LM9074EP Enhanced Plastic System Voltage Regulator with Keep-Alive ON/OFF Control

Check for Samples: LM9074EP

FEATURES

- **Automotive application reliability**
- **3% output voltage tolerance**
- **Insensitive to radiated RFI**
- **Dropout voltage less than 2.5V with 180mA output current**
- **Externally programmed reset delay interval**
- **Keep-alive feature with 2 logic control inputs**
- **+40V Load dump transient protection**
- **Thermal shutdown**
- **Short circuit protection and disable safety features**
- **Reverse battery protection**
- **Low OFF quiescent current, 60μA maximum**

APPLICATIONS

- **Selected Military Applications**
- **Selected Avionics Applications**

DESCRIPTION

The LM9074EP is a 5V, 3% accurate, 180 mA NPN voltage regulator. The regulator features an active low delayed reset output flag which can be used to reset a microprocessor system on turn-ON and in the event that the regulator output falls out of regulation for any reason. An external capacitor programs a delay time interval before the reset output can return high.

Designed for automotive application the LM9074EP contains a variety of protection features such as reverse battery, over-voltage shutdown, thermal shutdown, input transient protection and a wide operating temperature range.

A unique two-input logic control scheme is used to enable or disable the regulator output. An ON/OFF input can be provided by an ignition switch derived signal while a second, Keep-Alive input, is generated by a system controller. This allows for a system to remain ON after ignition has been switched OFF. The system controller can then execute a power-down routine and after which command the regulator OFF to a low quiescent current state (60 μA max).

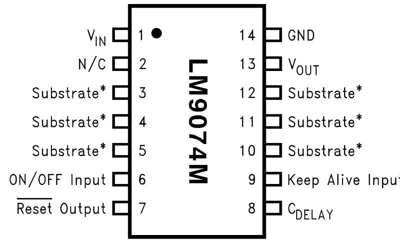
Design techniques have been employed to allow the regulator to remain operational and not generate false reset signals when subjected to high levels of RF energy (300V/m from 2 MHz to 400 MHz).

ENHANCED PLASTIC

- Extended Temperature Performance of −40°C to +125°C
- Baseline Control - Single Fab & Assembly Site
- Process Change Notification (PCN)
- Qualification & Reliability Data
- Solder (PbSn) Lead Finish is standard
- Enhanced Diminishing Manufacturing Sources (DMS) Support

Connection Diagram

14-Pin SO Package



* Substrate pins must be connected to Ground Pin

Figure 1. Top View

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings [(1)]

Input Voltage	
ON/OFF, Keep-Alive Inputs (through 1 kΩ)	
DC Input Voltage	−26V to +26V
Positive Input Transient (t<100 ms)	40V
Negative Input Transient (t<1 ms)	−50V
Reset Output Sink Current	5 mA
Power Dissipation	Internally Limited
Junction Temperature	150°C
ESD Susceptibility [(2)]	12 kV, 2 kV
Lead Temperature (Soldering, 10 seconds)	260°C
Storage Temperature	−50°C to +150°C

(1) **Absolute Maximum Ratings** indicate limits beyond which damage to the device may occur. **Operating Ratings** indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and conditions, see the **Electrical Characteristics.**

(2) All pins will survive an ESD impulse of ±2000V using the human body model of 100 pF discharged through a 1.5 kΩ resistor. In addition, input pins V_{IN} and the ON/OFF input will withstand ten pulses of ±12 kV from a 150 pF capacitor discharged through a 560Ω resistor with each pin bypassed with a 22 nF, 100V capacitor.

Operating Ratings [(1)]

Input Voltage	7.5V to 16.5V
Ambient Temperature	−40°C to +125°C
θja, M14A Package	88°C/W
θjc, M14A Package	34°C/W

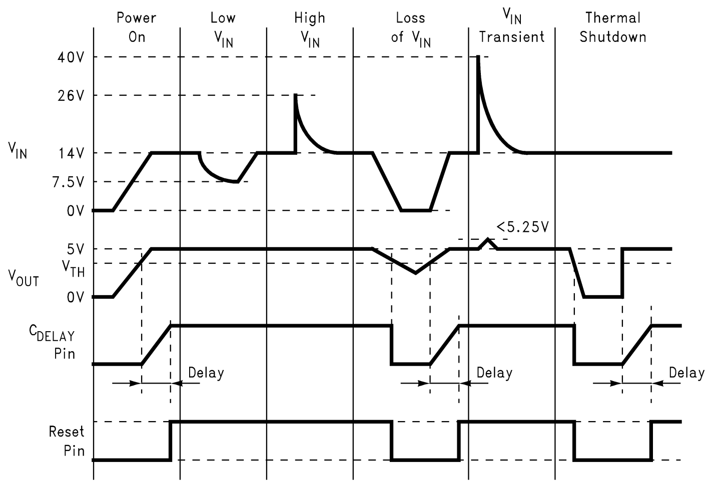
(1) **Absolute Maximum Ratings** indicate limits beyond which damage to the device may occur. **Operating Ratings** indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and conditions, see the **Electrical Characteristics.**

Electrical Characteristics

The following specifications apply for V_{CC}= 7.5V to 16.5V, −40°C ≤ T_A≤ 125°C, unless otherwise specified. C_{OUT}=0.1µF.

Symbol	Parameter	Conditions	Min	Max	Units
REGULATOR OUTPUT					
V_{OUT}	Output Voltage	20 mA ≤ I_{OUT} ≤ 180 mA	4.85	5.15	V
ΔV_{OUT} Line	Line Regulation	I_{OUT} = 20 mA, 9V ≤ V_{IN} ≤ 16.5V I_{OUT} = 20 mA, 7.5V ≤ V_{IN} ≤ 16.5V		25 50	mV mV
ΔV_{OUT} Load	Load Regulation	V_{IN} = 14.4V, 20 mA ≤ I_{OUT} ≤ 180 mA		50	mV
Iq	Quiescent Current	4V ≤ $V_{ON/OFF}$ ≤ V_{IN} 20mA ≤ I_{OUT} ≤ 180mA		25	mA
Ioff	OFF Quiescent Current	V_{IN} ≤ 16.5V, Regulator OFF			
		−40°C ≤ T_J ≤ 60°C 60°C ≤ T_J ≤ 135°C		20 60	µA µA
Vdo	Dropout Voltage	I_{OUT} = 20 mA I_{OUT} = 180 mA		2.0 2.5	V V
Isc	Short Circuit Current	R_L = 1Ω	0.4	1.0	A
PSRR	Ripple Rejection	V_{IN} = (14V_{DC}) + (1V_{RMS} @ 120Hz)			
		I_{OUT} = 50 mA	60		dB
$Voth_{OFF}$	Safety V_{OUT} Latch-OFF Threshold	In Keep-Alive mode			
		$V_{ON/OFF}$ = 0V, V_{KA} = 0V	4	4.5	V
Vo Transient	V_{OUT} during Transients	V_{IN} Peak ≤ 40V, R_L = 100Ω, τ = 100 ms		5.5	V
RESET OUTPUT					
Vth	Threshold Voltage	ΔV_{OUT} Required to Generate a Reset Output 4.85V ≤ V_{OUT} ≤ 5.15V	−300	−500	mV
Vlow	Reset Output Low Voltage	Isink = 1.6 mA, V_{OUT} > 3.2V		0.4	V
		1.4V ≤ V_{OUT} ≤ 3.2V		0.8	V
Vhigh	Reset Output High Voltage		0.9 V_{OUT}	V_{OUT}	V
t_{delay}	Delay Time	Cdelay = 0.1 µFd	7	45	ms
I_{delay}	Charging Current for Cdelay		−7	25	µA
Rpu	Internal Pull-up Resistance		12	80	kΩ
CONTROL LOGIC					
V_{KA} low	Low Input Threshold Voltage, Keep-Alive Input	3.5V ≤ V_{OUT} ≤ 5.25V	0.3 V_{OUT}	0.5 V_{OUT}	V
V_{KA} high	High Input Threshold Voltage, Keep-Alive Input	3.5V ≤ V_{OUT} ≤ 5.25V	0.6 V_{OUT}	0.8 V_{OUT}	V
$V_{ON/OFF}$ low	Low Input Voltage, ON/OFF Input	Rseries = 1 kΩ	−2	2	V
$V_{ON/OFF}$ high	High Input Voltage, ON/OFF Input	Rseries = 1 kΩ	4	V_{IN}	V
$I_{ON/OFF}$	Input Current, ON/OFF Input	$V_{ON/OFF}$ ≤ 4V		330	µA
		4V < $V_{ON/OFF}$ < 7V		670	µA
		$V_{ON/OFF}$ ≥ 7V		10	mA
Rpu_{KA}	Internal Pull-up Resistance, Keep-Alive Input		20	100	kΩ
$Rpd_{ON/OFF}$	Internal Pull-down Resistance ON/OFF Input		50	210	kΩ

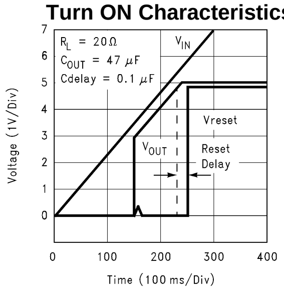
Reset Operation and Protection Features



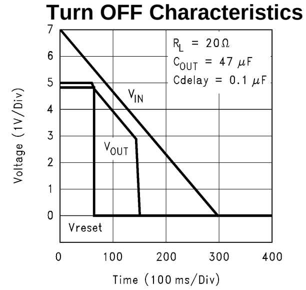
Typical Performance Characteristics

(T_A = 25°C unless indicated otherwise)

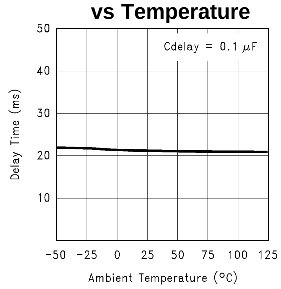
Turn ON Characteristics



Turn OFF Characteristics



Reset Delay Time vs Temperature



ON/OFF, Keep-Alive and Safety Latch-Off Control Diagrams

NOTE

If Keep-Alive is provided by a microprocessor powered by the output voltage of the LM9074EP, the logic “1” voltage level will track V_{OUT} as the regulator turns OFF.

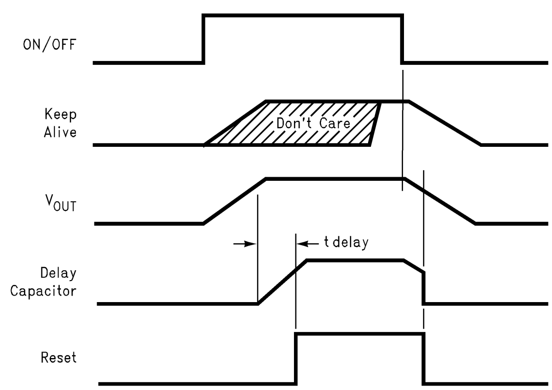


Figure 2. Simple ON/OFF control
(Keep-Alive input must be high to turn OFF output)

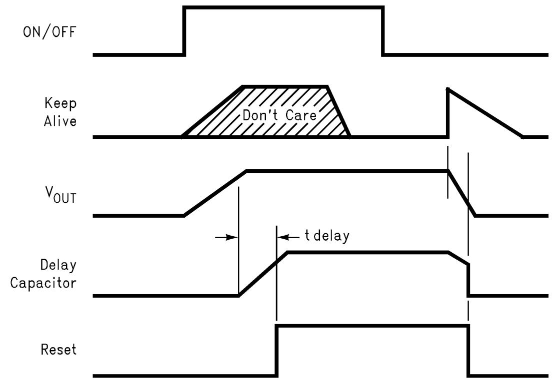


Figure 3. Keep-Alive Mode; Turn ON with ON/OFF control, Keep output biased with Keep-Alive input, Turn OFF with Keep-Alive (Keep-Alive low keeps output ON, Keep-Alive going high turns output OFF)

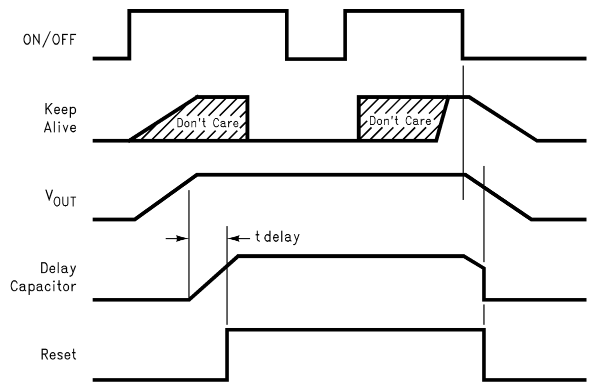


Figure 4. Switch ON with ON/OFF input; Keep output biased with Keep-Alive; Hold ouput ON with ON/OFF; Turn OFF with ON/OFF input. (Temporary Keep-Alive Mode)

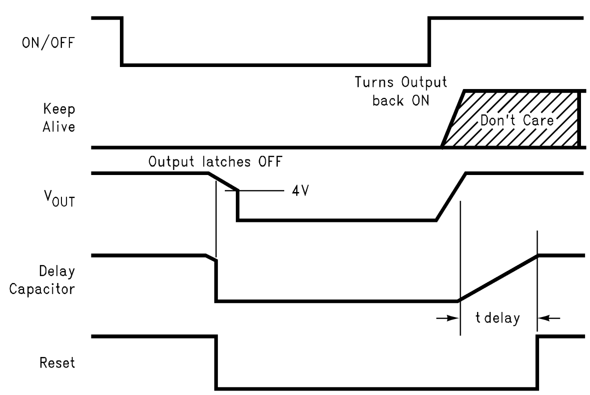


Figure 5. Safety Latch OFF of V_{OUT} when in Keep-Alive Mode (ON/OFF going high required to turn Output back ON)

Table 1. Control Logic Truth Table

ON/OFF Input	Keep-Alive Input	Output Voltage	Reset Output	Operating Condition
L	X	0V	L	Low quiescent current standby (OFF) condition

Table 1. Control Logic Truth Table (continued)

ON/OFF Input	Keep-Alive Input	Output Voltage	Reset Output	Operating Condition
↑	X	5V	↑ after delay	Output turns ON
H	X	5V	H	Normal ON condition
↓	H	0V	L	Output turns OFF
↓	L	5V	H	Output kept ON by Keep-Alive Input
↑	L	5V	H	Output remains ON (or turns ON)
H	X	$\Delta V_{OUT} \geq -300$ mV	L	Output pulled out of regulation, reset flag generated
L	L	$V_{OUT} \leq 4V$	L	Output latches OFF

Block Diagram

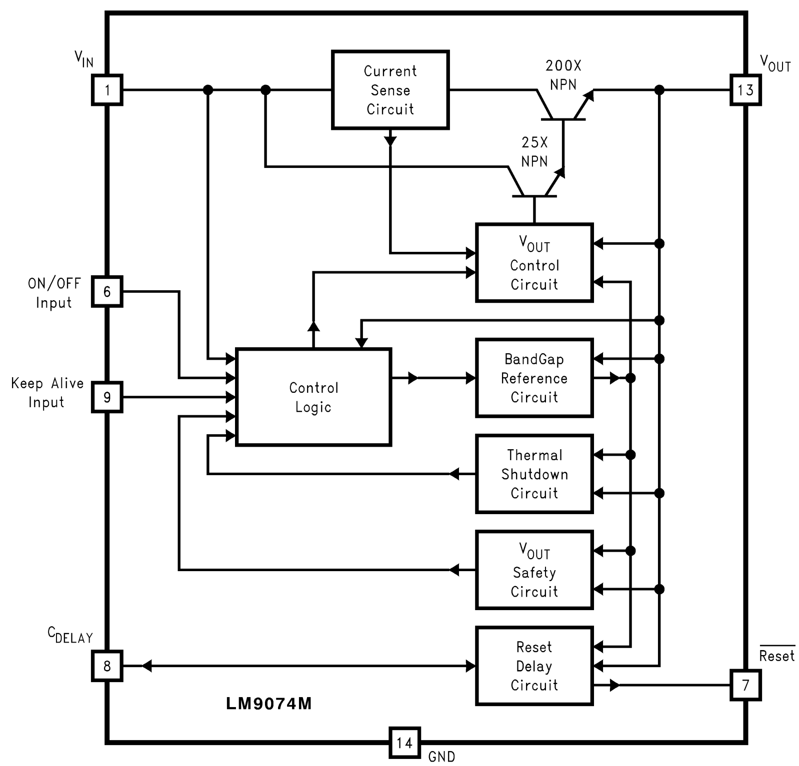


Figure 6. Block Diagram

Application Information

The LM9074EP voltage regulator has been optimized for use in microprocessor based automotive systems. Several unique design features have been incorporated to address many FMEA (Failure Mode Effects Analysis) concerns for fail-safe system performance.

FAULT TOLERANT FEATURES

While not specifically guaranteed due to production testing limitations, the LM9074EP has been tested and shown to continue to provide a regulated output and, not generate an erroneous system reset signal while subjected to high levels of RF electric field energy (up to 300 V/m signal strength over a 2 MHz to 400 MHz frequency range). This is very important in vehicle safety related applications where the system must continue to operate normally. To maintain this immunity to RFI the output bypass capacitor is important (47 μF is recommended).

This regulator is suitable for applications where continuous connection to the battery is required (*Refer to the Typical Application Circuit*). ON/OFF control of the regulator and system can be accomplished by switching the ON/OFF input to the battery or ignition supply V_{IN} supply through a SPST switch. If this input becomes open circuited, an internal pull-down resistor ensures that the regulator turns OFF. When the regulator is switched OFF the current load on the battery drops to less than 60 µA. With the possibility in many applications for V_{IN} and the ON/OFF input pins to be connected in a system through long lengths of wire, the ESD protection of these pins has been increased to 12 kV with the addition of small input bypass capacitors.

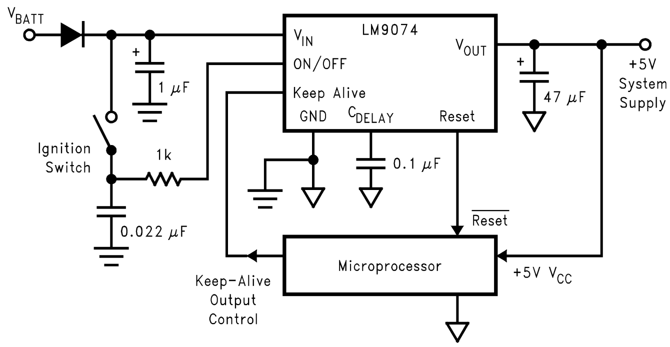


Figure 7. Typical Application Circuit

An output bypass capacitor of at least 0.1µF is required for stability (47 µF is recommended). An input capacitor of 1 µF or larger is recommended to improve line transient and noise performance.

With the Keep-Alive input, a system microprocessor has the ability to keep the regulator ON (with a logic “0” on Keep-Alive) after the ON/OFF input has been commanded OFF. A power-down sequence, when system variables are typically stored in programmable memory, can be executed and take as much time as necessary. At the end of the operation the micro then pulls Keep-Alive high and the regulator and system turn OFF and revert to the low quiescent current standby mode.

For additional system reliability, consideration has been made for the possibility of a short circuited load at the output of the regulator. When the regulator is switched ON, conventional current limiting and thermal shutdown protect the regulator. When the regulator is switched OFF however, a grounded V_{CC} supply to the micro (due to the shorted regulator output) will force the Keep-Alive input to be low and thus try to maintain the Keep-Alive mode of operation. With a shorted load, the drain on the battery could be as high as 1.5A. A separate internal circuit monitors the output voltage of the regulator. If V_{OUT} is less than 4V, as would be the case with a shorted load, the Keep-Alive function is logically disabled to ensure that the regulator turns OFF and reverts to less than a 60 µA load on the battery.

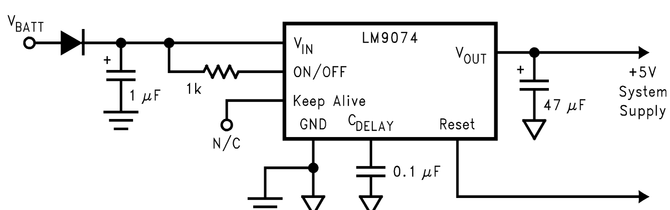


Figure 8. Control Logic Not Used

Conventional load dump protection is built in to withstand up to +60V and −50V transients. A 1 kΩ resistor in series with the ON/OFF and Keep-Alive inputs are recommended to provide the same level of transient protection for these pins if required. Protection against reverse polarity battery connections is also built in. With a reversed battery the output of the LM9074EP will not go more negative than one diode drop below ground. This will prevent damage to any of the 5V load circuits.

For applications where the control logic is not required the logic pins should be configured as shown in Figure 8. A separate device, called the LM9071, can be used. The LM9071 is available in a 5-lead TO-220 package and does not provide control logic functions, but still retains all of the protection features of the LM9074EP.

RESET FLAG

Excessive loading of the output to the point where the output voltage drops by 300 mV to 500 mV will signal a reset flag to the micro. This will warn of a V_{CC} supply that may produce unpredictable operation of the system. On power-up and recovery from a fault condition the delay capacitor is used to hold the micro in a reset condition for a programmable time interval to allow the system operating voltages and

clock to stabilize before executing code. The typical delay time interval can be estimated using the following equation:

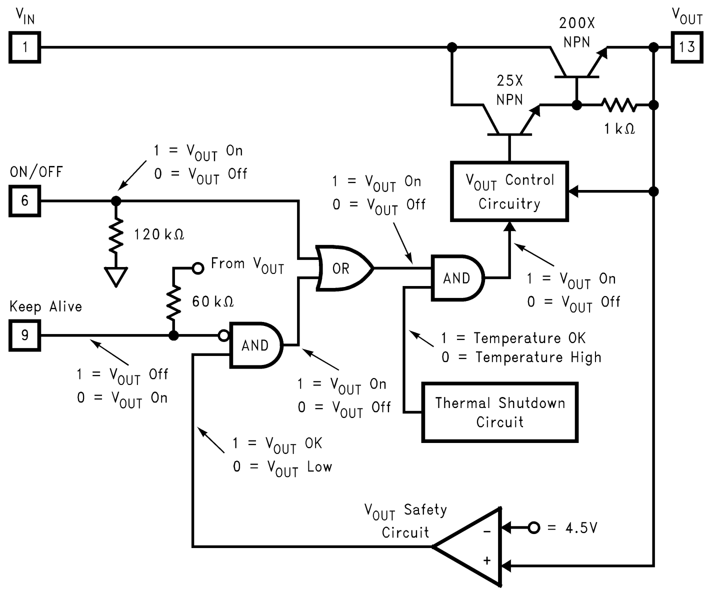
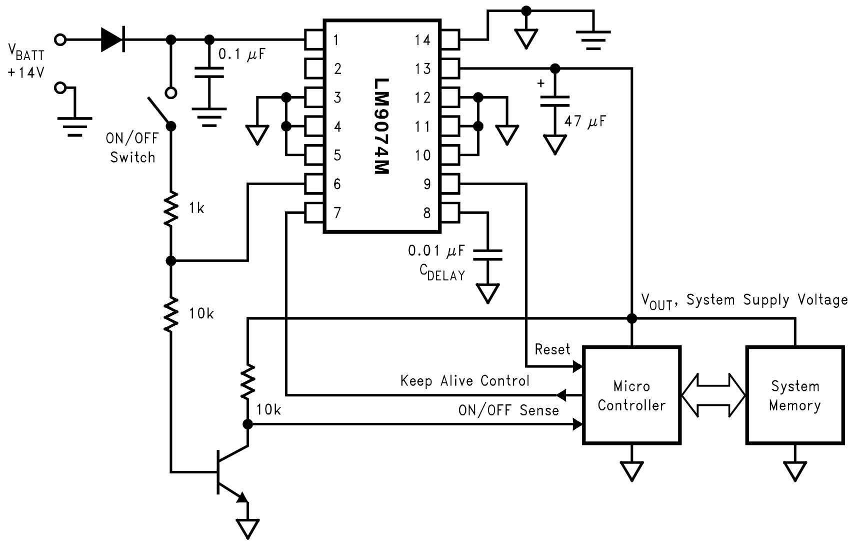


Figure 9.

MICROPROCESSOR SYSTEM REGULATOR WITH KEEP-ALIVE INTERVAL AT TURN-OFF

The following circuit illustrates a system application utilizing both of the logic control inputs of the LM9074EP. Closing the ON/OFF switch powers ON the system. Once powered, the system controller sets the Keep-Alive line low. The NPN transistor is used only to signal the controller that the ON/OFF switch has been opened and the system is to be turned OFF. Upon detecting this high level at the ON/OFF Sense input line, the controller can then perform a power down routine. The system will remain fully powered until the controller commands total shut down by taking the Keep-Alive line high. The system then shuts OFF and reverts to a very low current drain standby condition until switched back on.


VBATT +14V
0.1 μF
ON/OFF Switch
1k
10k
10k
LM9074M
47 μF
0.01 μF CDELAY
VOUT, System Supply Voltage
Reset
Keep Alive Control
ON/OFF Sense
Micro Controller
System Memory

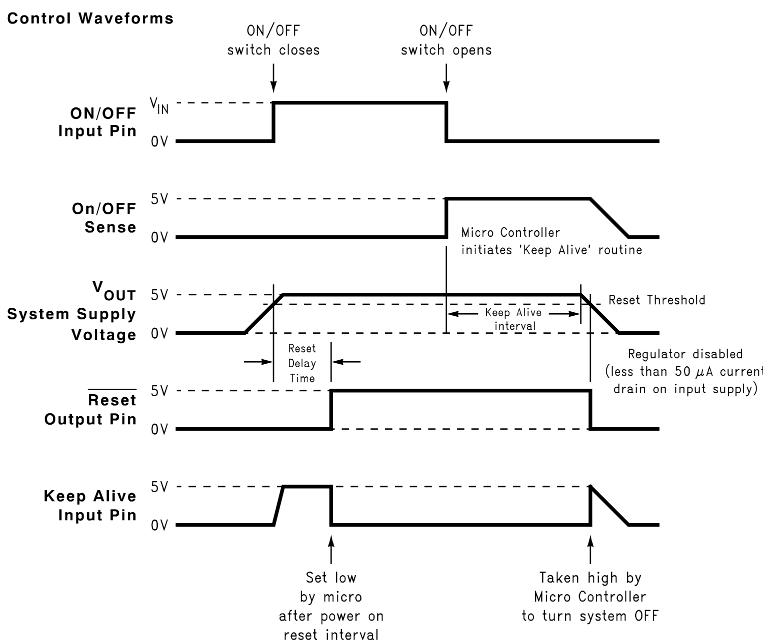

Control Waveforms
ON/OFF switch closes
ON/OFF switch opens
ON/OFF Input Pin
VIN
0V
On/OFF Sense
5V
0V
Micro Controller initiates 'Keep Alive' routine
VOUT System Supply Voltage
Reset Threshold
Keep Alive interval
Reset Delay Time
Regulator disabled (less than 50 μA current drain on input supply)
Reset Output Pin
Keep Alive Input Pin
Set low by micro after power on reset interval
Taken high by Micro Controller to turn system OFF

Figure 10.

IMPORTANT NOTICE

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