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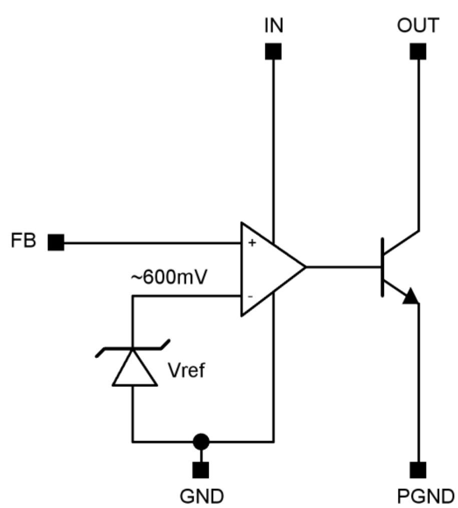
Pin Description

Pin (DFN)	Name	Function
1	PGND1	Power Ground 1: Ground return for emitter of output transistor: Connect PGND1/2 and GND together.
2	OUT1	Output 1. Connect a capacitor close to device between OUT1 and GND. See *Applications Information* section.
3	GND	Analog Ground: Ground return for reference and amplifiers: Connect GND and PGND1/2 together.
4	PGND2	Power Ground 2: Ground return for emitter of output transistor: Connect PGND1/2 and GND together.
5	OUT2	Output 2. Connect a capacitor close to device between OUT2 and GND. See *Applications Information* section.
6	FB2	Feedback Input 2. Regulates to 600mV nominal.
7	IN2	Supply Input 2. Connect a 0.1µF ceramic capacitor close to the device from IN2 to GND.
8	FB1	Feedback Input 1. Regulates to 600mV nominal.
9		No connection
10	IN1	Supply Input 1. Connect a 0.1µF ceramic capacitor close to the device from IN1 to GND.
Flag		Floating or connect to GND

Function Block Diagram



The ZXRD060 differs from most other shunt regulators in that it has separate input and output pins and a low voltage reference. This enables it to regulate rails down to 600mV and makes the part ideal for isolated power supply applications that use opto-couplers in the feedback loop and where the open-collector output is required to operate down to voltages as low as 200mV.

The wide input voltage range of 2V to 18V and output voltage range of 0.2V to 18V enables the ZXRD060 to be powered from an auxiliary rail, while controlling a master rail which is above the auxiliary rail voltage, or below the minimum V_{IN} voltage. This allows it to operate as a low-dropout voltage regulator for microprocessor/DSP/PLD cores.

As with other shunt regulators (and shunt references), the ZXRD060 compares its internal amplifier FB pin to a high accuracy internal reference; if FB is below the reference then OUT turns off, but if FB is above the reference then OUT sinks current – up to a maximum of 15mA.

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Absolute Maximum Ratings (Voltages to GND Unless Otherwise Stated)

Symbol	Parameter	Rating	Unit
V_{IN}	IN Voltage relative to GND	20	V
V_{OUT}	OUT Voltage relative to GND	20	V
V_{FB}	FB Voltage relative to GND	20	V
P_{GND}	PGND Voltage relative to GND	-0.3 to +0.3	V
I_{OUT}	OUT Pin Current	20	mA
T_J	Operating Junction Temperture	-40 to 150	°C
T_{ST}	Storage Temperature	55 to 150	°C

Stresses greater than the 'Absolute Maximum Ratings' specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

Package Thermal Data

Package	$θ_{JA}$	P_{DIS} T_A = 25°C, T_J = 150°C
DFN2626P10	152°C/W	0.8W

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Units
V_{IN}	IN Voltage Range (0 to 125°C)	2	18	V
V_{IN}	IN Voltage Range (-40 to 0°C)	2.2	18	
V_{OUT}	OUT Voltage Range	0.2	18	
I_{OUT}	OUT Pin Current	0.3	15	mA
T_A	Operating Ambient Temperature Range	-40	125	°C

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Electrical Characteristics

T_A = 25°C, V_{IN} = 3.3V, V_{OUT} = V_{FB}, I_{OUT} = 5mA unless otherwise stated (Note 3).

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_{FB}	Feedback voltage		ZXRD060A	0.597	0.6	0.603	V
			ZXRD060	0.594	0.6	0.606	
		T_A = 0°C to 85°C	ZXRD060A	0.595		0.605	
			ZXRD060	0.592		0.608	
		T_A = -40°C to 85°C	ZXRD060A	0.594		0.606	
			ZXRD060	0.591		0.609	
		T_A = -40°C to 125°C	ZXRD060A	0.593		0.607	
			ZXRD060	0.590		0.610	
FB_{LOAD}	Feedback pin load regulation	I_{OUT} = 1 to 15mA			3.8	6	mV
			T_A = -40 to 125°C			10	
FB_{LINE}	Feedback pin line regulation	V_{IN} = 2V to 18V			0.1	1	mV
		V_{IN} = 2.2V to 18V	T_A = -40 to 125°C			1.5	
FB_{OVR}	Output voltage regulation	V_{OUT} = 0.2V to 18V, I_{OUT} =1mA (Ref. Figure 1)				1	mV
			T_A = -40 to 125°C			1.5	
I_{FB}	FB input bias current	V_{IN} = 18V			-45		nA
			T_A = -40 to 125°C	-200		0	
I_{IN}	Input current	V_{IN} = 2V to 18V, I_{OUT} =0.3mA			0.35	0.7	mA
		V_{IN} = 2.2V to 18V, I_{OUT} =0.3mA	T_A = -40 to 125°C			1	
		V_{IN} = 2V to 18V, I_{OUT} =10mA			0.48	1	mA
		V_{IN} = 2.2V to 18V, I_{OUT} =10mA	T_A = -40 to 125°C			1.5	
$I_{OUT(LK)}$	OUT leakage current	V_{IN} = 18V, V_{OUT} = 18V, V_{FB} =0V				0.1	µA
			T_A = 125°C			1	
Z_{OUT}	Dynamic Output Impedance	I_{OUT} = 1 to 15mA f < 1kHz			0.25	0.4	Ω
			T_A = -40 to125°C			0.6	
PSRR	Power supply rejection ratio	f = 300kHz V_{AC}= $0.3V_{PP}$			>45		dB
BW	Amplifier Unity Gain Frequency	Ref: Fig 2			600		kHz
G	Amplifier Transconductance				5000		mA/V

Note: 3. Production testing of the device is performed at 25°C. Functional operation of the device and parameters specified over the operating temperature range are guaranteed by design, characterisation and process control.

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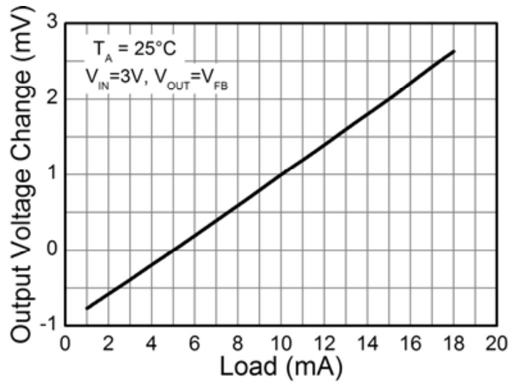
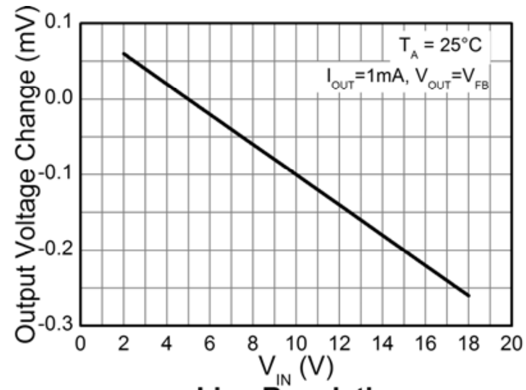
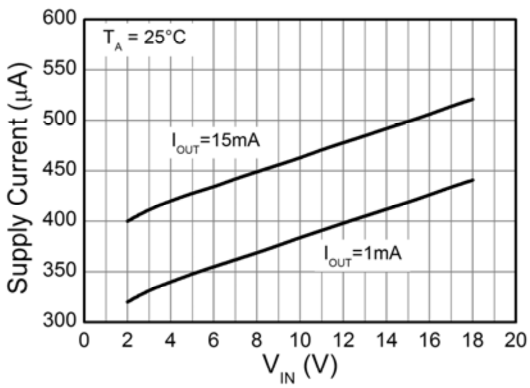
Typical Characteristics



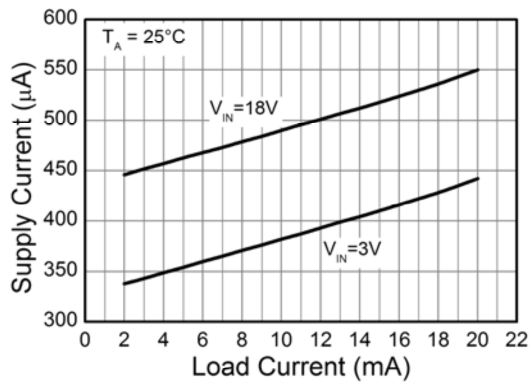
Load Regulation



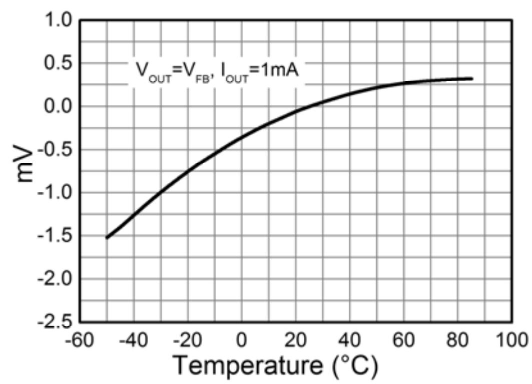
Line Regulation



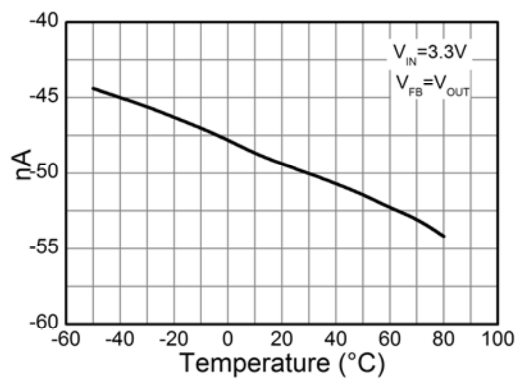
Supply Current vs Input Voltage



Supply Current vs Load Current



OUT Voltage Change with Temperature



FB Bias Current vs Temperature

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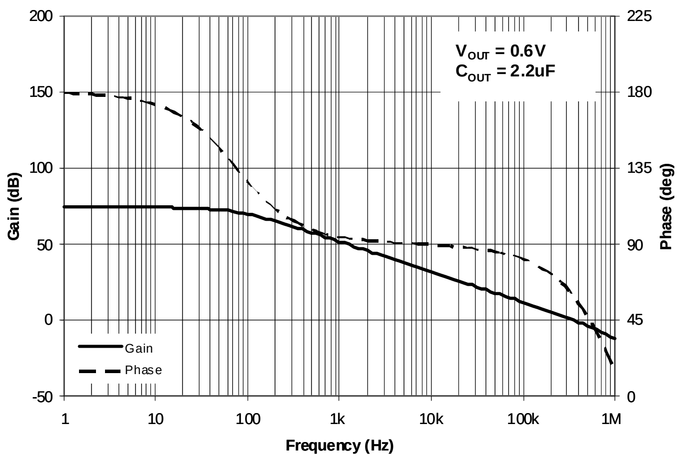
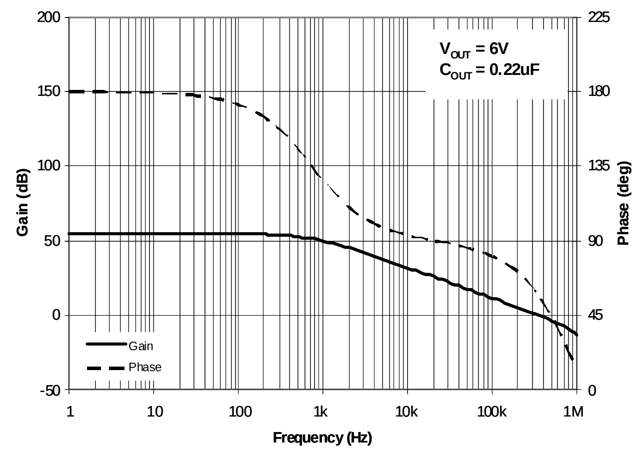
Typical Operating Conditions (cont.)



Gain and Phase vs Frequency, V_{OUT}=0.6V



Gain and Phase vs Frequency, V_{OUT}=6V

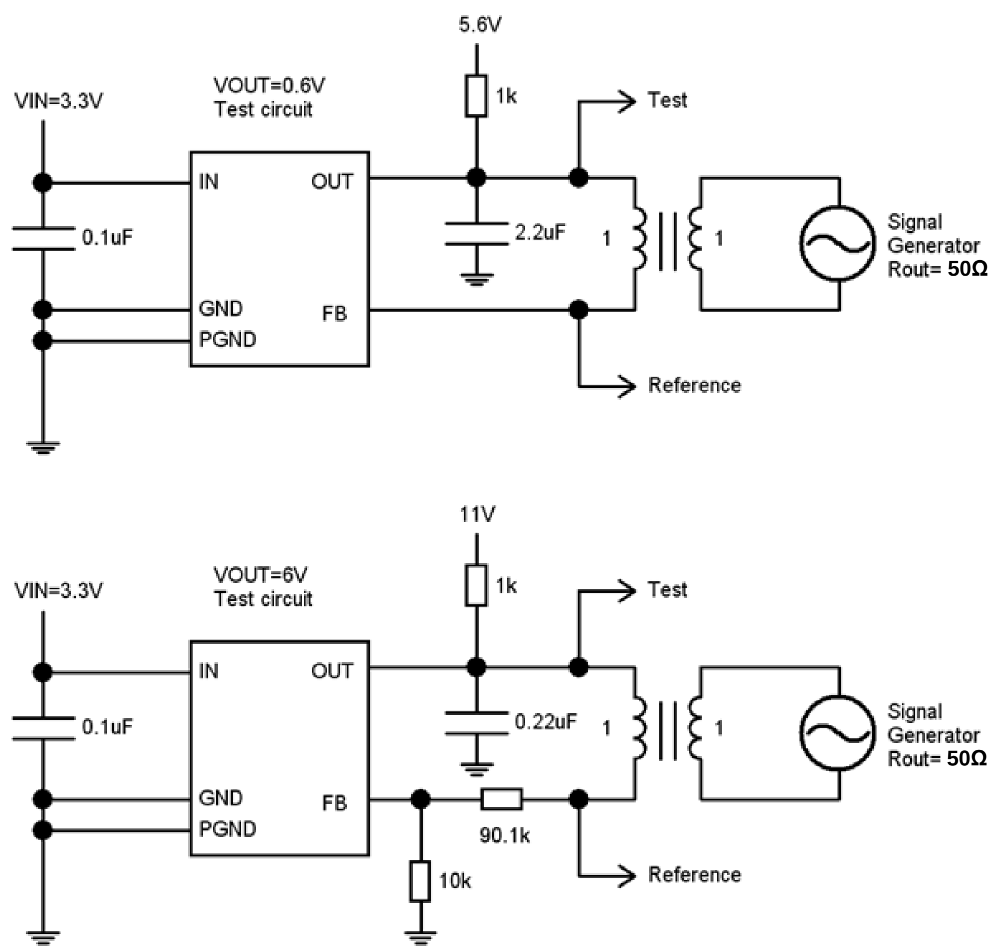


Fig. 2 Test Circuits for Gain and Phase Plots

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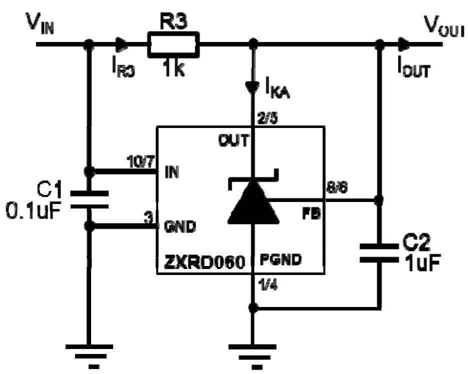
Applications Information

The following show some typical application examples for the ZXRD060. It is recommended to include the compensation capacitor C2 to guarantee stability. C2 may range in value from 0.1µF to 10µF depending on the application. The time constant formed by C2 and R3 should be greater than 1ms multiplied by the feedback factor R2/(R1 + R2).

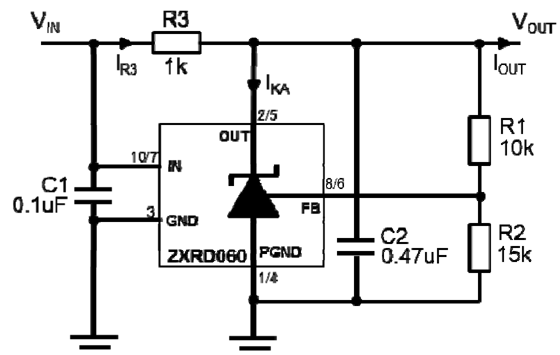
Both C1 and C2 should be as close to the ZXRD060 as possible and connected to it with the shortest possible track. In the case of fig 9 and fig10, it means the opto-coupler will have to be carefully positioned to enable this.



$$V_{OUT} = V_{REF}$$

$$R3 = \frac{V_{IN} - V_{OUT}}{I_{R3}}$$

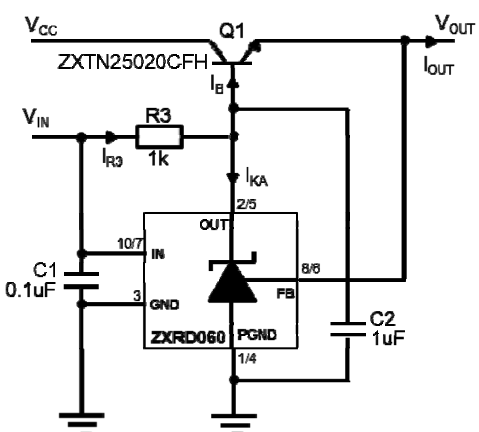
Fig.3 0.6V Shunt Regulator



$$V_{OUT} = V_{REF}\left(1+\frac{R1}{R2}\right)$$

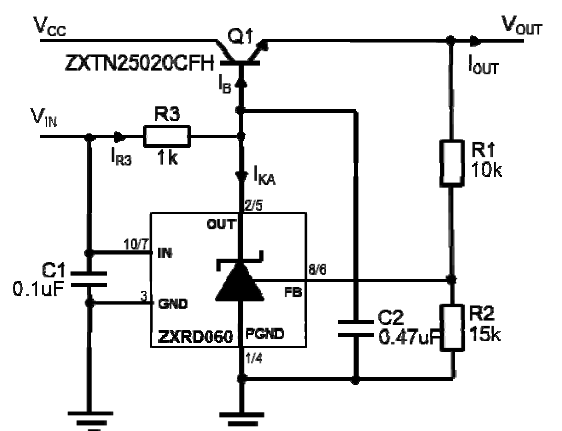
$$R3 = \frac{V_{IN} - V_{OUT}}{I_{R3}}$$

Fig.4 1.0V Shunt Regulator



$$V_{OUT} = V_{REF}$$

Fig.5 0.6V Series LDO regulator



$$V_{OUT} = V_{REF}\left(1+\frac{R1}{R2}\right)$$

Fig.6 1.0V Series LDO regulator

Design guide

1. Determine I_{OUT} and choose a suitable transistor taking power dissipation into consideration.
2. Determine I_B from $I_B = \frac{I_{OUT(max)}}{(h_{FE(min)} + 1)}$
3. Determine I_{R3} from $I_{R3} \geq I_B + I_{KA(min)}$. The design of the ZXRD060 effectively means there is no $I_{KA(min)}$ limitation as in conventional references. There is only an output leakage current which is a maximum of 1µA. Nevertheless, it is necessary to determine an $I_{KA(min)}$ to ensure that the device operates within its linear range at all times. $I_{KA(min)} \geq 10µA$ should be adequate for this.
4. Determine R3 from $R3 = \frac{V_{IN} - (V_{OUT} + V_{BE})}{I_{R3}}$.
5. Although unlikely to be a problem, ensure that $I_{R3} \leq 15$ mA.

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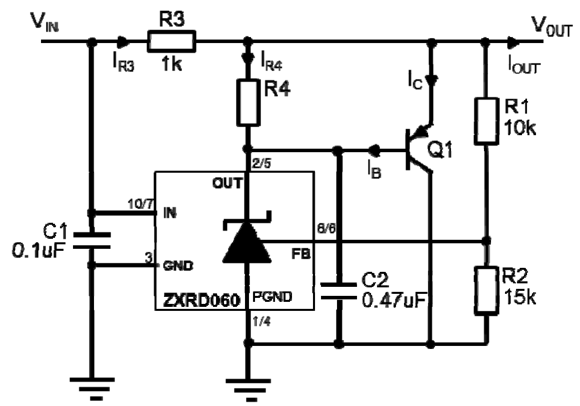
Applications Information (cont.)



$$V_{OUT} = V_{REF}\left(1+\frac{R1}{R2}\right)$$

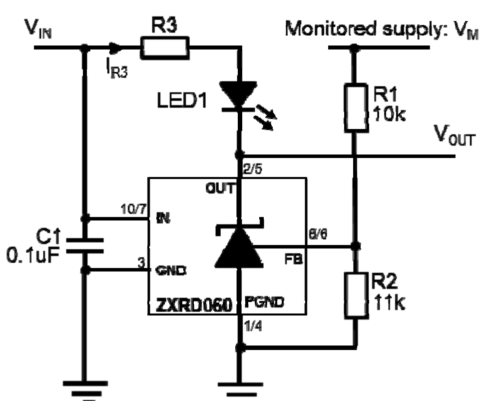
$$\left(V_{OUT} \geq 0.2V + V_{BE}\right)$$

$$R3 = \frac{V_{IN} - V_{OUT}}{I_{R3}}$$

Fig.7 1V Current-Boosted Shunt Regulator

Design guide

1. Determine I_{OUT} and choose a suitable transistor taking power dissipation into consideration.
2. Determine I_B from $I_B = \frac{I_{OUT(max)}}{(h_{FE(min)}+1)}$
3. Determine I_{R3} from $I_{R3} = I_{OUT(max)}$
4. Determine R3 from $R3 = \frac{V_{IN} - V_{OUT}}{I_{R3}}$
5. It is best to let the ZXRD060 supply as much current as it can before bringing Q1 into conduction. Not only does this minimise the strain on Q1, it also guarantees the most stable operation. Choose a nominal value between 10mA and <15mA for this current, I_{R4}.
6. Calculate R4 from $R4 = \frac{V_{BE}}{I_{R4}}$



V_{OUT} goes low and LED1 is lit when monitored supply

$$V_M > V_{REF}\left(1+\frac{R1}{R2}\right)$$

$$R3 = \frac{V_{IN} - (V_F + 0.2)}{I_{R3}}$$

$$15mA \geq I_{R3} \leq I_{F(MAX)}$$

V_F and I_F are forward voltage drop and current of LED1.

Fig. 8 1.15V Over-Voltage Indicator

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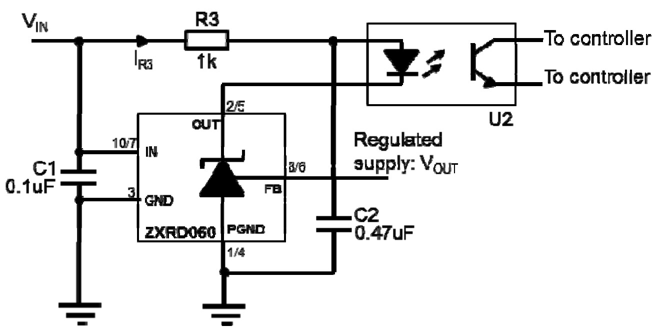
Applications Information (cont.)

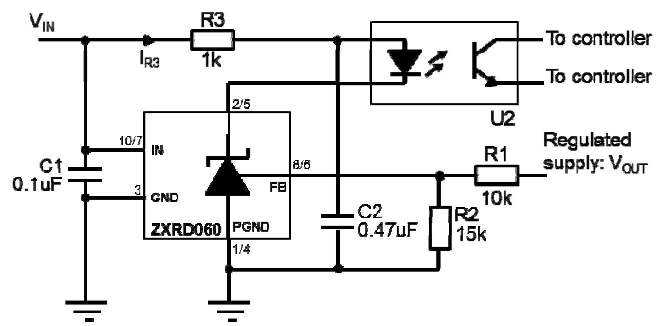


$$15mA \geq I_{R3} \leq I_{F(MAX)}$$

$$R3 = \frac{V_{IN} - (V_F + 0.2)}{I_{R3}}$$

$$V_{OUT} = V_{REF}$$

Fig.9 Opto-Isolated 0.6V Shunt Regulator



$$15mA \geq I_{R3} \leq I_{F(MAX)}$$

$$R3 = \frac{V_{IN} - (V_F + 0.2)}{I_{R3}}$$

$$V_{OUT} = V_{REF}\left(1 + \frac{R1}{R2}\right)$$

Fig. 10 Opto-Isolated 1.0V Shunt Regulator

V_F and I_F are forward voltage drop and forward current respectively for the opto-coupler LED.
More applications information is available in the following publications which can be found on Diodes' web site.

AN58 - Designing with Diodes' References – *Shunt Regulation*
AN59 - Designing with Diodes' References – *Series Regulation*
AN60 - Designing with Diodes' References – *Fixed Regulators and Opto-Isolation*
AN61 - Designing with Diodes' References – *Extending the operating voltage range*
AN62 - Designing with Diodes' References – *Other Applications*
AN63 - Designing with Diodes' References – *ZXRE060 Low Voltage Regulator*

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Ordering Information

ZXRD060 X XX XX

Tolerance	Package	Packing
A: ±0.5%	FK: DFN2626P10	-7: Tape & Reel
None: ±1%		

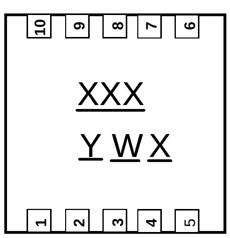
Tol.	Order Code	Part	Identification Code	Reel Size	Tape Width	Quantity/Reel
0.5%	ZXRD060AFK-7	DFN2626P10	S6A	7", 180mm	8mm	3000
1%	ZXRD060FK-7	DFN2626P10	S06	7", 180mm	8mm	3000

For packaging details, go to our website at http://www.diodes.com/datasheets/ap02007.pdf

Marking Information

DFN2626P10

Top View



XXX : Identification code
Y : Year : 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week;
z : represents 52 and 53
X : A~Z : Internal Code

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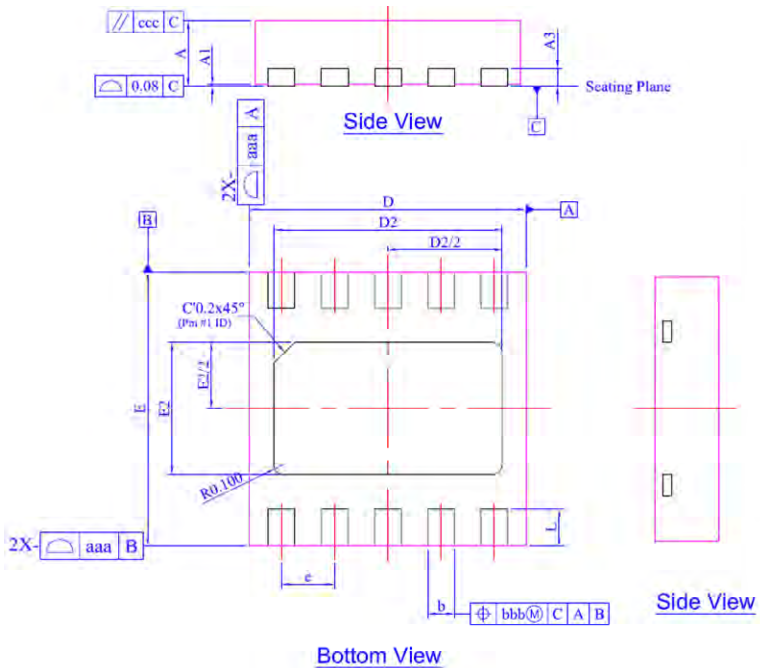
Package Outline Dimensions (All Dimensions in mm)

DFN2626P10



Dim	Min	Max	Typ
D	2.55	2.675	2.60
E	2.55	2.675	2.60
D2	2.05	2.25	2.15
E2	1.16	1.36	1.26
A	0.57	0.63	0.60
A1	0	0.05	0.03
A3	—	—	0.15
b	0.20	0.30	0.25
L	0.30	0.40	0.35
e	—	—	0.50
aaa	0.15		
bbb	0.05		
ccc	0.05		

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