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## MICROPOWER SC70-5/SOT353 & SOT25 LOW DROPOUT REGULATORS

### Description

The ZXCL series have been designed with space sensitive systems in mind. They are available in the ultra-small SC70-5/SOT353 package, which is half the size of SOT23 based regulators.

The devices can be used with all types of output capacitors including low ESR ceramics and typical dropout voltage is only 85mV at 50mA load. Supply current is minimized with a ground pin current of only 50μA at full 150mA load.

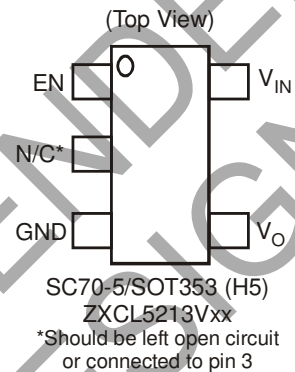
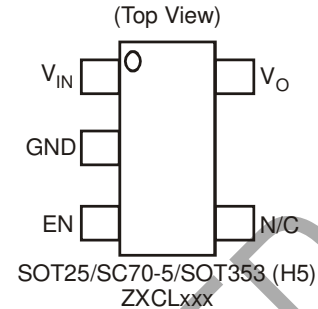
Logic control allows the devices to be shut down, consuming typically less than 10nA.

These features make the device ideal for battery powered applications where power economy is critical.

For applications requiring improved performance over alternative devices, the ZXCL is also offered in the 5 pin SOT23 package with an industry standard pinout.

The devices feature thermal overload and overcurrent protection and are available with output voltages of 2.5V, 2.6V, 2.8V, 3V, 3.3V.

### Pin Assignments



### Features

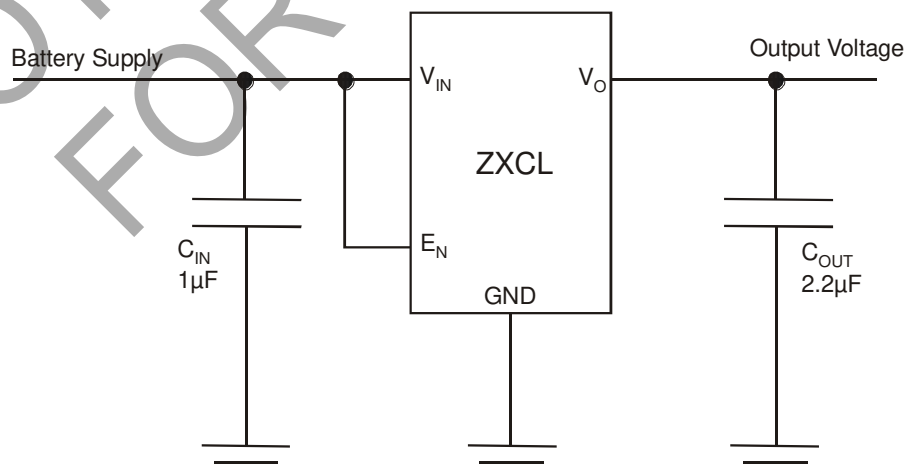
- Low 85mV dropout at 50mA load
- 50μA ground pin current with full 150mA load
- 2.5, 2.6, 2.8, 3, & 3.3 volts output
- Very low noise, without bypass capacitor
- 5-pin SC70/SOT353 and SOT25 package
- No-load stable

### Applications

- Cellular and Cordless Phones
- PDA
- Handheld Instruments
- Camera, Camcorder, Personal Stereo
- PC Cards
- Portable and Battery-Powered Equipment

**No-Load Stability** - the ZXCL device will maintain regulation and is stable with no external load. e.g. CMOS RAM applications

### Typical Application Circuit

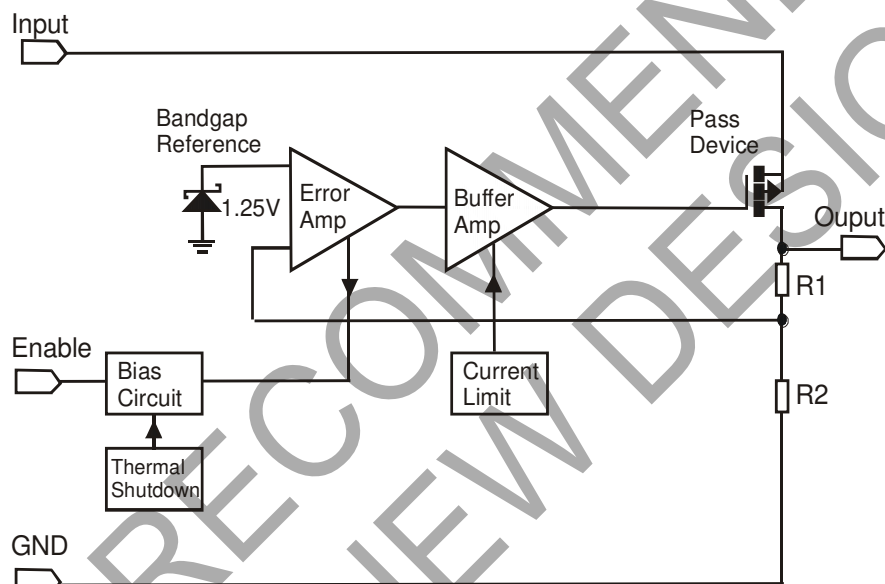


- ZXCLxx0E5TA: AP2121AK-x.xTRG1
- ZXCLxx0H5TA: AP7115-xxSEG-7 or AP2125KS-X.XTRG1
- ZXCL5213VxxH5TA: No Alternative

## Pin Descriptions

Pin Name	Pin Number		Description
	ZXCLxxx SC70-5/SOT353 (H5) SOT25/	ZXCL5213Vxx SC70-5/SOT353 (H5)	
$V_{IN}$	1	5	Supply Voltage
GND	2	3	Ground
$E_N$	3	1	Active HIGH enable input. TTL/CMOS logic compatible. Connect $V_{IN}$ or logic high for normal operation
N/C	4	2*	No Connection (*Should be left open circuit or connected to pin 3)
$V_O$	5	4	Regulator Output

## Functional Block Diagram





- ZXCLxx0E5TA: AP2121AK-x.xTRG1
- ZXCLxx0H5TA: AP7115-xxSEG-7 or AP2125KS-X.XTRG1
- ZXCL5213VxxH5TA: No Alternative

## Absolute Maximum Ratings ( $T_A = +25^\circ\text{C}$ )

Parameter	Rating	Unit
<b>Terminal voltage with respect to GND</b>		
$V_{IN}$	-0.3 to 7.0	V
$E_N$	-0.3 to 10	V
$V_O$	-0.3 to 5.5V	V
Output short circuit duration	Infinite	
Continuous power dissipation	Internally Limited	
Operating temperature range	-40 to +85	$^\circ\text{C}$
Storage temperature range	-55 to +125	$^\circ\text{C}$
<b>Package Power Dissipation (<math>T_A = +25^\circ\text{C}</math>)</b>		
SC70-5/SOT353	300 (Note 1)	mW
SOT25	450 (Note 1)	mW

Stresses beyond those listed under "Absolute maximum ratings" may 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 in the operational sections of the specifications is not implied. Exposure to absolute maximum conditions for extended periods may affect device reliability.

## Recommended Operating Conditions ( $T_A = +25^\circ\text{C}$ )

Symbol	Parameter	Min	Max	Unit
$V_{IN}$	Input voltage range	2.0*	5.5	V
$V_{ENH}$	Enable pin logic level High pin	2.2	10	V
$V_{ENL}$	Enable pin logic Low pin	0	0.8	V
$T_A$	Ambient temperature range	-40	+85	$^\circ\text{C}$

\* Output voltage will start to rise when  $V_{IN}$  exceeds a value or approximately 1.3V. For normal operation,  $V_{IN(min)} > V_{OUT(nom)} + 0.5V$ .

**Electrical Characteristics**  $V_{IN} = V_O = 0.5V$ , all values @  $T_A = 25^\circ C$  (Unless otherwise stated)

Symbol	Parameter	Conditions	Limit			Units
			Min	Typ	Max	
$V_O$	Output Voltage	$I_O = 1mA$ $I_O = 100mA$ $V_O + 0.5V < V_{IN} < V_{IN\ max}$	-2% -3%		+2% +3%	V
$\Delta V_O / \Delta T$	Output voltage temperature coefficient			-15		ppm/°C
$I_{O(Max)}$	Output current	XCL250/5213V25 only	150 100			mA
$I_{OLIM}$	Overcurrent limit	XCL250/5213V25 only	160 105	230	800 150	mA
$I_O$	Ground pin current	No Load		25	50	$\mu A$
		$I_O = 150mA$		50	120	$\mu A$
		$I_O = 100mA$		40	100	$\mu A$
$V_{DO}$	Dropout voltage (Note 3)	$I_O = 10mA$	All variants	15		mV
		$I_O = 50mA$		85		mV
		$I_O = 100mA$	XCL250 / 5213V25	163	325	mV
		$I_O = 100mA$	XCL260 / 5213V26	155	310	mV
		$I_O = 100mA$	XCL280 / 5213V28	140	280	mV
		$I_O = 100mA$	XCL300 / 5213V30	140	280	mV
		$I_O = 100mA$	XCL330 / 5213V33	140	280	mV
		$I_O = 100mA$	XCL400 / 5213V40	140	280	mV
$\Delta V_{LNR}$	Line regulation	$V_{IN} = (V_O + 0.5V)$ to 5.5V, $I_O = 1mA$		0.02	0.1	%/V
$\Delta V_{LDR}$	Load regulation	$I_O = 1mA$ to 100mA		0.01	0.04	%/mA
$E_N$	Output noise voltage	$f = 10Hz$ to 100kHz, $C_O = 10\mu F$		50		$\mu V_{RMS}$
$V_{ENHS}$	Enable pin hysteresis			150		mV
$I_{EN}$	Enable pin input current	$V_{EN} = 5.5V$			100	nV
$I_{OSD}$	Shutdown supply current	$V_{EN} = 0V$			1	$\mu A$
$T_{SD}$	Thermal shutdown temperature		125		+165	°C

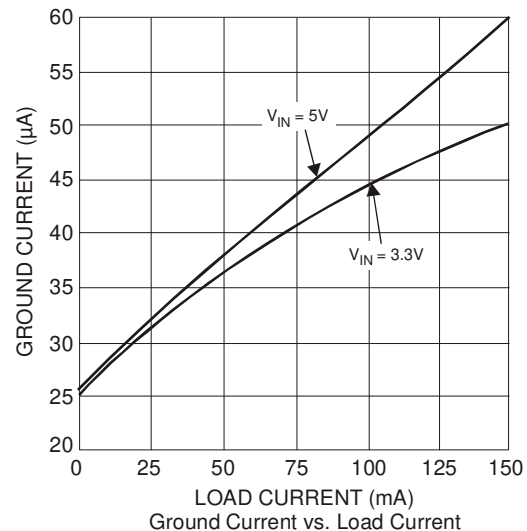
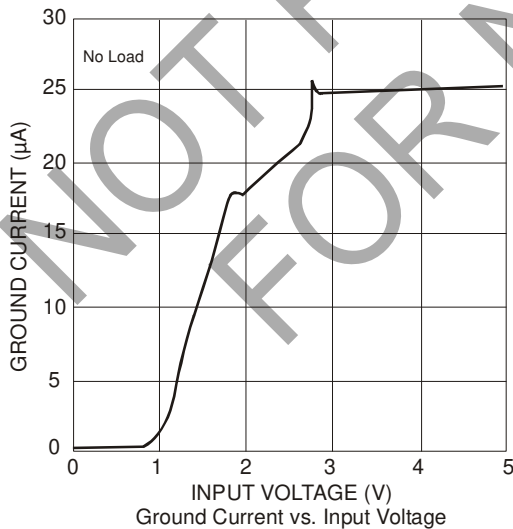
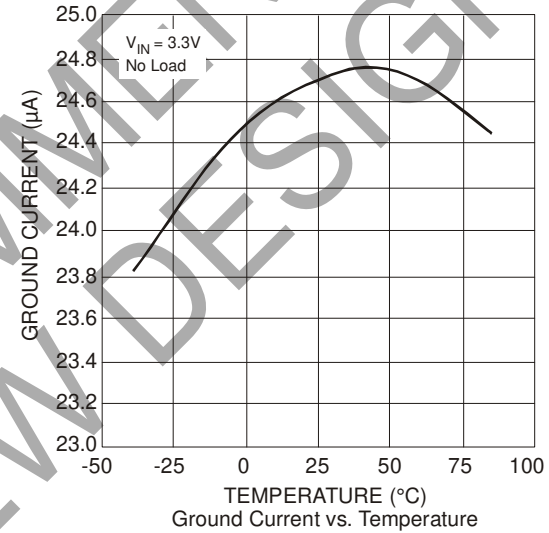
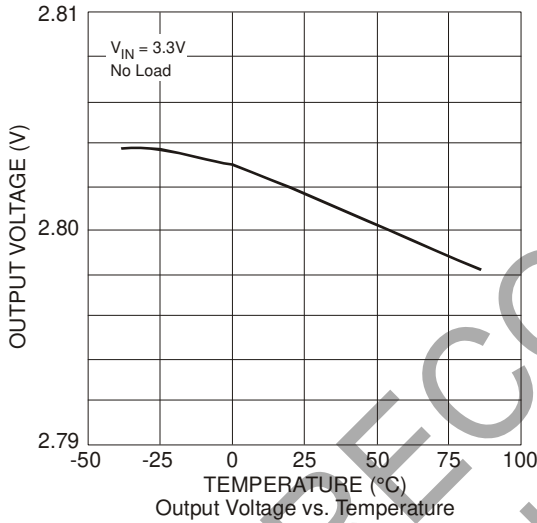
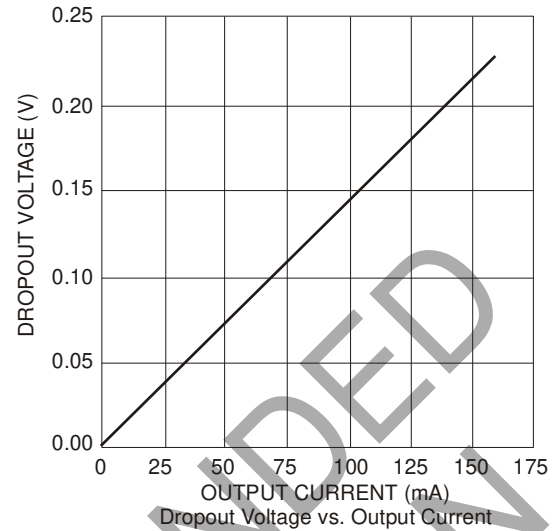
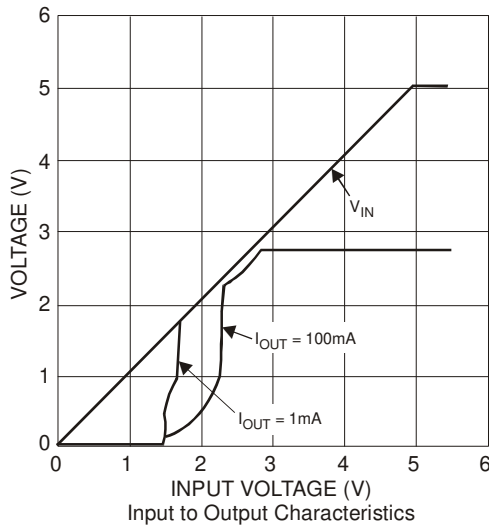
Device testing is performed at  $T_A = 25^\circ C$ . Device thermal performance is guaranteed by design.

Notes:

1. Maximum power dissipation is calculated assuming the device is mounted on a PCB measuring 2 inches square
2. Output voltage will start to rise when  $V_{IN}$  exceeds a value of approximately 1.3V. For normal operation,  $V_{IN(min)} > V_{OUT(nom)} + 0.5V$ .
3. Dropout voltage is defined as the difference between  $V_{IN}$  and  $V_O$ , when  $V_O$  has dropped 100mV below its nominal value. Nominal value of  $V_O$  is defined at  $V_{IN} = V_O + 0.5V$ .

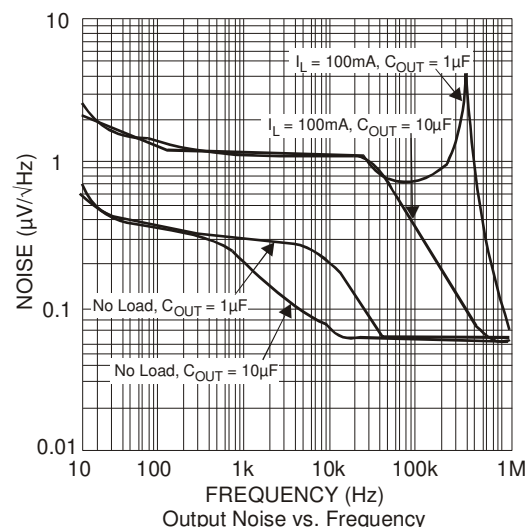
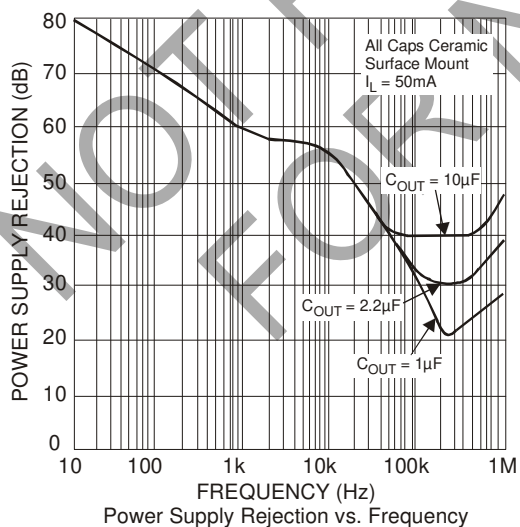
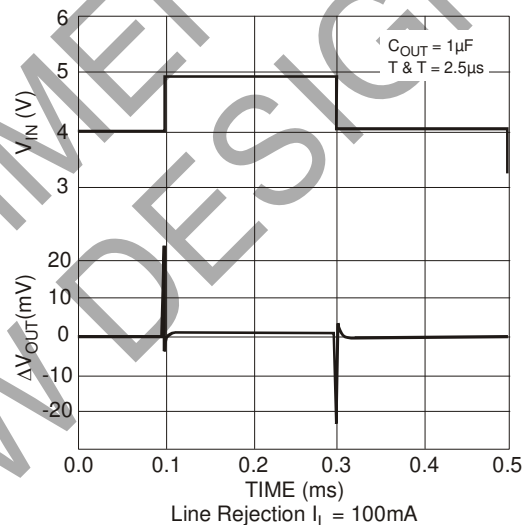
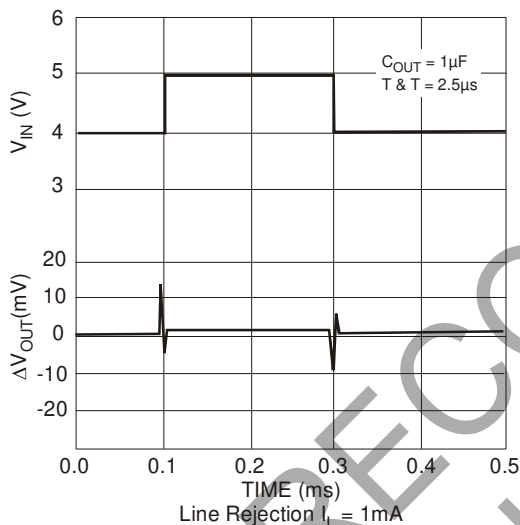
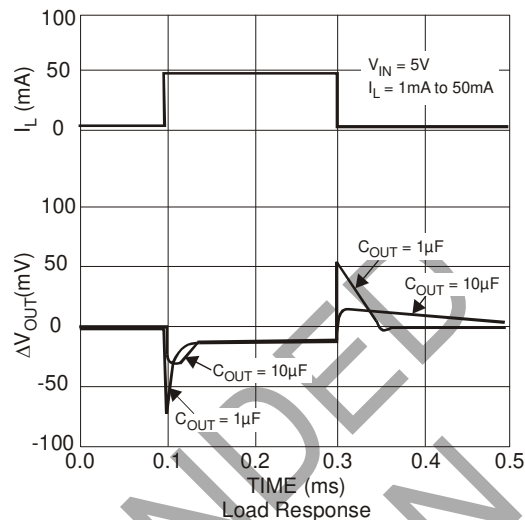
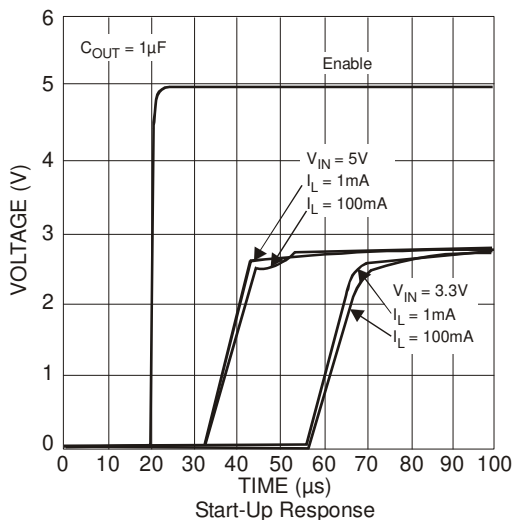
- ZXCLxx0E5TA: AP2121AK-x.xTRG1
- ZXCLxx0H5TA: AP7115-xxSEG-7 or AP2125KS-X.XTRG1
- ZXCL5213VxxH5TA: No Alternative

**Typical Characteristics (ZXCL280/5213 shown)**



- ZXCLxx0E5TA: AP2121AK-x.xTRG1
- ZXCLxx0H5TA: AP7115-xxSEG-7 or AP2125KS-X.XTRG1
- ZXCL5213VxxH5TA: No Alternative

## Typical Characteristics



- ZXCLxx0E5TA: AP2121AK-x.xTRG1
- ZXCLxx0H5TA: AP7115-xxSEG-7 or AP2125KS-X.XTRG1
- ZXCL5213VxxH5TA: No Alternative

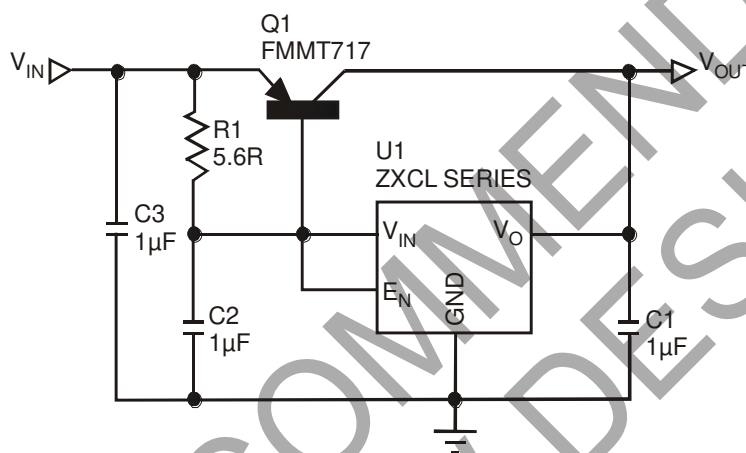
## Application Information

### Input to Output Diode

In common with many other LDO regulators, the ZXCL device has an inherent diode associated with the output series pass transistor. This diode has its anode connected to the output and its cathode to the input. The internal diode is normally reverse biased, but will conduct if the output is forced above the input by more than a  $V_{BE}$  (approximately 0.6V). Current will then flow from  $V_{OUT}$  to  $V_{IN}$ . For safe operation, the maximum current in this diode should be limited to 5mA continuous and 30mA peak. An external schottky diode may be used to provide protection when this condition cannot be satisfied.

### Increased Output Current

Any ZXCL series device may be used in conjunction with an external PNP transistor to boost the output current capability. In the application circuit shown below, a FM717 device is employed as the external pass element. This SOT23 device can supply up to 2.5A maximum current subject to the thermal dissipation limits of the package (625mW). Alternative devices may be used to supply higher levels of current. Note that with this arrangement, the dropout voltage will be increased by the  $V_{BE}$  drop of the external device. Also, care should be taken to protect the pass transistor in the event of excessive output current.



**Scheme to Boost Output Current to 2A**



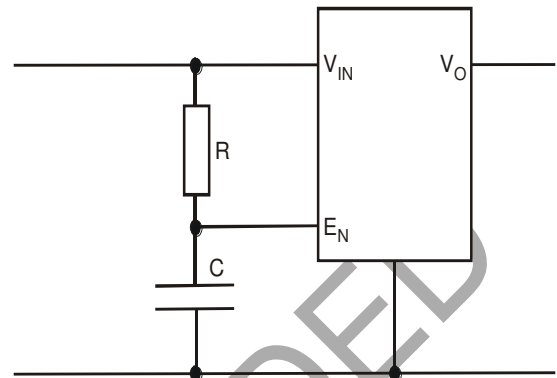
- ZXCLxx0E5TA: AP2121AK-x.xTRG1
- ZXCLxx0H5TA: AP7115-xxSEG-7 or AP2125KS-X.XTRG1
- ZXCL5213VxxH5TA: No Alternative

## Application Information (cont.)

### Enable Control

A TTL compatible input is provided to allow the regulator to be shut down. A low voltage on the Enable pin puts the device into shutdown mode. In this mode the regulator circuit is switched off and the quiescent current reduces to virtually zero (typically less than 10nA) for input voltages above the minimum operating threshold of the device. A high voltage on the Enable pin ensures normal operation.

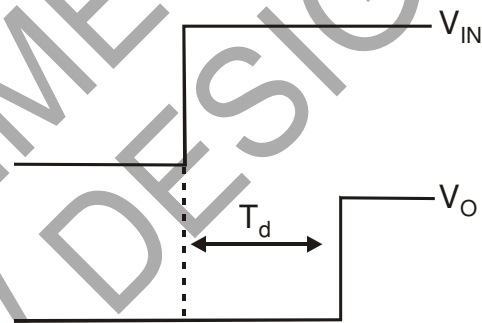
The Enable pin can be connected to  $V_{IN}$  or driven from an independent source of up to 10V maximum. (e.g. CMOS logic) for normal operation. There is no clamp diode from the Enable pin to  $V_{IN}$ , so the  $V_{IN}$  pin may be at any voltage within its operating range irrespective of the voltage on the Enable pin. However input voltage rise time should be kept below 5ms to ensure consistent start-up response.



**Fig. 1 Circuit Connection**

### Current Limit

The ZXCL devices include a current limit circuit which restricts the maximum output current flow to typically 230mA. Practically the range of overcurrent should be considered as minimum 160mA to maximum 800mA. The device's robust design means that an output short circuit to any voltage between ground and  $V_{OUT}$  can be tolerated for an indefinite period.



**Fig. 2 Start Up Delay ( $T_d$ )**

### Thermal Overload

Thermal overload protection is included on chip. When the device junction temperature exceeds a minimum 125°C the device will shut down. The sense circuit will re-activate the output as the device cools. It will then cycle until the overload is removed. The thermal overload protection will be activated when high load currents or high input to output voltage differentials cause excess dissipation in the device.

### Start up delay

A small amount of hysteresis is provided on the Enable pin to ensure clean switching. This feature can be used to introduce a start up delay if required. Addition of a simple RC network on the Enable pin provides this function. The following diagram illustrates this circuit connection. The equation provided enables calculation of the delay period.

$$T_{d(NOM)} = RC \ln \left( \frac{V_{IN}}{V_{IN} - 1.5} \right)$$

Calculation of start up delay as above

## Application Information (cont.)

### Power Dissipation

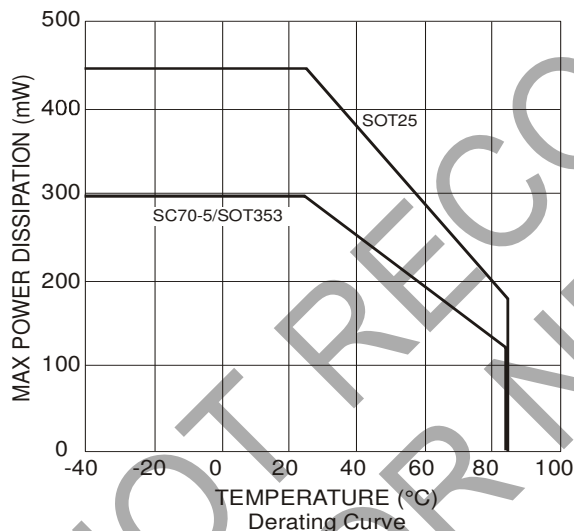
The maximum allowable power dissipation of the device for normal operation ( $P_{MAX}$ ), is a function of the package junction to ambient thermal resistance ( $\theta_{JA}$ ), maximum junction temperature ( $T_{JMAX}$ ), and ambient temperature ( $T_{AMB}$ ), according to the expression:

$$P_{MAX} = (T_{JMAX} - T_{AMB}) / \theta_{JA}$$

The maximum output current ( $I_{MAX}$ ) at a given value of Input voltage ( $V_{IN}$ ) and output voltage ( $V_{OUT}$ ) is then given by:

$$I_{MAX} = P_{MAX} / (V_{IN} - V_{OUT})$$

The value of  $\theta_{JA}$  is strongly dependent upon the type of PC board used. Using the SC70 package it will range from approximately 280°C/W for a multi-layer board to around 450°C/W for a single sided board. It will range from 180°C/W to 300°C/W for the SOT25 package. To avoid entering the thermal shutdown state,  $T_{jmax}$  should be assumed to be 125°C and  $I_{max}$  less than the overcurrent limit, ( $I_{OLIM}$ ). Power derating for the SC70 and SOT25 packages is shown in the following graph.



### Capacitor Selection and Regulator Stability

The device is designed to operate with all types of output capacitor, including tantalum and low ESR ceramic. For stability over the full operating range from no load to maximum load, an output capacitor with a minimum value of 1µF is recommended, although this can be increased without limit to improve load transient performance. Higher values of output capacitor will also reduce output noise. Capacitors with ESR less than 0.5V are recommended for best results.

The dielectric of the ceramic capacitance is an important consideration for the ZXCL Series operation over temperature. Zetex recommends minimum dielectric specification of X7R for the input and output capacitors. For example a ceramic capacitor with X7R dielectric will lose 20% of its capacitance over a -40°C to +85°C temperature range, whereas a capacitor with a Y5V dielectric loses 80% of its capacitance at -40°C and 75% at +85°C.

An input capacitor of 1µF (ceramic or tantalum) is recommended to filter supply noise at the device input and will improve ripple rejection.

The input and output capacitors should be positioned close to the device, and a ground plane board layout should be used to minimise the effects of parasitic track resistance.

### Dropout Voltage

The output pass transistor is a large PMOS device, which acts like a resistor when the regulator enters the dropout region. The dropout voltage is therefore proportional to output current as shown in the typical characteristics.

### Ground Current

The use of a PMOS device ensures a low value of ground current under all conditions including dropout, start-up and maximum load.

### Power Supply Rejection and Load Transient Response

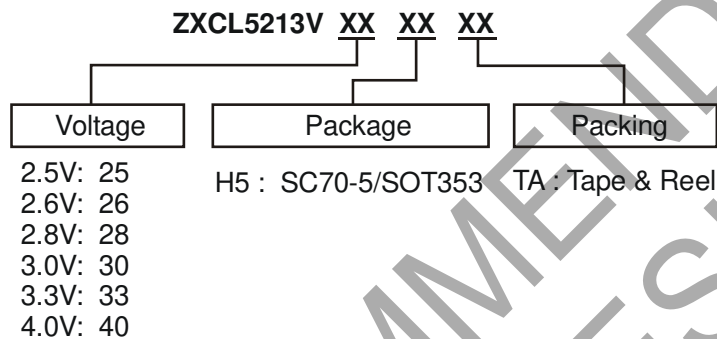
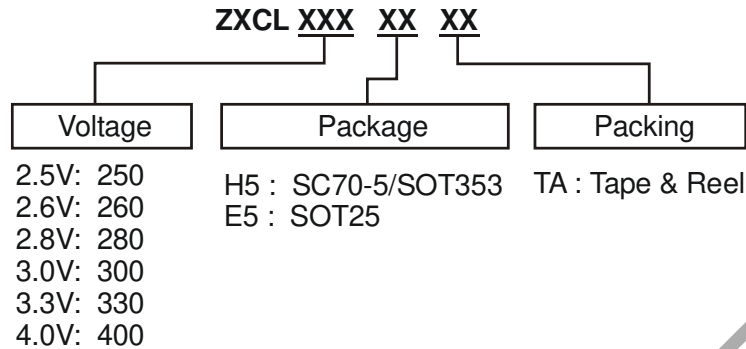
Line and Load transient response graphs are shown in the typical characteristics.

These show both the DC and dynamic shift in the output voltage with step changes of input voltage and load current, and how this is affected by the output capacitor.

If improved transient response is required, then an output capacitor with lower ESR value should be used. Larger capacitors will reduce over/undershoot, but will increase the settling time. Best results are obtained using a ground plane layout to minimise board parasitics.

- ZXCLxx0E5TA: AP2121AK-x.xTRG1
- ZXCLxx0H5TA: AP7115-xxSEG-7 or AP2125KS-X.XTRG1
- ZXCL5213VxxH5TA: No Alternative

## Ordering Information



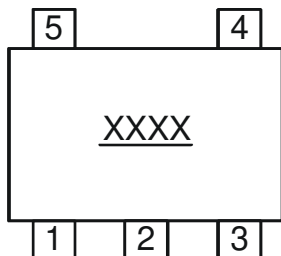
Device	Voltage	Packaging	Packaging Code	Identification Code	Status – recommended alternative	7" Tape & Reel Quantity
ZXCL250H5TA	2.5	SC70-5/SOT353	H5	L25A	NRND – AP7115-25SEG-7 or AP2125KS-2.5TRG1	3000
ZXCL260H5TA	2.6	SC70-5/SOT353	H5	L26A	NRND – No Alternative	3000
ZXCL280H5TA	2.8	SC70-5/SOT353	H5	L28A	NRND – AP7115-28SEG-7 or AP2125KS-2.8TRG1	3000
ZXCL300H5TA	3.0	SC70-5/SOT353	H5	L30A	NRND – AP7115-30SEG-7 or AP2125KS-3.0TRG1	3000
ZXCL330H5TA	3.3	SC70-5/SOT353	H5	L33A	NRND – AP7115-33SEG-7 or AP2125KS-3.3TRG1	3000
ZXCL400H5TA	4.0	SC70-5/SOT353	H5	L40C	Obsolete – No Alternative	3000
ZXCL5213V25H5TA	2.5	SC70-5/SOT353	H5	L25C	NRND – No Alternative	3000
ZXCL5213V26H5TA	2.6	SC70-5/SOT353	H5	L26C	NRND – No Alternative	3000
ZXCL5213V28H5TA	2.8	SC70-5/SOT353	H5	L28C	NRND – No Alternative	3000
ZXCL5213V30H5TA	3.0	SC70-5/SOT353	H5	L30C	NRND – No Alternative	3000
ZXCL5213V33H5TA	3.3	SC70-5/SOT353	H5	L33C	NRND – No Alternative	3000
ZXCL5213V40H5TA	4.0	SC70-5/SOT353	H5	L40C	NRND – No Alternative	3000
ZXCL250E5TA	2.5	SOT25	E5	L25B	NRND – AP2121AK-2.5TRG1	3000
ZXCL260E5TA	2.6	SOT25	E5	L26B	NRND – No Alternative	3000
ZXCL280E5TA	2.8	SOT25	E5	L28B	NRND – AP2121AK-2.8TRG1	3000
ZXCL300E5TA	3.0	SOT25	E5	L30B	NRND – AP2121AK-3.0TRG1	3000
ZXCL330E5TA	3.3	SOT25	E5	L33B	NRND – AP2121AK-3.3TRG1	3000
ZXCL400E5TA	4.0	SOT25	E5	L40B	Obsolete – No Alternative	3000

- ZXCLxx0E5TA: AP2121AK-x.xTRG1
- ZXCLxx0H5TA: AP7115-xxSEG-7 or AP2125KS-X.XTRG1
- ZXCL5213VxxH5TA: No Alternative

## Marking Information

### SOT25, SC70-5/SOT353

( Top View )

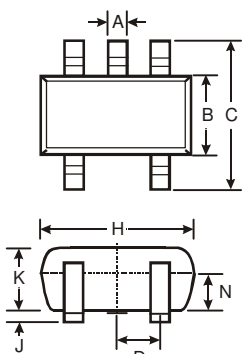


XXXX : Identification code

## Package Outline Dimensions (All Dimensions in mm)

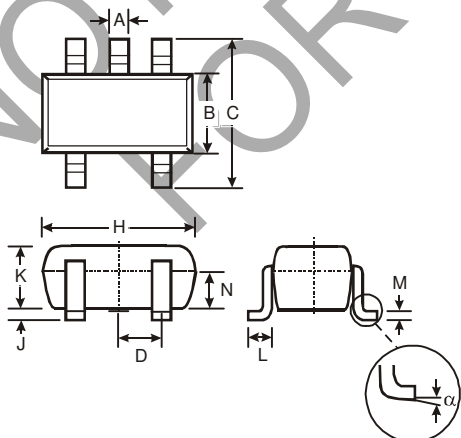
Please see AP02002 at <http://www.diodes.com/datasheets/ap02002.pdf> for the latest version.

### SOT25



SOT25			
Dim	Min	Max	Typ
A	0.35	0.50	0.38
B	1.50	1.70	1.60
C	2.70	3.00	2.80
D	—	—	0.95
H	2.90	3.10	3.00
J	0.013	0.10	0.05
K	1.00	1.30	1.10
L	0.35	0.55	0.40
M	0.10	0.20	0.15
N	0.70	0.80	0.75
$\alpha$	0°	8°	—
All Dimensions in mm			

### SC70-5/SOT353



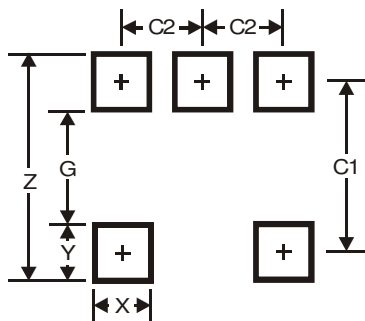
SOT353			
Dim	Min	Max	Typ
A	0.10	0.30	0.25
B	1.15	1.35	1.30
C	2.00	2.20	2.10
D	0.65 Typ		
F	0.40	0.45	0.425
H	1.80	2.20	2.15
J	0	0.10	0.05
K	0.90	1.00	1.00
L	0.25	0.40	0.30
M	0.10	0.22	0.11
$\alpha$	0°	8°	-
All Dimensions in mm			

- ZXCLxx0E5TA: AP2121AK-x.xTRG1
- ZXCLxx0H5TA: AP7115-xxSEG-7 or AP2125KS-X.XTRG1
- ZXCL5213VxxH5TA: No Alternative

## Suggested Pad Layout

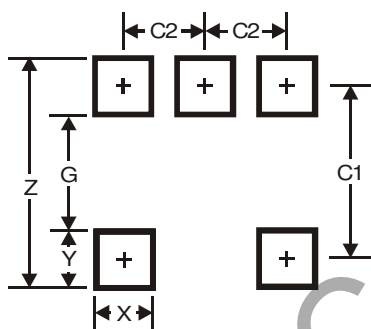
Please see AP02001 at <http://www.diodes.com/datasheets/ap02001.pdf> for the latest version.

### SOT25



Dimensions	Value (in mm)
Z	3.20
G	1.60
X	0.55
Y	0.80
C1	2.40
C2	0.95

### SC70-5/SOT353



Dimensions	Value (in mm)
Z	2.5
G	1.3
X	0.42
Y	0.6
C1	1.9
C2	0.65



- ZXCLxx0E5TA: AP2121AK-x.xTRG1
- ZXCLxx0H5TA: AP7115-xxSEG-7 or AP2125KS-X.XTRG1
- ZXCL5213VxxH5TA: No Alternative

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