PHOTOFLASH CHARGER

DESCRIPTION

The ZXSC440 is a dedicated photoflash charger, charging an 80µF photoflash capacitor to 300V in 3.5 seconds from a 3V supply.

The flyback conversion efficiency is typically 75%, much higher than the commonly used discrete charging circuits.

The Charge pin enables the circuit to be initiated from the camera's microprocessor, using negligible current when flash is not being used.

The Ready pin signals the microprocessor when the flash is charged and ready to be fired.

A small amount of hysteresis on the voltage feedback shuts down the device as long as the capacitor remains fully charged, again using negligible current.

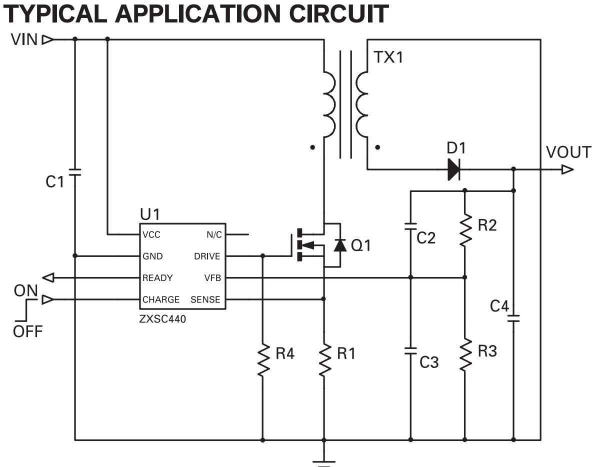
FEATURES

- Charges a 80µF photoflash capacitor to 300V in 3.5 seconds from 3V
- Charges various value photoflash capacitors
- Over 75% flyback efficiency
- Charge and Ready pins
- Consumes only 4.5µA when not charging
- Small MSOP8 low profile package

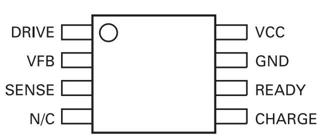
APPLICATIONS

- Digital camera flash unit
- Film camera flash unit

TYPICAL APPLICATION CIRCUIT



PINOUT



MSOP8 pin TOP VIEW

ORDERING INFORMATION

DEVICE	DEVICE DESCRIPTION	TEMPERATURE RANGE	PART MARK	TAPING OPTIONS
ZXSC440X8TA	Camera flash charger	-40°C to +85°C	ZXSC440	TA, TC
ZXSC440X8TC				

- TA reels hold 1000 devices
- TC reels hold 4000 devices

ZXSC440

ABSOLUTE MAXIMUM RATINGS

PARAMETER	LIMIT	UNIT
V_{CC}	-0.3 to +10	V
DRIVE	-0.3 to V_{CC} + 0.3	V
READY	-0.3 to V_{CC} + 0.3	V
CHARGE	-0.3 to The lower of (+5.0) or (V_{CC} +0.3)	V
V_{FB}, SENSE	-0.3 to The lower of (+5.0) or (V_{CC} +0.3)	V
Operating temperature	-40 to +85	°C
Storage temperature	-55 to +150	°C
Power dissipation at 25°C	450	mW

ELECTRICAL CHARACTERISTICS (Test conditions V_{CC}= 3V, T= 25°C unless otherwise stated)

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{CC}	V_{CC} range		1.8		8	V
Iq (1)	Quiescent current	V_{CC} =8V			220	μA
I_{STDN}	Shutdown current			4.5		μA
Eff (2)	Efficiency			85		%
Acc_{REF}	Reference tolerance	1.8V < V_{CC} < 8V	-3.0		3.0	%
TCO_{REF}	Reference temp co			0.005		%/°C
T_{DRV}	Discharge pulse width	1.8V < V_{CC} < 8V		1.7		μs
F_{OSC}	Operating frequency				200	kHz
INPUT PARAMETERS						
V_{SENSE}	Sense voltage		22	28	34	mV
I_{SENSE}	Sense input current	V_{FB}=0V;V_{SENSE}=0V	-1	-7	-15	μA
V_{FB}	Feedback voltage		291	300	309	mV
I_{FB} (2)	Feedback input current	V_{FB}=0V;V_{SENSE}=0V	-1.2		-4.5	μA
VIH (3)	Shutdown threshold		1.5		V_{CC}	V
VIL	Shutdown threshold		0		0.55	V
dV_{LN}	Line voltage regulation			0.5		%/V
OUTPUT PARAMETERS						
I_{DRIVE}	Transistor drive current	V_{DRIVE} = 0.7V	2	3.4	5	mA
V_{DRIVE}	Transistor voltage drive		0		V_{CC}-0.4	V
C_{DRIVE}	Mosfet gate drive cpbty			300		pF
VOH_{READY}	Ready flag output high	I_{EOR} = -300nA, T_A=25°C	2.5		V_{CC}	V
VOL_{READY}	Ready flag output low	I_{EOR} = 1mA, T_A=25°C	0		1	V
T_{READY}		T_A=25°C		195		μs
dI_{LD}	Load current regulation				0.01	%/mA

NOTES

(1) Excluding gate/base drive current.

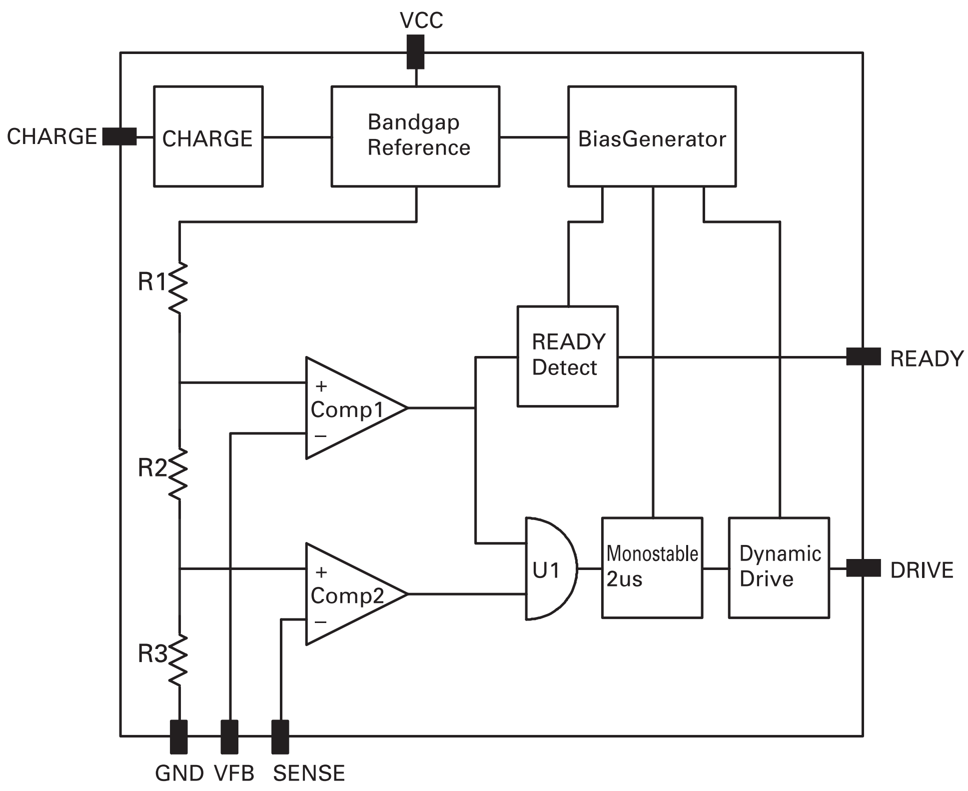
(2) I_{FB} is typically half of these at 3V.

(3) Shutdown pin voltage must not exceed (V_{CC}+0.3V) or 5V, whichever is lower.

ABSOLUTE MAXIMUM RATINGS

PIN #	NAME	DESCRIPTION
1	DRIVE	Drive output for external switching transistor. Connect to base or gate of external switching transistor
2	V_{FB}	Reference voltage. Internal threshold set to 300mV. Connect external resistor network to set output voltage
3	SENSE	Inductor current sense input. Internal threshold voltage set to 28mV. Connect external sense resistor
4	N/C	
5	CHARGE	Initiate photoflash capacitor charging
6	READY	Signal to microprocessor when photoflash capacitor charged
7	GND	Ground
8	V_{CC}	Supply voltage, 1.8V to 8V

BLOCK DIAGRAM



ZETEX SEMICONDUCTORS

DEVICE DESCRIPTION

Bandgap reference

All threshold voltages and internal currents are derived from a temperature compensated bandgap reference circuit with a reference voltage of 1.22V nominal. If the REF terminal is used as a reference for external devices, the maximum load should not exceed ±2µA.

Dynamic drive output

Depending on the input signal, the output is either "LOW" or "HIGH". In the high state a 3.4mA current source (max drive voltage = V_{CC}-0.4V) drives the base or gate of the external transistor. In order to operate the external switching transistor at optimum efficiency, both output states are initiated with a short transient current in order to quickly discharge the base or the gate of the switching transistor.

Switching circuit

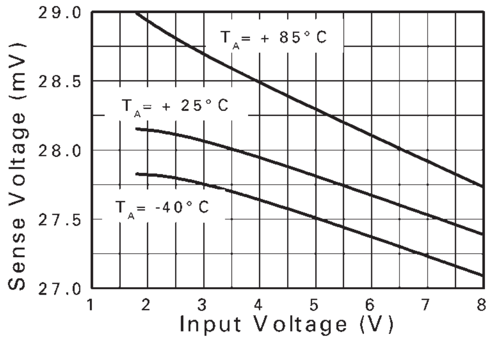
The switching circuit consists of two comparators, Comp1 and Comp2, a gate U1, a monostable and the drive output. Normally the DRIVE output is "HIGH"; the external switching transistor is turned on. Current ramps up in the inductor, the switching transistor and external current sensing resistor. This voltage is sensed by comparator, Comp2, at input SENSE. Once the current sense voltage across the sensing resistor exceeds 28mV, comparator, Comp2, through gate U1, triggers a re-triggerable monostable and turns off the output drive stage for 1.7µs. The inductor discharges into the reservoir capacitor. After 1.7µs a new charge cycle begins, thus ramping the output voltage. When the output voltage reaches the nominal value and V_{FB} gets an input voltage of more than 300mV, the monostable is forced "on" from Comp1 through gate U1, until the feedback voltage falls below 300mV. The above action continues to maintain regulation, with slight hysteresis on the feedback threshold.

READY detector

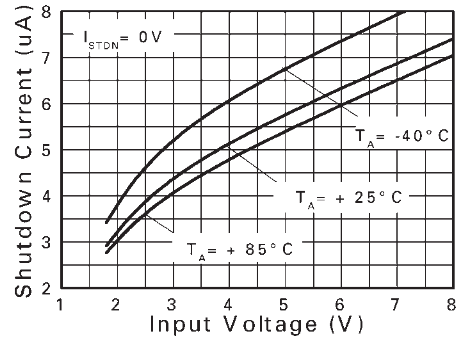
The READY circuit is a re-triggerable 195µs monostable, which is re-triggered by every down regulating action of comparator Comp1. As long as regulation takes place, output READY is "HIGH" (high impedance, 100K to V_{CC}). Short dips of the output voltage of less than 195µs are ignored. If the output voltage falls below the nominal value for more than 195µs, output READY goes "LOW". This can be used to signal to the camera controller that the flash unit has charged fully and is ready to use.

TYPICAL OPERATING CHARACTERISTICS

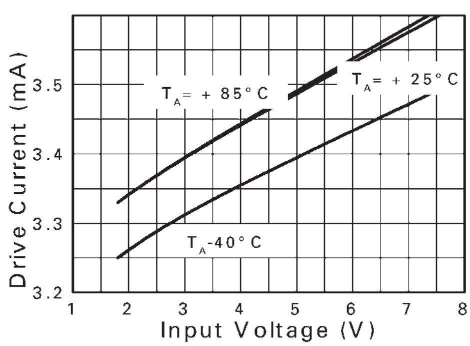
(For typical application circuit at V_{IN}=3V and T_A=25 °C unless otherwise stated)



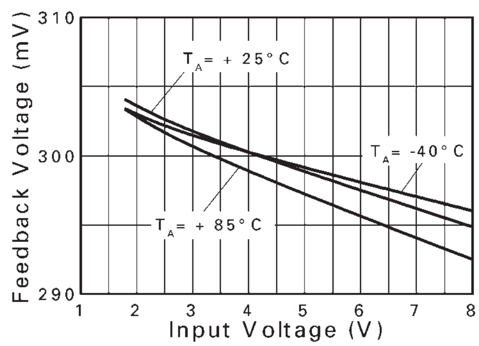
Input Voltage vs Sense Voltage



Input Voltage vs Shutdown Current



Input Voltage vs Drive Current



Input Voltage vs Feedback Voltage

ZETEX SEMICONDUCTORS

APPLICATIONS

Switching transistor selection

The choice of switching transistor has a major impact on the converter efficiency. For optimum performance, a bipolar transistor with low $V_{CE(SAT)}$ and high gain is required. The V_{CEO} of the switching transistor is also an important parameter as this sees typically three times the input voltage when the transistor is switched off. Zetex SuperSOT™ transistors are an ideal choice for this application. At input voltages above 4V, suitable Zetex MOSFET transistors will give almost the same performance with a simpler drive circuit, omitting the ZXTD6717 pre-drive stage. Using a MOSFET, the Schottky diode may be omitted, as the body diode of the MOSFET will perform the same function, with just a small loss of efficiency.

Output rectifier diode selection

The diode should have a fast recovery, as any time spent in reverse conduction removes energy from the reservoir capacitor and dumps it, via the transformer, into the protection diode across the output transistor. This seriously reduces efficiency. Two BAS21 diodes in series have been used, bearing in mind that the reverse voltage across the diode is the sum of the output voltage together with the input voltage multiplied by the step-up ratio of the transformer:

$$V_{R(DIODE)} = V_{OUT(MAX)} + (V_{IN} \times \text{TurnsRatio})$$

Sense resistor

A low value sense resistor is required to set the peak current. Power in this resistor is negligible due to the low sense voltage threshold, V_{SENSE}. Below is a table of recommended sense resistors:

Therefore, with a 300V output, a supply of 8 volts and a 1:12 step-up transformer, there will be a 396V across the diode. This occurs during the current ramp-up in the primary, as it transforms the input voltage up by the turns ratio and the polarity at the secondary is such as to *add* to the output voltage already being held off by the diode.

Peak current definition

In general, the I_{PK} value must be chosen to ensure that the switching transistor, Q1, is in full saturation with maximum output power conditions, assuming worse-case input voltage and transistor gain under all operating temperature extremes.

Once I_{PK} is decided the value of R_{SENSE} can be determined by:

$$R_{SENSE} = \frac{V_{SENSE}}{I_{PK}}$$

Manufacturer	Series	$R_{DC}(\Omega)$ Range	Size	Tolerance	URL
Cyntec	RL1220	0.022 - 10	0805	±5%	http://www.cyntec.com
IRC	LR1206	0.010 - 1.0	1206	±5%	http://www.irctt.com

Using a 22mΩ sense resistor results in a peak current of just over 1.2A.

Transformer parameters

Proprietary transformers are available, for example the Pulse PAO367, Primary inductance: 24uH, Core: Pulse PAO367, Turns ratio: 1:12, see Bill of Materials below. If designing a transformer, bear in mind that the primary current may be over an amp and, if this flows through 10 turns, the primary flux will be 10 Amp. Turns and small cores will need an air gap to cope with this value without saturation. Secondary winding capacitance should not be too high as this is working at 300V and could soon cause excessive losses.

ZXSC440 Transformer specifications

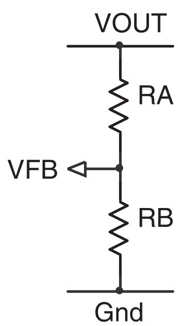
Part No.	Size (WxLxH) mm	L_{PRI} (μH)	$L_{PRI\ -LEAK}$ (nH)	N	R_{PRI} (mΩ)	R_{SEC} (Ω)	Manufacturer
T-15-089	6.4x7.7x4	12	400	10:2	211	27	Tokyo Coil Eng. www.tokyo-coil.co.jp
T-15-083	8x8.9x2	20	500	10:2	675	35	
SBL-5.6-1	5.6x8.5x4	10	200	10:2	103	26	Kijima Musen Kijimahk@netvigator.com
PAO367	9.1x9.1x5.1	24		12:1			Pulse www.pulseeng.com

Output power calculation

This is approximately the power stored in the coil times the frequency of operation times the efficiency. Assuming a current of 1.2 amps in a 30µH primary, the stored energy will be 21.6µJ. The frequency is set by the time it takes the primary to reach 1.2 amps plus the 1.7µs time allowed to discharge the energy into the reservoir capacitor. Using 3 volts, the ramp time is 12µs, so the frequency will be 73kHz, giving an input power of about 1.6 watts. With an efficiency of 75% the output power will be 1.2 watts. An 80µF capacitor charged to 300 volts stores 3.6J, so 1.2 watts will take 3 seconds to charge it. Higher input voltages reduce the ramp time, the frequency therefore goes up and the output power is increased, resulting in shorter charging times.

Output voltage adjustment

The ZXSC440 are adjustable output converters allowing the end user the maximum flexibility. For adjustable operation a potential divider network is connected as follows:



The output voltage is determined by the equation:

$V_{OUT} = V_{FB}$ (1 + RA / RB),

where V_{FB}=300mV

In a circuit giving 300 volts, the "1" in the above equation becomes negligible compared to the ratio which is around 1000. It will not be exactly 1000because of the negative input current in the feedback pin. The resistor values, RA and RB, should be maximized to improve efficiency and decrease battery drain. Optimization can be achieved by providing a minimum current of $I_{FB(MAX)}$=200nA to the V_{FB} pin. Output is adjustable from V_{FB} to the (BR)V_{CEO} of the switching transistor, Q1.

In practice, there will be some stray capacitance across RA and this will cause a lead in the feedback which can affect hysteresis (it makes the device shut down too early) and it is best to swamp this with a capacitor CA and then use a capacitor CB across RB where CB/CA = RA/RB. This is similar to the method used for compensating oscilloscope probes.

Layout issues

Layout is critical for the circuit to function in the most efficient manner in terms of electrical efficiency, thermal considerations and noise.

For 'step-up converters' there are four main current loops, the input loop, power-switch loop, rectifier loop and output loop. The supply charging the input capacitor forms the input loop. The power-switch loop is defined when Q1 is 'on', current flows from the input through the transformer primary, Q1, R_{SENSE} and to ground. When Q1 is 'off', the energy stored in the transformer is transferred from the secondary to the output capacitor and load via D1, forming the rectifier loop. The output loop is formed by the output capacitor supplying the load when Q1 is switched back off.

To optimize for best performance each of these loops kept separate from each other and interconnected with short, thick traces thus minimizing parasitic inductance, capacitance and resistance. Also the R_{SENSE} resistor should be connected, with minimum trace length, between emitter lead of Q1 and ground, again minimizing stray parasitics.

ZXSC440

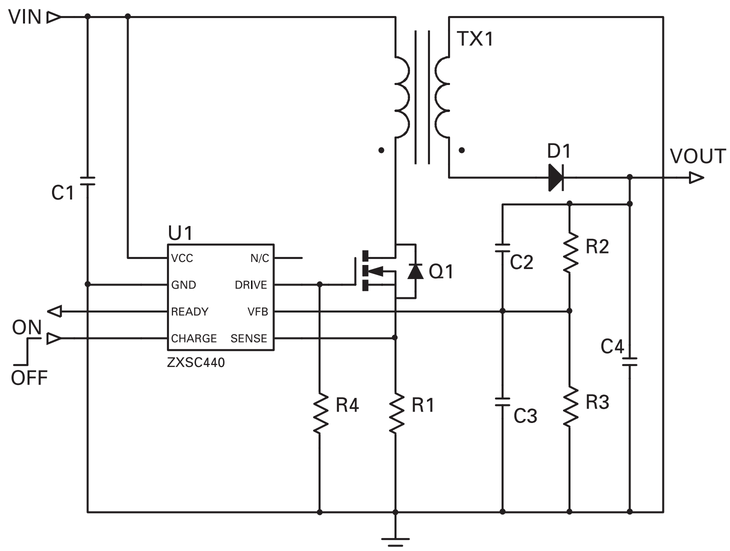
REFERENCE DESIGNS

General camera photoflash charger

Specification

V_{IN} =	5V
V_{OUT} =	275V
Efficiency =	71%
Charging time =	4 seconds

Circuit diagram



Bill of materials

Ref	Value	Package	Part number	Manufacturer	Notes
U1		MSOP8	ZXSC440	Zetex	
Q1		SOT23	ZXMN6A07F	Zetex	60V N-channel MOSFET
D1 (2)	200V	SOT23	BAS21	Philips	x2 200V fast rectifier diodes connected in series
Tx1				Pulse	See note (1)
R1	22mΩ	0805	RL1210	Cyntec	
R2	10MΩ/400V	Axial	Generic	Generic	Output voltage across resistor
R3	10kΩ	0805	Generic	Generic	
R4	100kΩ	0805	Generic	Generic	
C1	100uF/10V	0805	Generic	Murata	
C2	10pF/500V	1206	Generic	Generic	Output voltage seen across capacitor
C3	10nF/6V3	1206	Generic	Generic	
C4	120uF/330V	Radial	FW Series	Rubycon	Photoflash capacitor

NOTES:

(1) **Transformer specification:** Primary inductance: 24uH, Core: Pulse PAO367, Turns ratio: 1:12

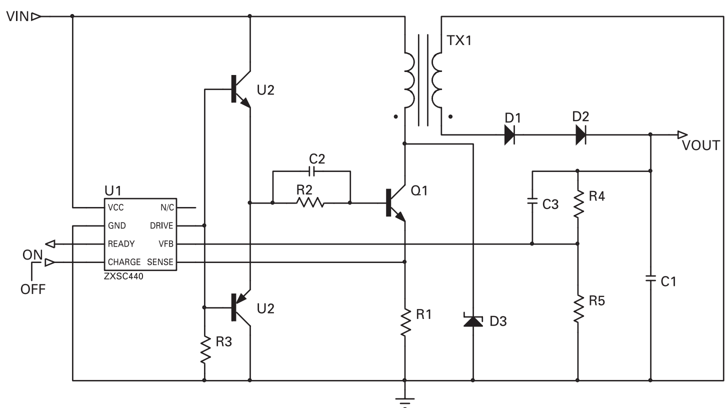
(2) Two BAS21 200V rectifier diodes are connected in series and used in place of a 400V rectifier diode to provide faster switching speeds and higher efficiency.

High power digital camera photoflash charger

Specification

V_{IN} = 3V
V_{OUT} = 275V
Efficiency = 69%
Charging time = 5 seconds

Circuit diagram



Bill of materials

Ref	Value	Package	Part number	Manufacturer	Notes
U1		MSOP8	ZXSC440	Zetex	
U2		SOT23-6	ZXTD6717	Zetex	NPN/PNP dual
Q1		SOT23	FMMT619	Zetex	50V NPN low sat
D1	200V	SOT23	BAS21	Philips	200V fast rectifier
D2	200V	SOT23	BAS21	Philips	200V fast rectifier
D3	2A	SOT23-6	ZLLS2000	Zetex	2A Schottky diode
Tx1			PAO367	Pulse	See note (1)
R1	22mΩ	0805	RL1210	Cyntec	
R2	130Ω	0805	Generic	Generic	
R3	2k2Ω	0805	Generic	Generic	
R4	10MΩ/400V	Axial	Generic	Generic	Output voltage across resistor
R5	10kΩ	0805	Generic	Generic	
C1	100uF/10V	0805	Generic	Murata	
C2	220nF	0805	GRM Series	Murata	
C3	10pF/500V	1206	Generic	Generic	Output voltage seen across capacitor
C4	10nF/6V3	1206	Generic	Generic	
C5	120uF/330V	Radial	FW Series	Rubycon	Photoflash capacitor

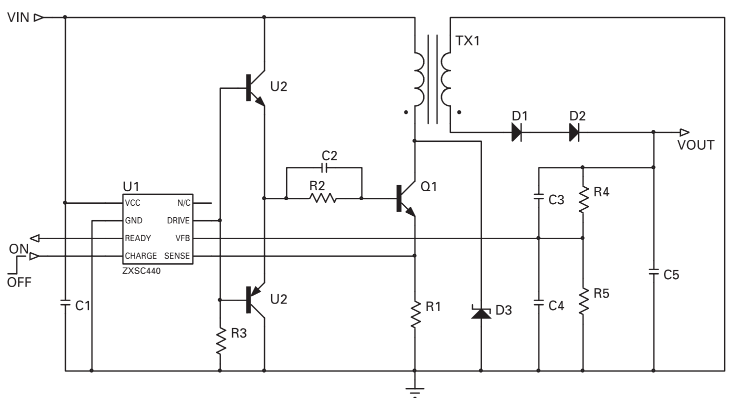
NOTES:
(1) **Transformer specification:** Primary inductance: 24uH, Core: Pulse PAO367, Turns ratio: 1:12

Low power digital camera photoflash charger

Specification

V_{IN} =	3V
V_{OUT} =	275V
Efficiency =	58%
Charging time =	6.8 seconds

Circuit diagram



Bill of materials

Ref	Value	Package	Part number	Manufacturer	Notes
U1		MSOP8	ZXSC440	Zetex	
U2		SOT23-6	ZXTD6717	Zetex	NPN/PNP dual
Q1		SOT23	FMMT619	Zetex	50V NPN low sat
D1	200V	SOT23	BAS21	Philips	200V fast rectifier
D2	200V	SOT23	BAS21	Philips	200V fast rectifier
D3	2A	SOT23-6	ZLLS2000	Zetex	2A Schottky diode
Tx1				Sumida	See note (1)
R1	33mΩ	0805	RL1210	Cyntec	
R2	200Ω	0805	Generic	Generic	
R3	2k2Ω	0805	Generic	Generic	
R4	10MΩ/400V	Axial	Generic	Generic	Output voltage across resistor
R5	10kΩ	0805	Generic	Generic	
C1	100uF/10V	0805	Generic	Murata	
C2	220nF	0805	GRM Series	Murata	
C3	10pF/500V	1206	Generic	Generic	Output voltage seen across capacitor
C4	10nF/6V3	1206	Generic	Generic	
C5	80uF/330V	Radial	FW Series	Rubycon	Photoflash capacitor

NOTES:

(1) **Transformer specification:** Primary inductance: 32uH, Core: Sumida CEEH64, Turns ratio: 1:10

NOTES:

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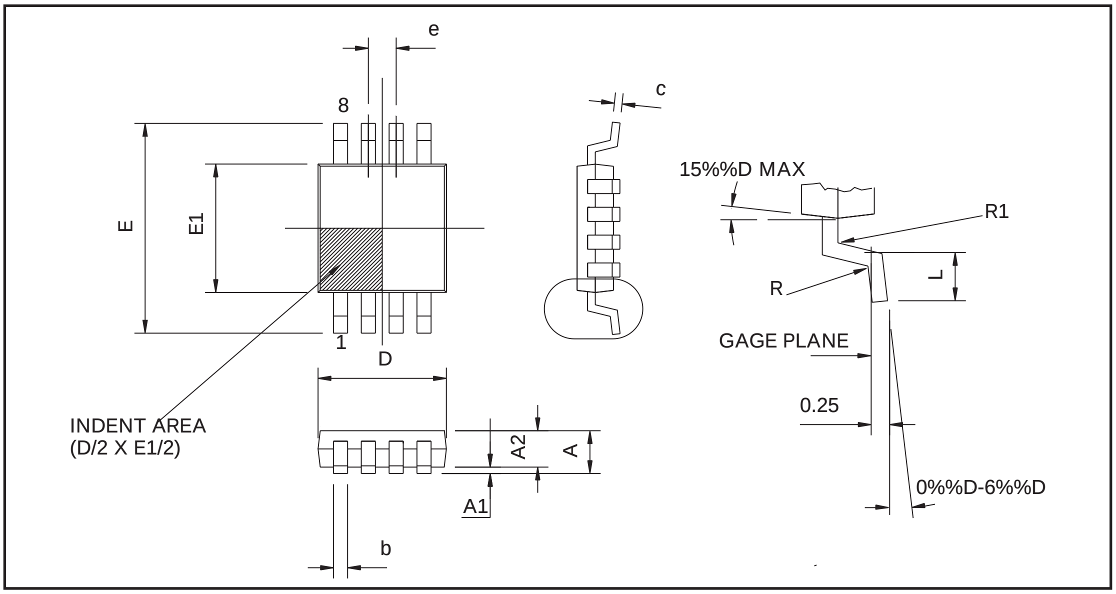
ZETEX SEMICONDUCTORS

PACKAGE OUTLINE



Controlling dimensions are in millimeters. Approximate conversions are given in inches

PACKAGE DIMENSIONS

DIM	Millimeters		Inches		DIM	Millimeters		Inches	
	Min	Max	Min	Max		Min	Max	Min	Max
A	-	1.10	-	0.0433	E	4.90 BSC		0.025 BSC	
A1	0.05	0.15	0.002	0.006	E1	2.90	3.10	0.114	0.122
A2	0.75	0.95	0.0295	0.0374	e	0.65 BSC		0.193 BSC	
b	0.25	0.40	0.010	0.0157	L	0.40	0.70	0.0157	0.0192
c	0.13	0.23	0.005	0.009	R	0.07	-	0.0027	-
D	2.90	3.10	0.114	0.122	R1	0.07	-	0.0027	-

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