current	—	—	4.6	054	uA
V$_{CLCKTHH}$	C$_{LCK}$ High Threshold Voltage	—	—	3	—	V
V$_{CLCKTHL}$	C$_{LCK}$ Low Threshold Voltage	—	—	1	—	V
—	Lock Condition On: Off Ratio	—	—	1:12	—	—
I$_{FGOL}$	FG Low Level Output Current	—	—	—	5	mA
V$_{FGOL}$	FG Low Level Output Voltage	I$_{FGOL}$ = 5mA	—	—	0.5	V
I$_{RDOL}$	RD Low Level Output Current	—	—	—	5	mA
V$_{RDOL}$	RD Low Level Output Current	I$_{RDOL}$ = 5mA	—	—	0.5	V
t$_{CD}$	Commutation Delay	—	—	7.5	—	µs

Functional Description

H+ and H- Hall Inputs

The rotor position is detected by a Hall sensor, with the output applied to the H+ and H- pins. This sensor can be either a 4 pin 'naked' Hall device or of the 3 pin buffered switching type. For a 4 pin device, the differential Hall output signal is connected to the H+ and H- pins. For a buffered Hall sensor, the Hall device output is attached to the H+ pin, with a pull-up attached if needed, whilst the H- pin has an external potential divider attached to hold the pin at half V_{CC}. When H+ is high in relation to H-, Ph2 is the active drive.

ThRef – Output Reference Voltage

This is a reference voltage of nominal 3V. It is designed for the ability to 'source' and therefore it will not 'sink' any current from a higher voltage. The current drawn from the pin by the minimum speed potential divider to pin S_{MIN} and any voltage setting network should not exceed 1mA in total at maximum temperature.

SPD – Speed Control Input

The voltage applied to the SPD pin provides control over motor speed by varying the Pulse Width Modulated (PWM) drive ratio at the Ph1 and Ph2 outputs. The control signal takes the form of a voltage input of range 3V to 1V, representing 0% to 100% drive respectively.

If variable speed control is not required, this pin can be left with an external potential divider to set a fixed speed or tied to ground to provide full speed i.e. 100% PWM drive.

If required, this pin can also be used as an enable pin. The application of a voltage >3.0V will force the PWM drive fully off, in effect disabling the drive.

S$_{MIN}$ – Minimum Speed Setting

A voltage can be set on S_{MIN} pin via a potential divider between the ThRef and GND pins. This voltage is monitored by the SPD pin such that internally SPD voltage cannot rise above S_{MIN} voltage. As a higher voltage on the SPD pin represents a lower speed, it therefore restricts the lower speed range of the fan. If this feature is not required, the pin is left tied to ThRef so no minimum speed will be set.

If the fan is being controlled from an external voltage source onto the SPD pin, then either this feature should not be used or if it is required that a resistor greater than 1kΩ should be placed in series with the SPD pin.

C$_{PWM}$ – Output PWM Frequency Setting

This pin has an external capacitor attached to set the PWM frequency for the Phase drive outputs. A capacitor value of 0.1nF will provide a PWM frequency of typically 24kHz. The C_{PWM} timing period (t_{PWM}) is determined by the following equation:

$$t_{PWM} = \frac{(V_{THH} - V_{THL}) \times C}{I_{PWMC}} + \frac{(V_{THH} - V_{THL}) \times C}{I_{PWMD}}$$

Where: $C = (C_{PWM} + 15)$ in pF

V_{THH} and V_{THL} are the C_{PWM} pin threshold voltages

I_{PWMC} and I_{PWMD} are the charge and discharge currents in µA.

t_{PWM} is in ms

As these threshold voltages are nominally set to V_{THH} = 3V and V_{THL} = 1V the equations can be simplified as follows:

$$t_{PWM} = \frac{2C}{I_{PWMC}} + \frac{2C}{I_{PWMD}}$$

ZXBM2004
Document number: DS33433 Rev. 7 - 4

6 of 19
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August 2022
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Functional Description (continued)

C~LCK~ – Locked Rotor Timing Capacitor

Should the fan stop rotating for any reason, i.e. an obstruction in the fan blade or a seized bearing, then the device will enter a Rotor Locked condition. In this condition after a predetermined time (t_{LOCK}), the RD pin will go high and the Phase outputs will be disabled. After a further delay (t_{OFF}), the controller will re-enable the Phase drive for a defined period (t_{ON}) in an attempt to restart the fan. This cycle of (t_{OFF}) and (t_{ON}) will be repeated indefinitely or until the fan restarts.

GND – Supply Return

This is the device supply ground return pin and will generally be the most negative supply pin to the fan.

RD – Rotor Lock Detect Output

This pin is the Locked Rotor status output as referred to in the C~LCK~ timing section above. It is high when the rotor is stopped and low when it is running.

This is an open collector drive giving an active pull down with the high level being provided by an external pull up resistor.

RD Timing Diagram

ZXBM2004
Document number: DS33433 Rev. 7 - 4

7 of 19
www.diodes.com

August 2022
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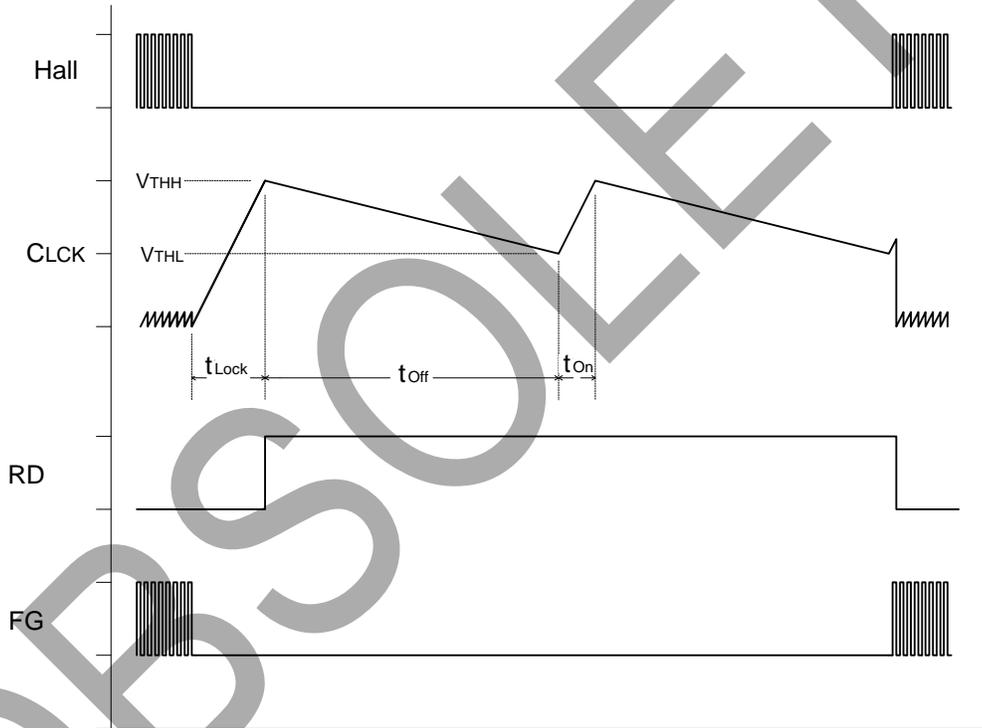
Functional Description (continued)

FG – Frequency Generator (Tachometer) Output
This is the Frequency Generator output and is a buffered signal from the Hall sensor.

This is an open collector drive giving an active pull down with the high level being provided by an external pull up resistor.

Ph1 and Ph2 Output Drives
This pair of outputs drives the external devices. These outputs provide both the commutation and PWM waveforms. The outputs are of the Darlington emitter follower type with an active pull-down to help faster switch off when using bipolar devices. When in the high state the outputs will provide up to 80mA of drive into the base or gates of external transistors as shown in the Typical Application circuit following.

When in the low state, the active Phase drive is capable of sinking up to 16mA when driving low to aid turn off times during PWM operation. When the Phase is inactive, the output is held low by an internal pull-down resistor.

V+OP Phase Outputs Supply Voltage
This pin is the supply to the Phase outputs and will be connected differently dependant upon external transistor type. For bipolar devices, this pin will be connected by a resistor to the V_{CC} pin. The resistor is used to control the current into the transistor base so its value is chosen accordingly. For MOSFET devices, the pin will connect directly to the V_{CC} pin.

V_{CC} – Supply Voltage
This is the device internal circuitry supply voltage. For 5V to 12V fans, this can be supplied directly from the Fan Motor supply. For fans likely to run in excess of the 18V maximum rating for the device, this will be supplied from an external regulator such as a Zener diode.

ZXBM2004
Document number: DS33433 Rev. 7 - 4

8 of 19
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August 2022
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Application Note

The ZXBM2004 is primarily controlled by a voltage on the SPD pin. A voltage of 1V represents a 100% PWM at the Phase Outputs and in turn represents full speed. 3V on the SPD pin conversely represents 0% PWM. The motor can therefore be controlled simply by applying a control voltage onto the SPD pin with the minimal use of external components.

This voltage control method easily lends itself to control by other signal types. For example, if a Thermistor is applied to the SPD pin, a varying voltage can be generated at the SPD pin as the resistance of the Thermistor varies with temperature.

A common form of control of fans is by a PWM signal derived from a central processor or controller. This signal can be converted into a voltage and that voltage adjusted as necessary to compensate for motor none linearity, inclusion of the Minimum speed feature etc.

Full applications details and further examples of how to control the ZXBM2004 are available in the Applications Notes AN41, AN42 and AN43.
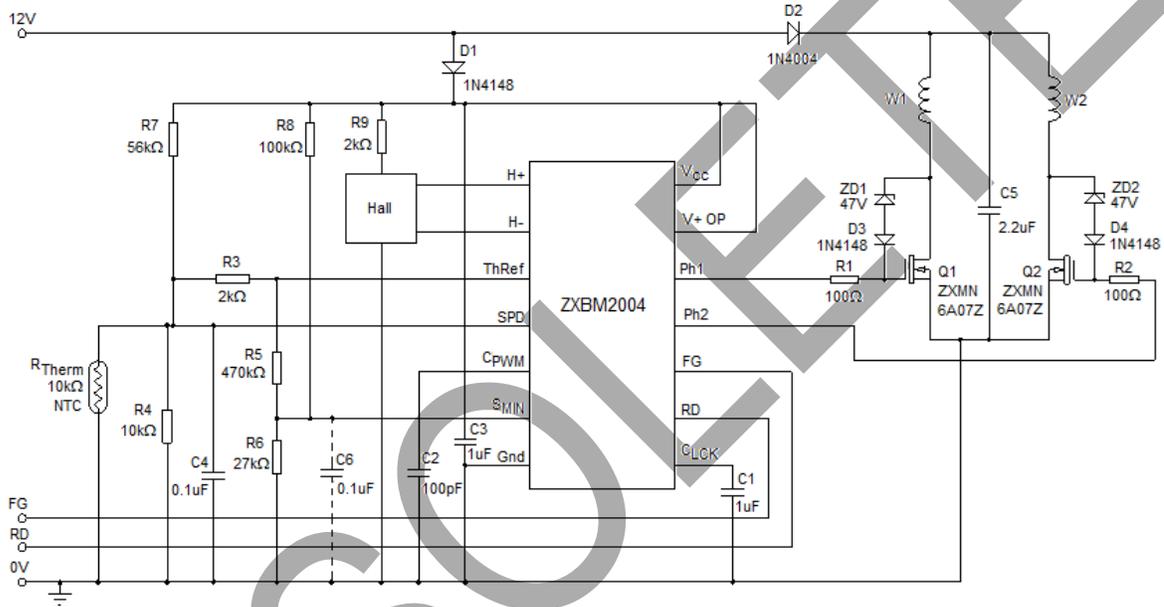
Fig 1. 12V Typical Circuit for Thermistor Controlled Speed

ZXBM2004
Document number: DS33433 Rev. 7 - 4

9 of 19
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August 2022
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Application Note (continued)
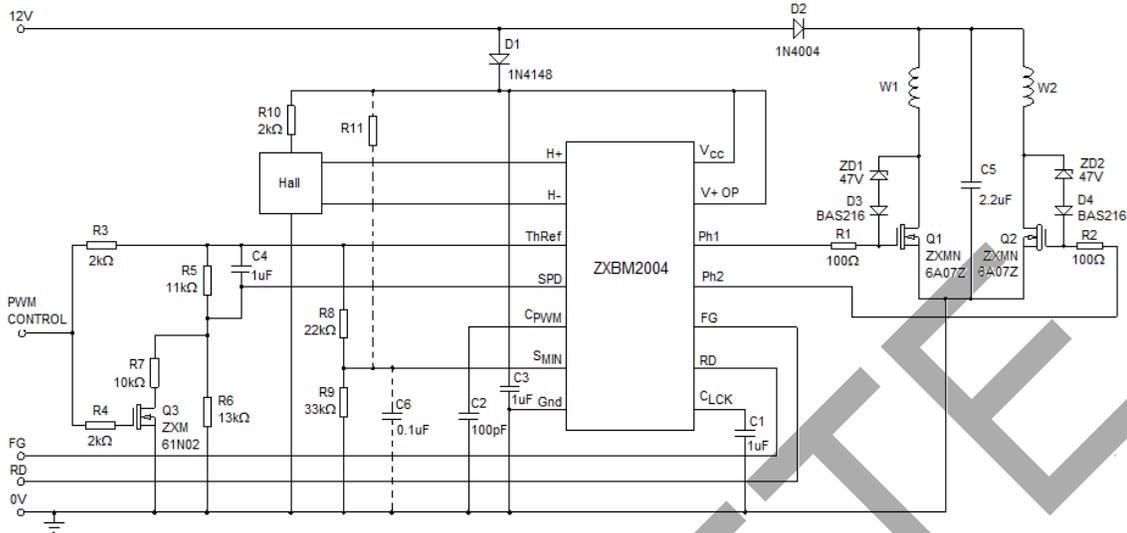
Fig. 2 Typical Circuit for External PWM Controlled Speed (Single MOSFET)
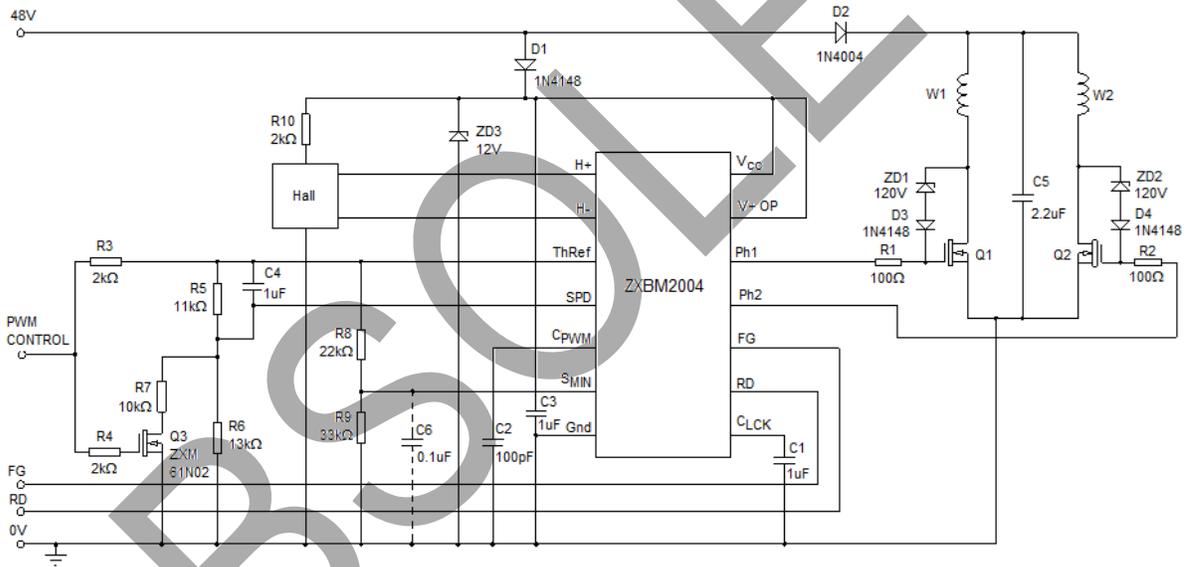
Fig. 3 Typical Circuit for 48V Input and External PWM Control

ZXBM2004
Document number: DS33433 Rev. 7 - 4

10 of 19
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Application Note (continued)
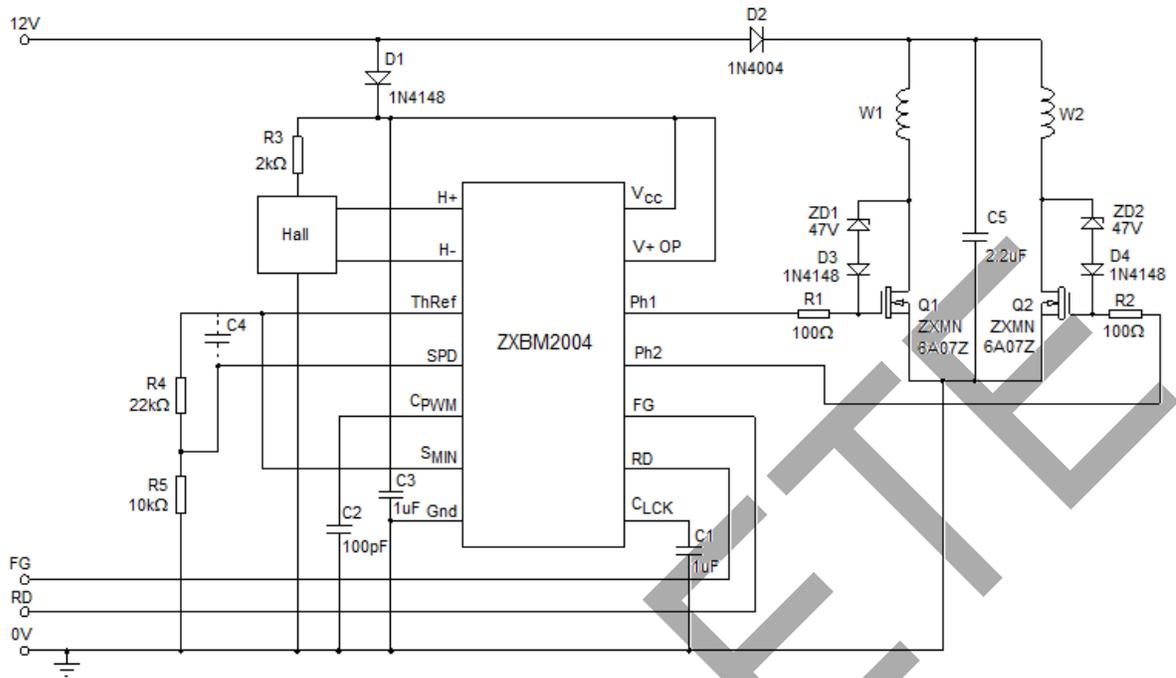
Fig. 4 Typical Circuit for Constant Speed Operation

ZXBM2004
Document number: DS33433 Rev. 7 - 4

11 of 19
www.diodes.com

August 2022
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Application Note (continued)

External Drive Transistors

Diodes Incorporated offers a range of devices that are ideally suited to interface between the ZXBM2004 controller and the motor. The following tables show a selection of products. If your needs are not covered by this selection, then please refer to the more comprehensive listings that can be found on the Diodes Incorporated's website: https://www.diodes.com.

MOSFETS

Part Number	Type	BV$_{DSS}$ (V)	I$_D$ (A)	R$_{DS(ON)}$ @ V$_{GS}$ = 10V (Ω)	Package
Power Switch					
DIODES™ ZXMN10A09K	N	100	7.7	0.085	TO252-3L
DIODES™ ZXMN10A25K	N	100	6.4	0.125	TO252-3L
DIODES™ ZXMN10A25G	N	100	4.0	0.125	SOT223
DIODES™ ZXMN10A11G	N	100	2.4	0.35	SOT223
DIODES™ ZXMN10A08DN8	2 x N	100	2.1	0.25	SO8
DIODES™ ZXMN10B08E6	N	100	1.9	0.230	SOT23-6
DIODES™ ZXMN10A07Z	N	100	1.4	0.7	SOT89
DIODES™ ZXMN6A09K	N	60	11.2	0.04	TO252-3L
DIODES™ ZXMN6A25K	N	60	10.7	0.05	TO252-3L
DIODES™ DMN6068LK3	N	60	8.5	0.068	TO252-3L
DIODES™ ZXMN6A09G	N	60	7.5	0.04	SOT223
DIODES™ ZXMN6A25G	N	60	6.7	0.05	SOT223
DIODES™ ZXMN7A11K	N	60	6.1	0.120	TO252-3L
DIODES™ ZXMN6A09DN8	2 x N	60	5.6	0.04	SO8
DIODES™ DMN6068SE	N	60	5.6	0.068	SOT223
DIODES™ ZXMN6A08G	N	60	5.3	0.08	SOT223
DIODES™ ZXMN6A25DN8	2 x N	60	4.7	0.055	SO8
DIODES™ ZXMN6A11Z	N	60	3.6	0.120	SOT89
DIODES™ ZXMN6A07Z	N	60	2.2	0.250	SOT89
DIODES™ ZXMN6A07F	N	60	1.4	0.250	SOT23

ZXBM2004
Document number: DS33433 Rev. 7 - 4

12 of 19
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August 2022
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Application Note (continued)

Bipolar Transistors

Part Number	Type	V_CEO (V)	I_C (A)	V_CE(sat) @I_C/I_B (mV @ A/mA)	Package
Power switch					
DIODES™ FZT855	NPN	150	4	65 @ 0.5/50	SOT223
DIODES™ FMMT624	NPN	125	1	150 @ 0.5/50	SOT23
DIODES™ ZX5T853G	NPN	100	6	125 @ 2/100	SOT223
DIODES™ ZXTN19100CZ	NPN	100	5.25	65 @ 1/100	SOT89
DIODES™ ZXTN25100BFH	NPN	100	3	135 @ 0.5/10	SOT23
DIODES™ ZXTN25100DFH	NPN	100	2.5	170 @ 0.5/10	SOT23
DIODES™ FCX493	NPN	100	1	300 @ 0.5/50	SOT89
DIODES™ FCX1053A	NPN	75	3	200 @ 1/10	SOT89
DIODES™ ZXTN19060CG	NPN	60	7	155 @ 1/10	SOT223
DIODES™ ZX5T851G	NPN	60	6	135 @ 2/50	SOT223
DIODES™ DXT2010P5	NPN	60	5	70 @ 1/10	PowerDI5
DIODES™ FCX493A	NPN	60	1	500 @ 1/50	SOT89
DIODES™ FCX619	NPN	50	3	260 @ 2/50	SOT89
DIODES™ FMMT619	NPN	50	2	220 @ 2/50	SOT23
DIODES™ FCX619	NPN	50	3	260 @ 2/50	SOT89
Drive Buffer and Level Shift					
DIODES™ FMMT493	NPN	100	1	300 @ 0.5/50	SOT23
DIODES™ FMMT493A	NPN	60	1	250 @ 0.5/50	SOT23
DIODES™ ZXTN2038F	NPN	60	1	250 @ 0.5/50	SOT23
DIODES™ DSS4160	NPN	60	1	140 @ 0.5/50	SOT563

ZXBM2004
Document number: DS33433 Rev. 7 - 4

13 of 19
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August 2022
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Thermal Performance Characteristics

(1)   Package Type: QSOP-16

QSOP-16 Derating Curve
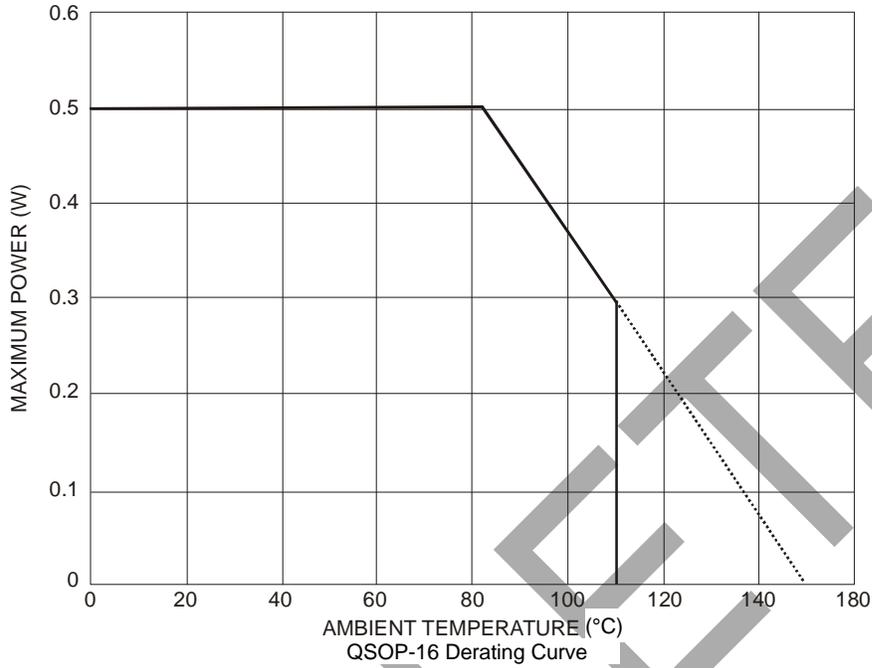
(2)   Package Type: U-QFN3030-16 (Note 10)

U-QFN3030-16 Derating Curve
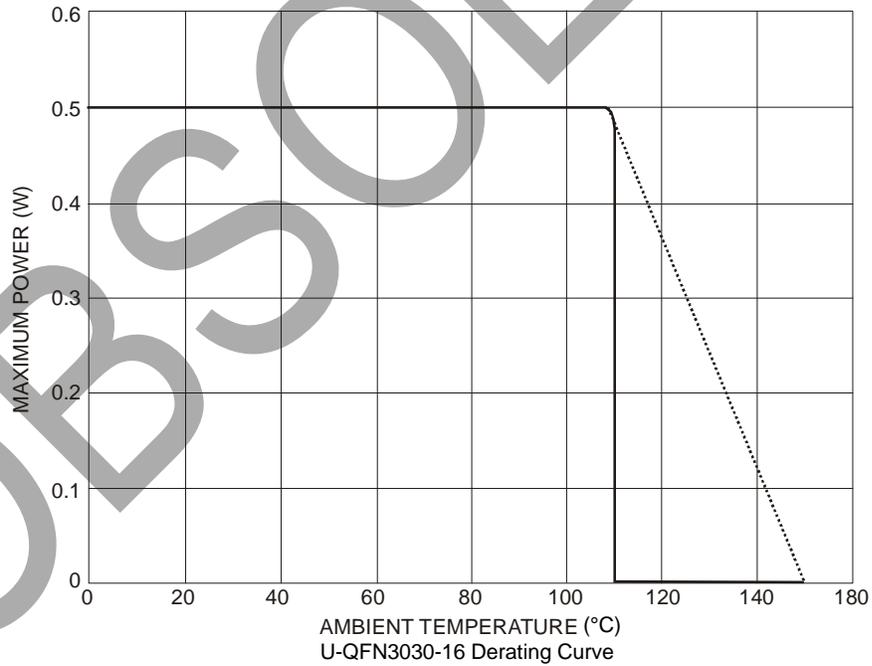
Note: 10. U-QFN3030-16 dissipation is based on a two-layer 2oz. copper 2" x 2" FR4 substrate PCB with thermal vias to the bottom layer.

DIODES
INCORPORATED

Ordering Information

ZXBM2004 X TC

Package	Packing
Q16 : QSOP-16	TC : 13" Tape & Reel
JA16 : U-QFN3030-16	
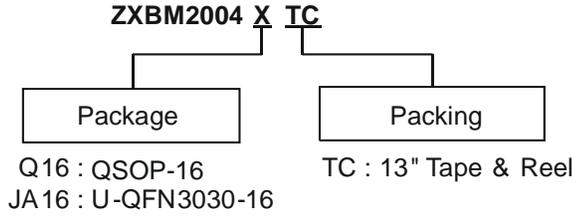
Part Number	Part Number Suffix	Package (Note 11)	Packing	
			Qty.	Carrier
ZXBM2004Q16TC	TC	QSOP-16	2500	13" Tape and Reel
ZXBM2004JA16TC	TC	U-QFN3030-16	3000	13" Tape and Reel

Note: 11. Pad layout as shown on Diodes Incorporated's suggested pad layout, which can be found on our website at http://www.diodes.com/package-outlines.html.

Marking Information

(1) Package Type: QSOP-16

(Top View)
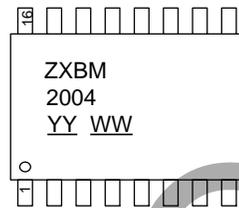
ZXBM
2004
YY WW

YY : Year 00 to 99 (ex: 22 = 2022)
WW : Week : Week 01 to 52 ;
      52 represents Week 52 and 53

Part Number	Package	Identification Code
ZXBM2004Q16TC	QSOP-16	ZXBM 2004

(2) Package Type: U-QFN3030-16

(Top View)

XX
Y W Z
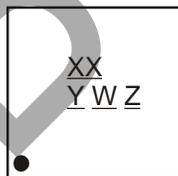
XX : Identification Code
Y : Year 0 to 9 (ex: 2 = 2022)
W : Week: A to Z: Week 1 to 26;
      a to z: Week 27 to 52; z represents
      Week 52 and 53
Z : A to Z: Internal Code

Part Number	Package	Identification Code
ZXBM2004JA16TC	U-QFN3030-16	24

Package Outline Dimensions

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

(1) Package Type: QSOP-16
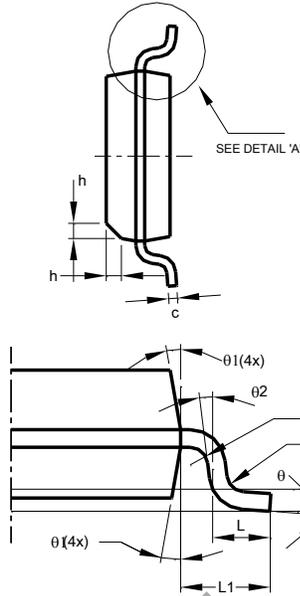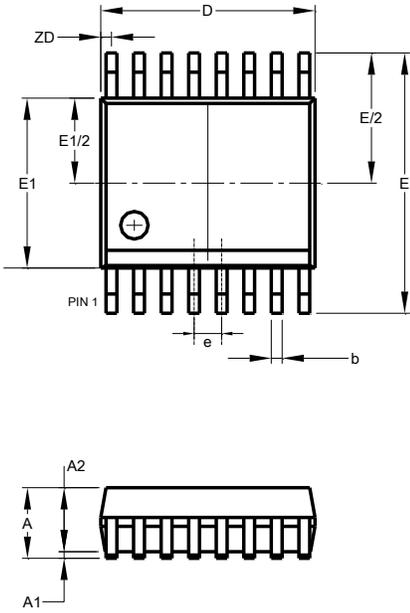
QSOP-16			
Dim	**Min**	**Max**	**Typ**
A	1.55	1.73	-
A1	0.10	0.25	-
A2	1.40	1.50	-
b	0.20	0.30	-
c	0.18	0.25	-
D	4.80	5.00	-
E	5.79	6.20	-
E1	3.81	3.99	-
e	0.635 BSC		
h	0.254	0.508	-
L	0.41	1.27	-
L1	1.03 REF		
L2	0.254 BSC		
R	0.0762	-	-
R1	0.0762	-	-
ZD	0.23 REF		
θ	0°	8°	-
θ1	5°	15°	-
θ2	0°	-	-
All Dimensions in mm			

(2) Package Type: U-QFN3030-16

Side View

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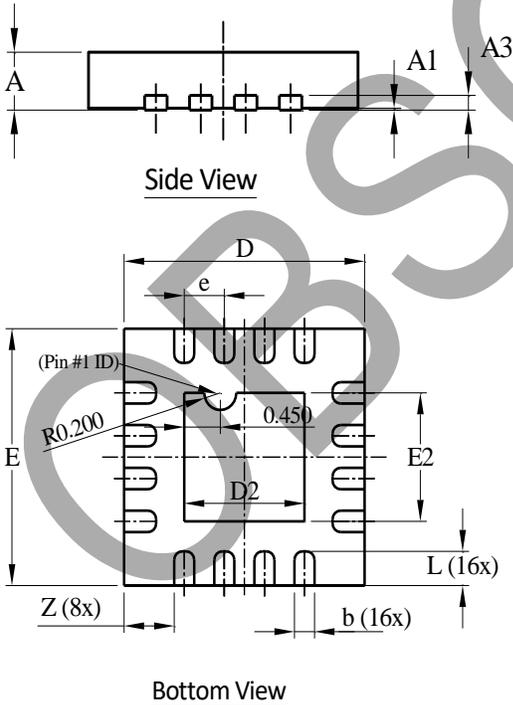
U-QFN3030-16			
Dim	**Min**	**Max**	**Typ**
A	0.55	0.65	0.60
A1	0	0.05	0.02
A3	—	—	0.15
b	0.18	0.28	0.23
D	2.95	3.05	3.00
D2	1.40	1.60	1.50
E	2.95	3.05	3.00
E2	1.40	1.60	1.50
e	—	—	0.50
L	0.35	0.45	0.40
Z	—	—	0.625
All Dimensions in mm			

Suggested Pad Layout

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

(1)   Package Type: QSOP-16
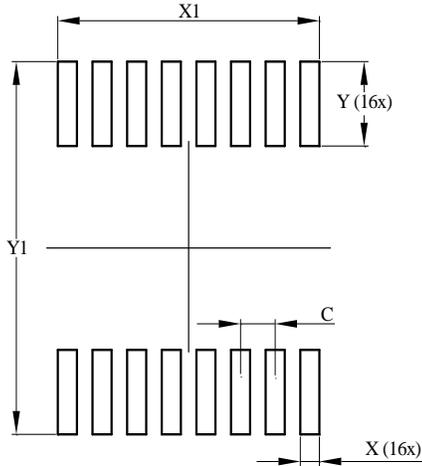
Dimensions	Value (in mm)
C	0.635
X	0.350
X1	4.795
Y	0.1.450
Y1	6.400
All Dimensions in mm	

(2)   Package Type: U-QFN3030-16
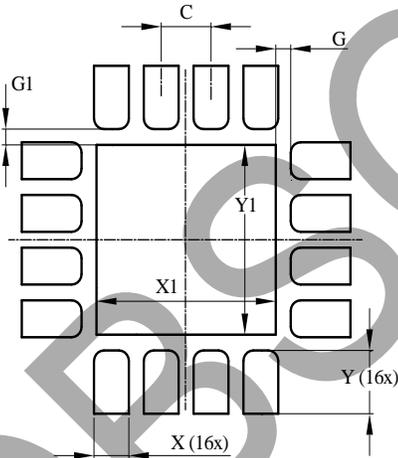
Dimensions	Value (in mm)
C	0.500
G	0.150
G1	0.150
X	0.350
X1	1.800
Y	0.600
Y1	1.800
All Dimensions in mm	

Taping Orientation

For QSOP-16 and U-QFN3030-16

Top cover tape thickness 0.10mm Max.

Embossed Carrier

Cavity

Direction of feed
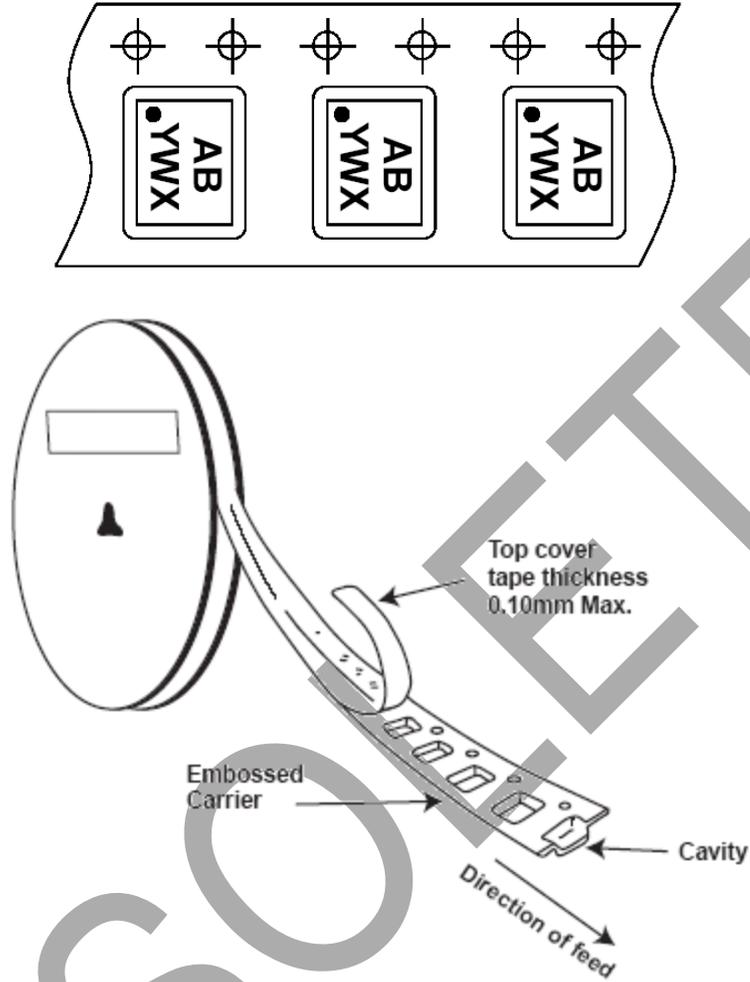
Note: 12. The taping orientation of the other package type can be found on our website at http://www.diodes.com/datasheets/ap02007.pdf.

ZXBM2004
Document number: DS33433 Rev. 7 - 4

18 of 19
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IMPORTANT NOTICE

ZXBM2004
Document number: DS33433 Rev. 7 - 4

19 of 19
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