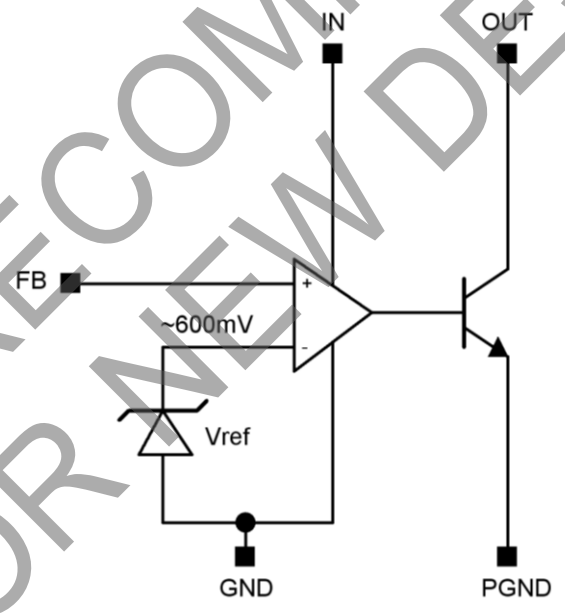
Pin Description

Pin Number (SC70-5 /SOT353, TSOT23-5)	Pin Number (DFN1520H4-6)	Pin Name	Function
1	1	PGND	Power Ground: Ground return for emitter of output transistor: Connect PGND and GND together.
—	2	N/C	No connection
5	3	OUT	Output. Connect a capacitor close to device between OUT and GND. See the Applications Information section.
4	4	FB	Feedback Input. Regulates to 600mV nominal.
2	5	GND	Analog Ground: Ground return for reference and amplifier: Connect GND and PGND together.
3	6	IN	Supply Input. Connect a 0.1µF ceramic capacitor close to the device from IN to GND.
—	Flag	—	Floating or connect to GND

Function Block Diagram



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The ZXRE060 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 ZXRE060 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 ZXRE060 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 Temperature	-40 to +150	°C
T_{ST}	Storage Temperature	55 to +150	°C

These are stress ratings only. Operation outside the absolute maximum ratings may cause device failure. Operation at the absolute maximum rating for extended periods may reduce device reliability.

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
SC70-5/SOT353	400°C/W	310mW
TSOT23-5	250°C/W	500mW
DFN1520H4-6	TBD	TBD

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
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 4))

Symbol	Parameter	Conditions			Min	Typ	Max	Unit
V_{FB}	Feedback Voltage	—		ZXRE060A	0.597	0.6	0.603	V
				ZXRE060	0.594	0.6	0.606	
		T_A = 0°C to +85°C		ZXRE060A	0.595	—	0.605	
				ZXRE060	0.592	—	0.608	
		T_A = -40°C to +85°C		ZXRE060A	0.594	—	0.606	
				ZXRE060	0.591	—	0.609	
		T_A = -40°C to +125°C		ZXRE060A	0.593	—	0.607	
				ZXRE060	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		—	—	—	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		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		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 to +125°C	—	—	0.6	
PSRR	Power Supply Rejection Ratio	f = 300kHz V_{AC} = 0.3V_{PP}		—	—	>45	—	dB
BW	Amplifier Unity Gain Frequency	Ref: Figure 1			—	600	—	kHz
G	Amplifier Transconductance	—			—	5000	—	mA/V

Note: 4. 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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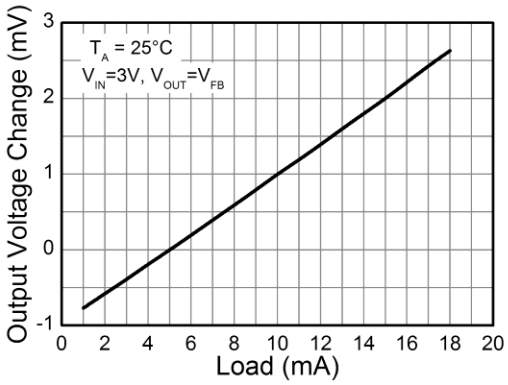
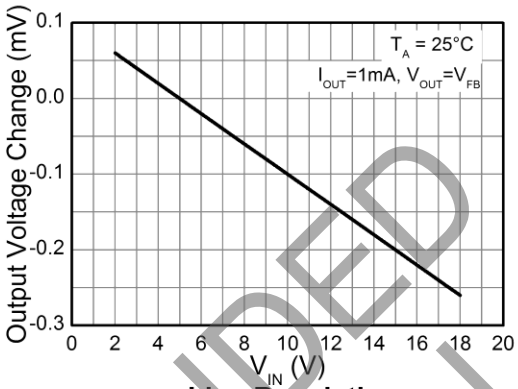
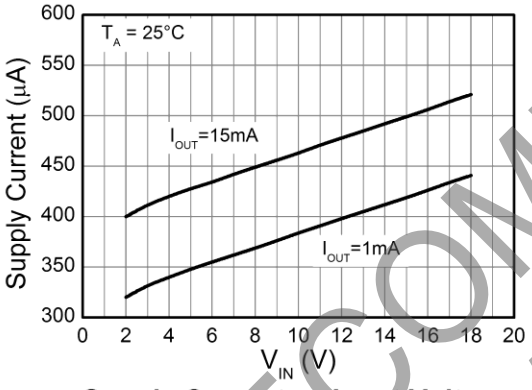
Typical Characteristics



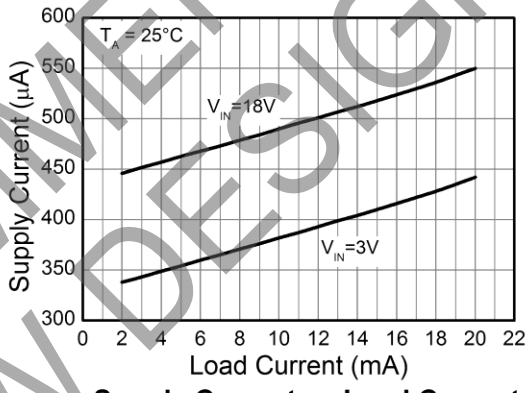
Load Regulation



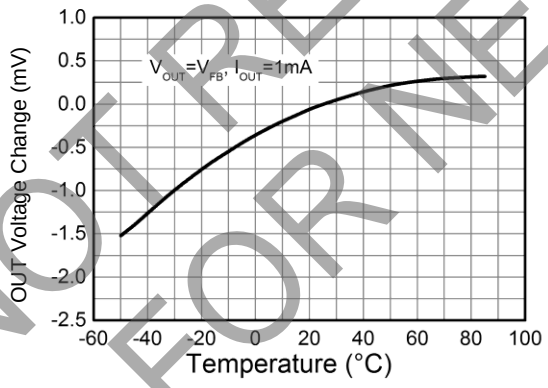
Line Regulation



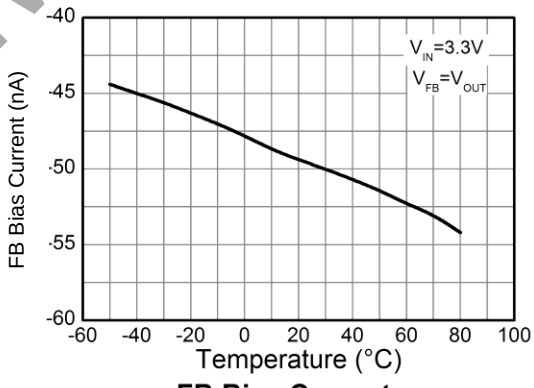
Supply Current vs Input Voltage



Supply Current vs Load Current



OUT Voltage Change with Temperature



FB Bias Current vs Temperature

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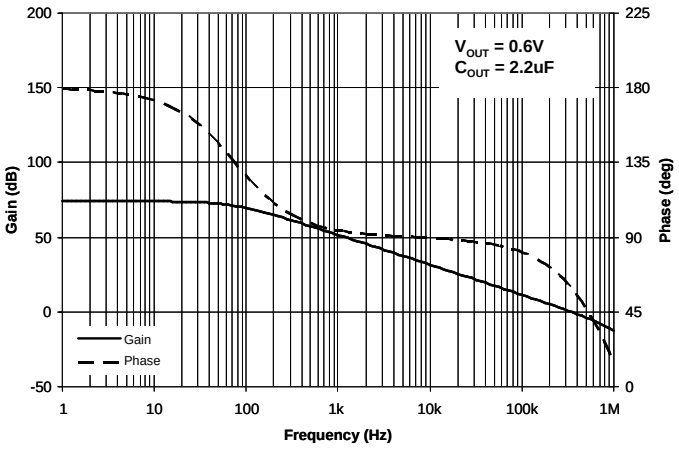
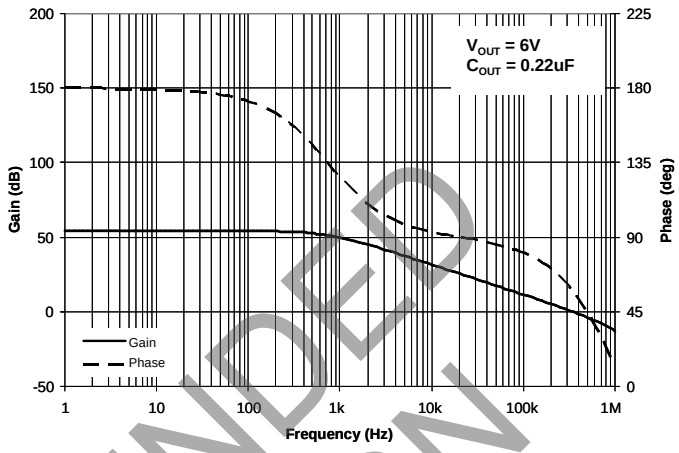
Typical Operating Conditions (Cont.)



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



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

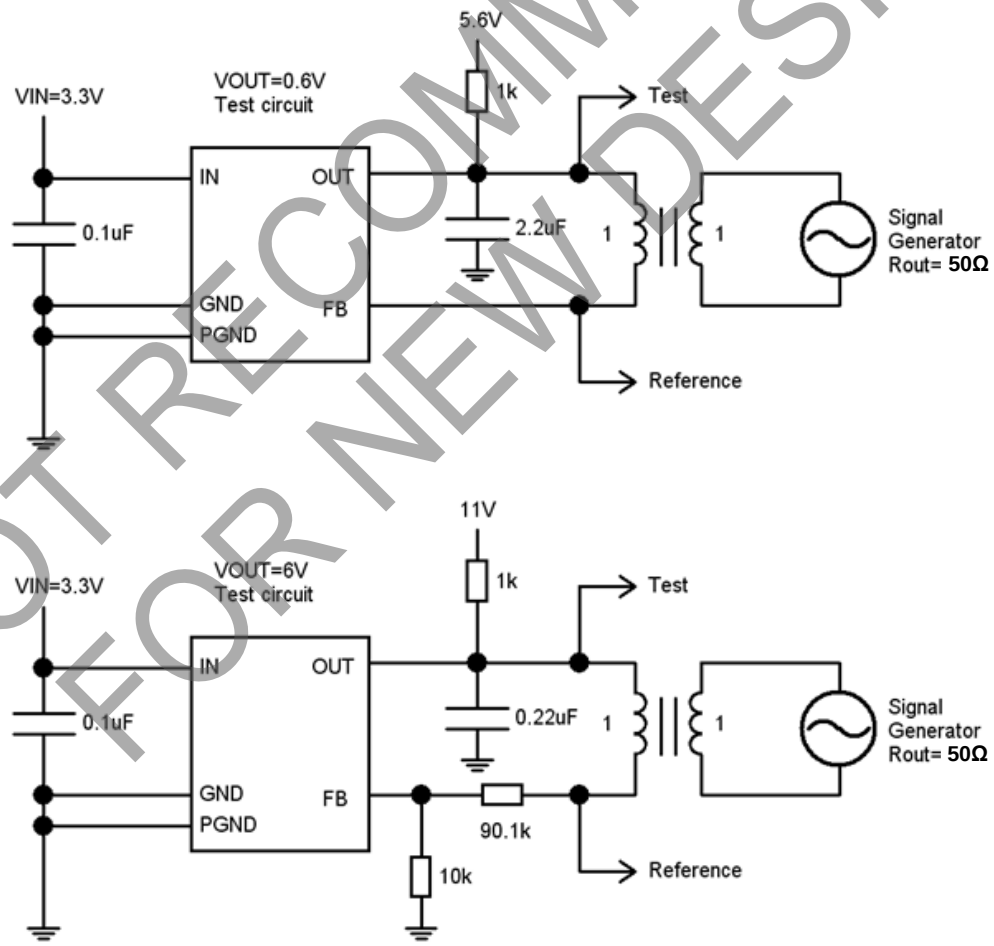


Figure 1. Test Circuits for Gain and Phase Plots

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Application Information

The following show some typical application examples for the ZXRE060. 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 ZXRE060 as possible and connected to it with the shortest possible track. In the case of Figure 8 and Figure 9, it means the opto-coupler will have to be carefully positioned to enable this.

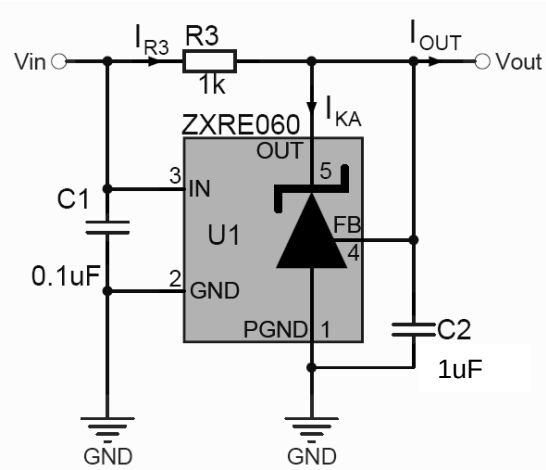

Figure 2. 0.6V Shunt Regulator

$V_{OUT} = V_{REF}$

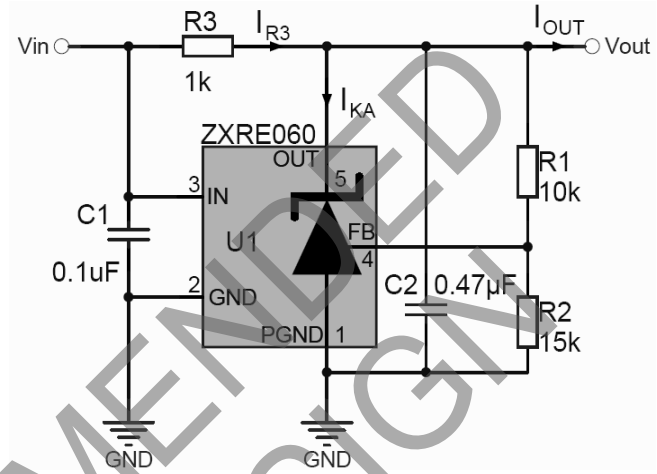

Figure 3. 1.0V Shunt Regulator

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

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

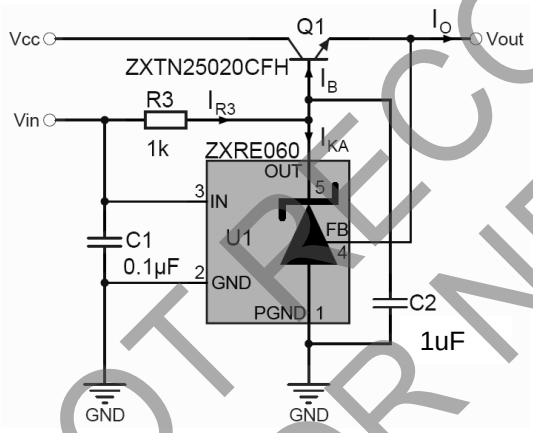

Figure 4. 0.6V series LDO regulator

$V_{OUT} = V_{REF}$

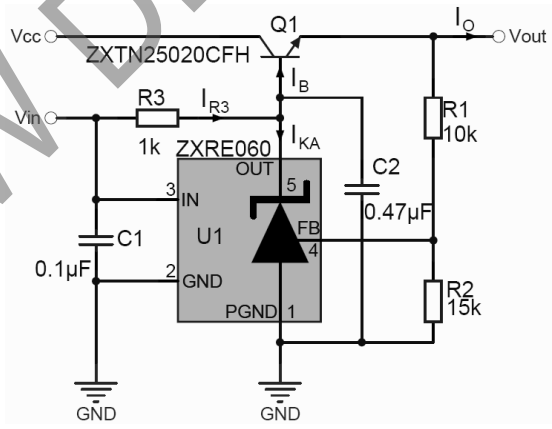

Figure 5. 1.0V series LDO regulator

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

Design Guides

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 ZXRE060 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. $I_{KA(min)} \geq 10\mu A$ 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 $I_{R3} \leq 15mA$.

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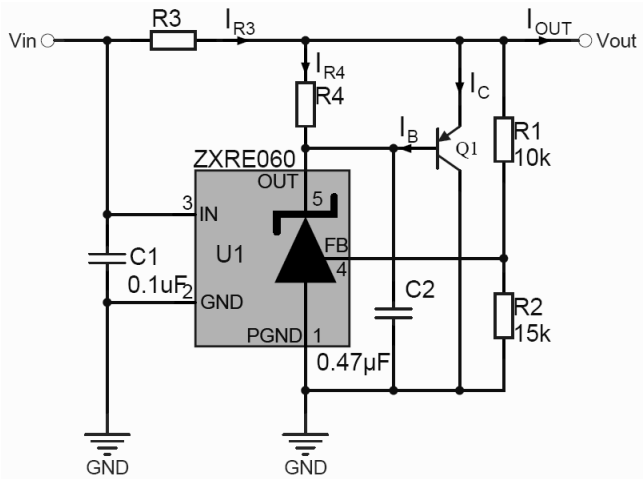
Application Information (Cont.)



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

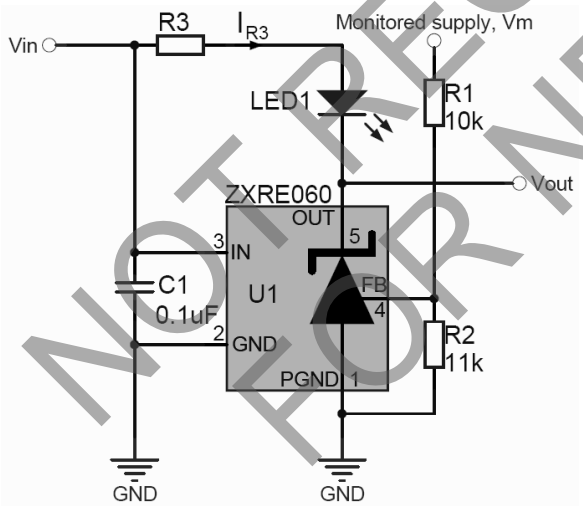
$$(V_{OUT} \geq 0.2V + V_{BE})$$

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

Figure 6. 1V Current-boosted Shunt Regulator

Design Guides

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 ZXRE060 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 LED 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.

Figure 7. 1.15V Over-voltage Indicator

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Application Information (Cont.)

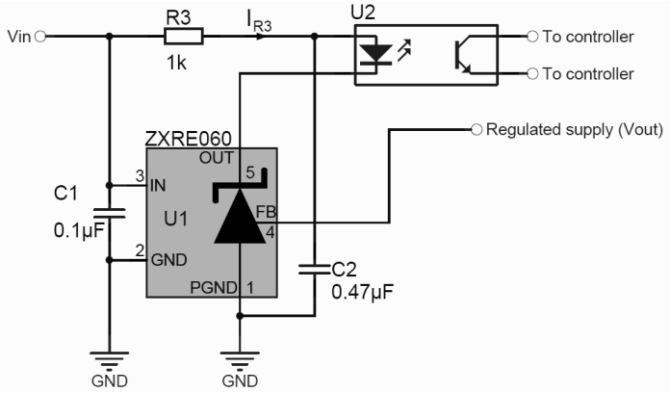

Figure 8. Opto-isolated 0.6V Shunt Regulator

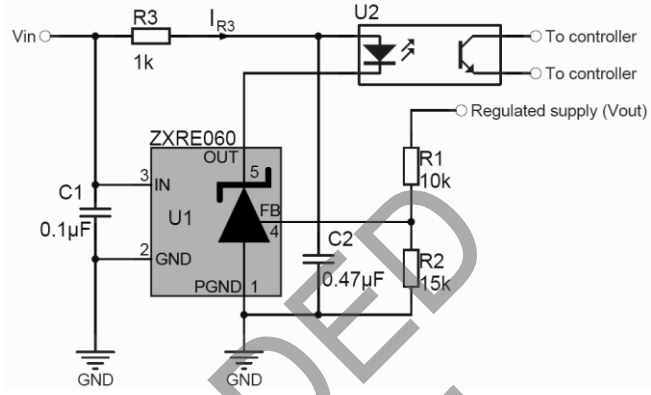

Figure 9. Opto-isolated 1.0V Shunt Regulator

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

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

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

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

V_F and I_F are forward voltage drop and forward current respectively for the optocoupler LED.

More applications information is available in the following publications which can be found on Diodes Incorporated's web site.

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

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Ordering Information

ZXRE060 X X X

Tolerance	Package	Packing
A : ±0.5% None : ±1%	ET5 : TSOT23-5 H5 : SC70-5/SOT353 FT4 : DFN1520H4-6	-7 : Tape & Reel TA : Tape & Reel

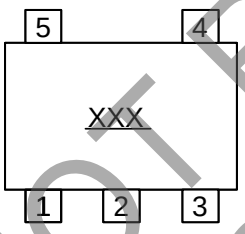
Tol.	Order Code	Package	Identification Code	Reel Size	Tape Width	Quantity/Reel
0.5%	ZXRE060AET5TA	TSOT23-5	S6A	7", 180mm	8mm	3000
	ZXRE060AH5TA	SC70-5/SOT353	S6A	7", 180mm	8mm	3000
	ZXRE060AFT4-7	DFN1520H4-6	S6A	7", 180mm	8mm	3000
1%	ZXRE060ET5TA	TSOT23-5	S06	7", 180mm	8mm	3000
	ZXRE060H5TA	SC70-5/SOT353	S06	7", 180mm	8mm	3000
	ZXRE060FT4-7	DFN1520H4-6	S06	7", 180mm	8mm	3000

Note: 5. For packaging details, go to our website at https://www.diodes.com/design/support/packaging/diodes-packaging/.

Marking Information

(1) TSOT23-5, SC70-5/SOT353

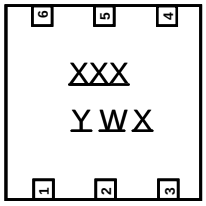
(Top View)



XXX : Identification code

(2) DFN1520H4-6

(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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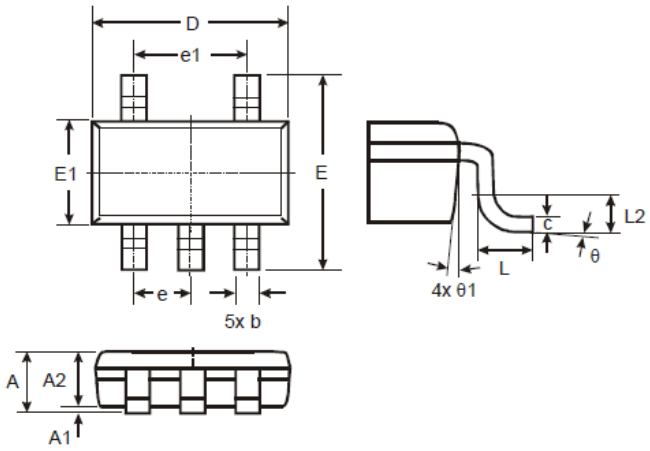
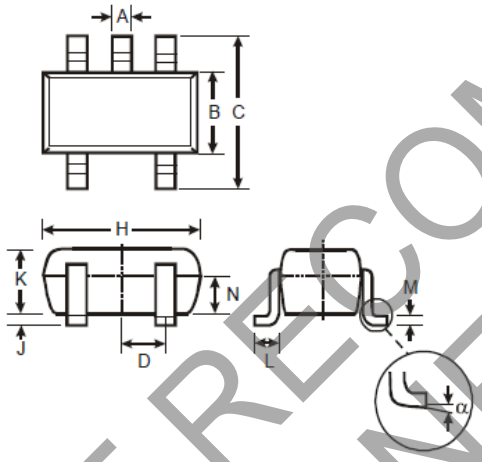
Package Outline Dimensions

(1) TSOT23-5



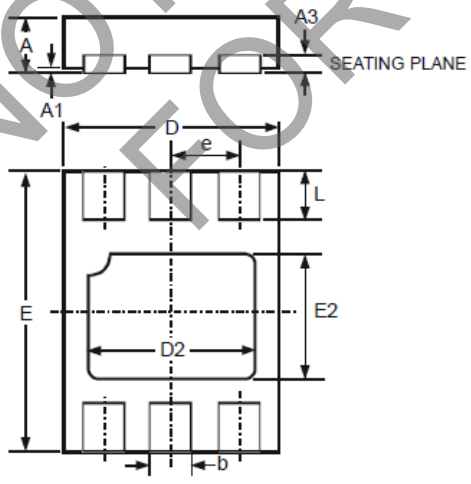
TSOT23-5			
Dim	Min	Max	Typ
A	–	1.00	–
A1	0.01	0.10	–
A2	0.84	0.90	–
D	–	–	2.90
E	–	–	2.80
E1	–	–	1.60
b	0.30	0.45	–
c	0.12	0.20	–
e	–	–	0.95
e1	–	–	1.90
L	0.30	0.50	
L2	–	–	0.25
θ	0°	8°	4°
θ1	4°	12°	–
All Dimensions in mm			

(2) SC70-5/SOT353



SOT-353		
Dim	Min	Max
A	0.10	0.30
B	1.15	1.35
C	2.00	2.20
D	0.65 Typ	
F	0.40	0.45
H	1.80	2.20
J	0	0.10
K	0.90	1.00
L	0.25	0.40
M	0.10	0.22
α	0°	8°
All Dimensions in mm		

(3) DFN1520H4-6



DFN1520H4-6			
Dim	Min	Max	Typ
A	–	0.40	–
A1	0	0.05	–
A3	–	–	0.13
b	0.20	0.30	–
D	1.45	1.575	–
D2	1.00	1.20	–
e	–	–	0.50
E	1.95	2.075	–
E2	0.70	0.90	–
L	0.25	0.35	–
All Dimensions in mm			

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