Preliminary Information

Micropower Step-up Switching Regulator

GENERAL INFORMATION

The XR-8073 is a bipolar micropower switching regulator designed specifically for low voltage battery powered instruments where high efficiency and minimum size are crucial. The extremely low minimum input voltage gives the device the unique ability to boost single-cell battery voltages. The XR-8073 contains a 172mV temperature compensated voltage reference, a voltage comparator, a gated oscillator, low voltage detection circuitry, and an internal 250mA switch transistor required to make a complete low power switching regulator.

The XR-8073 regulator is available in 8-pin plastic SO and DIL packages for use over the commercial and industrial temperature ranges.

FEATURES

- No Design Required
- +0.9V to +20V Operation
- 100µA Quiescent Current
- Low Component Count
- Remote Shutdown / Power-Down Capability
- On-Board Low Battery Detector
- Adjustable Output Voltage Level
- Same Pin Assignment as Raytheon 4191/2/3

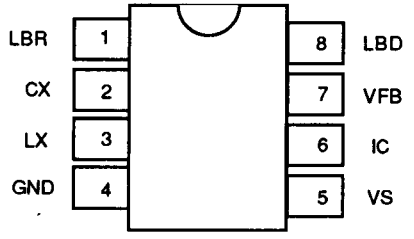
APPLICATIONS

- Battery Powered Systems
- Single-Cell or Multi-Cell Portable Equipment
- Pagers, Cameras, & Cellular Telephones
- Laptop, Palmtop, & Pocket Computers
- High Efficiency DC to DC Converters

ABSOLUTE MAXIMUM RATINGS

Power Supply Voltage	20V
Power Dissipation (package limitation)	
8 Pin PDIP package	400mW
8 Pin SO package	300mW
Storage Temperature	-65°C to +150°C
Maximum Input Voltage	VS +0.3V
Minimum INput Voltage	GND -0.3V

PIN ASSIGNMENT



ORDERING INFORMATION

Part Number	Package	Operating Temperature
XR-8073CP	8 Pin DIP	0°C to +70°C
XR-8073CD	8 Pin SO	0°C to +70°C
XR-8073IP	8 Pin DIP	-25°C to +85°C
XR-8073ID	8 Pin SO	-25°C to +85°C

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SYSTEM DESCRIPTION

The XR-8073 is a gated-oscilliator implementation of the standard step-up switching regulator architecture. The benefit of this implementation is low supply current since the switch is gated off much of the time.

Operation of the XR-8073 can be understood by examining the voltage regulating loop of Fig.1. A fraction of the output voltage divided by resistors R4 and R5 is compared to the 172mV reference by comparator A1. When this voltage is lower than Vref, the comparator activates the oscillator by turning on its bias current. Output pulses from the oscillator are passed through a driver stage to the base of the power switch Q1 which drives inductor L1 with a series of pulses at the frequency and duty cycle of the oscillator. During the closed time of switch Q1, L1 stores energy as magnetic flux within its core. When Q1 opens, the energy is transfered through diode D1 to capacitor C2 where it is stored in the form of charge. As the stored charge on C2 increases with subsequent pulses, output voltage rises. When the output voltage reaches a level such that comparator A1 sees a voltage greater than the 172mV reference, bias current to the oscillator is disconnected and Q1 is left open. During this time, capacitor C2 provides current to the load. When voltage across C2 eventually drops below the regulated value, the cycle will be repeated.

PIN DESCRIPTION

PIN #	SYMBOL	TYPE	DESCRIPTION
1	LBR	I	**Low Battery Set Resistor.** A voltage less than 170mV at LBR wil activate the LBD output
2	CX	I	**Oscillator Timing Capacitor.** An external capacitor connected between OX and ground sets the frequency of oscillation.
3	LX	O	**External Inductor.** Open collectér output of the internal power switch transistor.
4	GND	P	**Ground.**
5	VS	P	**Supply Voltage.**
6	IC	I	**Bias Set Current (10μA).** Current into this pin activates the regulator. With supply voltages less than 1.5V, connect directly to VS.
7	VFB	I	**Feedback Voltage.** A DC voltage less than 170mV at this pin enables the oscillator and switch driver.
8	LBD	O	**Low Battery Detector Output.** Open collector output of the low battery detector. Active low.

BIAS GENERATOR

The bias generator generates two voltages to bias various internal current mirrors at a current level independent of supply voltage and temperature. The generator is activated by a current into the IC (pin 6) input. This current is determined by an external resistor connected between IC and VS (pin 5). The minimum value for the current is 5mA, the maximum 50mA, and the optimum value 10mA. The correct value for the external resistor is calculated from:

$$R_6 = \frac{V_S - 1.5V}{10\mu A}\ \Omega$$

IC (pin 6) can be connected directly to the supply voltage if VS is less than orequal to +1.5V.

POWER DOWN MODE

IC can also be used as a power-down control input. Removing the current to IC disables the regulator and current consumption is dropped to 15μA.

BANDGAP VOLTAGE REFERENCE

A temperature compensated reference voltage of 172mV is generated by the bandgap voltage reference. This voltage is used as reference voltage at the output voltage feedback and low battery comparators.

COMPARATOR

A fraction of the regulated output voltage at VFB (pin 7) determined by external resistors R4 and R5 is compared to the internal reference voltage by comparator A1. When the VFB voltage is lower than the reference voltage, the output of the comparator is high and the bias current of the oscillator is on. Otherwise, the comparator output is low and the oscillator bias current is switched off, disabling the oscillator. In this way R4 and R5 are used to control the output voltage level according to:

$$V_{OUT} = (1 + R4 / R5) (0.172) V$$

ELECTRICAL CHARACTERISTICS : VS = +1.25VDC, T_A = +25°C unless otherwise specified.

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS	CONDITIONS
GENERAL CHARACTERISTICS						
VS	Supply Voltage	0.9		20	V	Operating
		1			V	Start-up
I_S	Supply Current		100		µA	I_{switch} = 0
			15	40	µA	Disabled
V_{REF}	Internal Reference Voltage		172		mV	
eff	Efficiency		TBD		%	
$\Delta V_O/\Delta VS$	Line Regulation		TBD		mV/V	
$\Delta V_O/\Delta I_O$	Load Regulation		TBD		mV/MA	0 to 50 mW load
OSCILLATOR						
F_O	Operating Frequency			75	kHz	
%On	Switch Duty Cycle	75		85	%	
$-I_{CX}$	Capacitor Charcing Current		3		µA	
$+I_{CX}$	Capacitor Discharging Current		12		µA	
$-V_{TH}$	CX-Threshold Voltage		0.20		V	
$+V_{TH}$	CX+Threshold Voltage		0.32		V	
BIAS / SWITCH / FEEDBACK / LB CURRENT						
I_{IC}	IC Input Bias Current	5	10	50	µA	
I_{SW}	Switch Current	150			mA	V_3=250mV
I_{fb}	Feedback Input Current			0.05	µA	
I_1	Low Battery Bias Current			0.1	µA	V_7=170mV
I_{LBO}	Low Battery Output Current	100	300		µA	

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OSCILLATOR

The oscillator consists of two comparators, a threshold voltage generator, and a charging / discharging current generator. The voltage of external capacitor C3 connected to CX (pin 2) is compared to an internal threshold voltage of VTH. When the voltage at CX is lower than VTH, the capacitor is charged by a current of approximately 3mA. When the voltage of the capacitor reaches VTH, the threshold voltage is switched to a lower value and the capacitor is discharged by a current of 12mA. Discharging goes on until the capacitor voltage reaches VTH which is then switched back to the higher value, and a new cycle begins. Voltage difference between the low and high threshold values is approximately 0.12V. The 1:4 ratio of the charging and discharging currents results in an oscillator duty cycle of 4:1 (switch-on/switch-off). Approximate frequency of the oscillation can be calculated from:

$$F_{osc} = \frac{1}{50000\ (C3)}\ H_Z$$

DRIVER

The output pulses of the oscillator are passed to a driver stage which providesthe output power transistor with sufficient base current to ensure saturation at all current levels. The driver stage is adaptive in such a way that the power transistor is always only saturated to a point where its current gain drops approximately to 50. This results in a good efficiency since no current is wasted for unnecessarily hard driving of the output transistor.

LOW BATTERY DETECTOR

The low battery detector consists of a comparator which compares the voltage at LBR (pin 1) to the internal reference voltage and, when the voltage at LBR is lower, outputs a logic "0" at the open-collector output LBD (pin 8). The low battery voltage limit is set by two external resistors, R1 and R2, to a value calculated from:

$$V_{LB} = (\ 1 + R1 / R2\ )\ (0.172)\ V$$

The low battery indicator has a large hysteresis dependent of R1. With R1 = 330k, the hysteresis is approximately 1V.

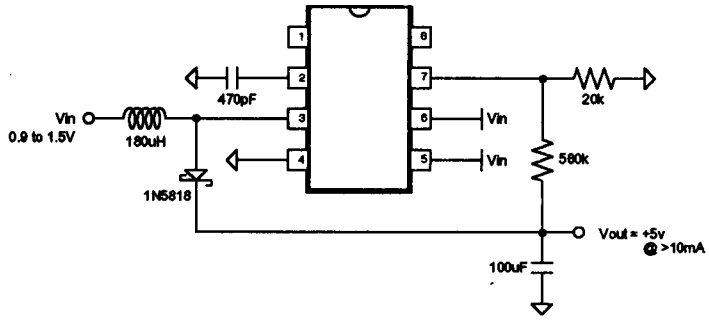

Figure 1. Typical Application Schematic

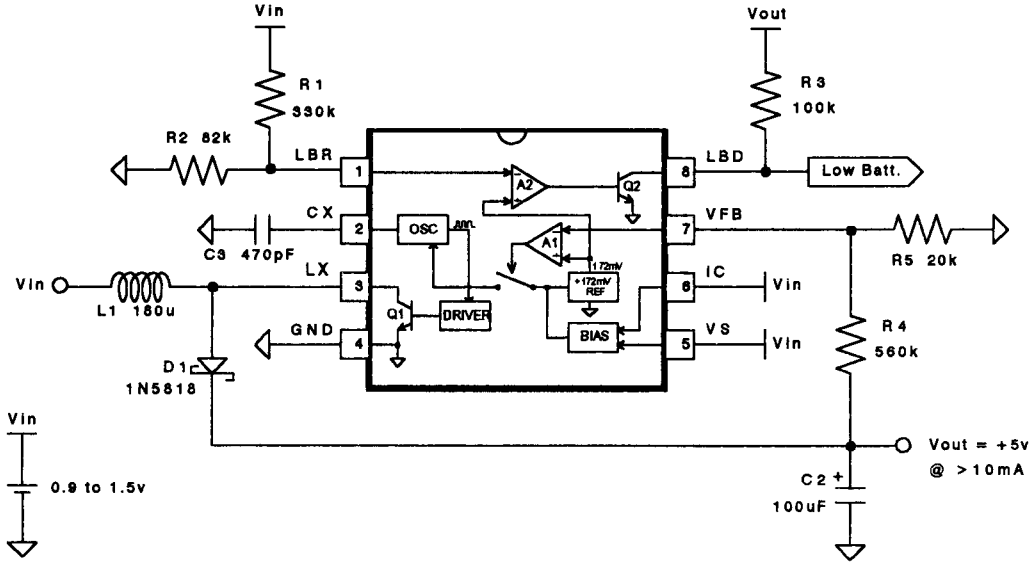

Figure 2. Block Diagram and System Schematic