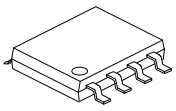
NON-ISOLATED HIGH EFFICIENCY BUCK CONSTANT CURRENT LED DRIVER



SOP-8

■ DESCRIPTION

UL9024 is a high precision LED constant current control chip operating at critical conduction mode (CRM) with zero current switched-on and peak current switched-off. It's mainly targeted for 85Vac~265Vac universal mains and non-isolated buck LED power systems.

UL9024 integrates proprietary high voltage supply circuit, which eliminates V_{CC} capacitor and startup resistor. The IC also combines a high power MOSFET. Very simple application circuit is achieved.

UL9024 adopts critical conduction mode, which can turns on the internal power MOSFET when the inductance current reaches zero, reducing the power MOSFET switching loss, and achieving high efficiency. With critical conduction mode, **UL9024** outputs high accuracy LED current, and further achieves excellent line regulation and load regulation. It's insensitive to inductance and the I-shape inductance can be used.

UL9024 provides various protection features to enhance the system reliability, including over current protection (OCP), short circuit protection (SCP), and thermal adjustment, etc.

■ FEATURES

* No V_{CC} capacitor and start-up resistor
* Wide input voltage range
* High efficiency (up to 95%)
* Highly accurate constant LED current
* Cycle-by-cycle current limitation
* LED short circuit protection
* Leading edge blanking control
* Under-voltage Lockout protection (UVLO)
* Thermal adjustment

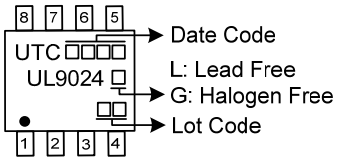
■ ORDERING INFORMATION

Ordering Number		Package	Packing
Lead Free	Halogen Free		
UL9024L-S08-R	UL9024G-S08-R	SOP-8	Tape Reel

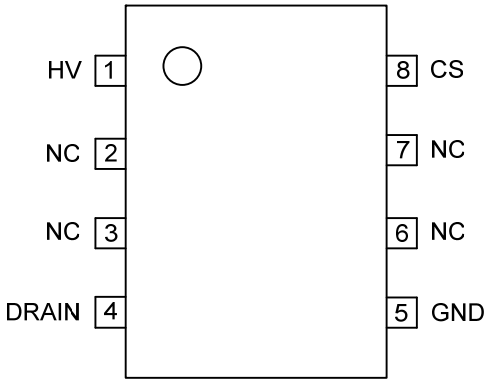
UL9024G-S08-R

(1)Packing Type	(1) R: Tape Reel
(2)Package Type	(2) S08: SOP-8
(3)Green Package	(3) G: Halogen Free and Lead Free, L: Lead Free

■ MARKING



■ PIN CONFIGURATION



■ PIN DESCRIPTION

PIN NO	PIN NAME	DESCRIPTION
HV	1	Chip high voltage power supply pin.
NC	2, 3, 6, 7	No connect.
DRAIN	4	Internal high voltage power MOSFET drain.
GND	5	Ground
CS	8	Current sampling, connect the sampling resistor to the ground.

■ ABSOLUTE MAXIMUM RATING (T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	RATINGS	UNIT
Limit the Voltage	HV	-0.3 ~ 500	V
Internal High Voltage Power MOSFET Drain	DRAIN	-0.3 ~ 500	V
Current Detection Pin	CS	-0.3 ~ 5	V
Power Dissipation	P_D	450	mW
Junction Temperature	T_J	+150	°C
Storage Temperature	T_{STG}	-55 ~ +150	°C

Note: Absolute maximum ratings are those values beyond which the device could be permanently damaged. Absolute maximum ratings are stress ratings only and functional device operation is not implied.

■ THERMAL DATA

PARAMETER	SYMBOL	RATINGS	UNIT
Junction to Ambient	θ_{JA}	165	°C/W

■ RECOMMENDED OPERATION CONDITIONS

PARAMETER	SYMBOL	RATINGS	UNIT
Output LED Current (V_{IN}=176V~265V, V_{OUT}=72V)		<110	mA
Minimum Load LED Voltage	V_{LED_MIN}	>35	V
Ambient Temperature	T_A	-40 ~ +125	°C

■ ELECTRICAL CHARACTERISTICS (H_V=15V, T_A=25°C, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
START AND SUPPLY VOLTAGE (HV PIN)						
Starting Current	I_{START}	V_{CC}<V_{CC_UV}		1		mA
Under-Voltage Lock Voltage(UVLO)	H_{V_UV}	The HV pin voltage drops		8		V
Start the Voltage	H_{V_START}	The HV pin voltage increases		13		V
Working Current	I_{OP}			0.3		mA
INTERNAL TIME CONTROL						
Maximum turn-on time	t_{ON_MAX}			45		us
Minimum cut-off time	t_{OFF_MIN}			2.5		us
Maximum cut-off time	t_{OFF_MAX}			280		us
CURRENT SAMPLING (CS PIN)						
Peak current sampling threshold	V_{CS}		260	280	300	mV
CS pin have built-in leading-edge blanking time	LEB			500		ns
OVER-TEMPERATURE ADJUSTMENT						
Over-temperature adjustment threshold	T_{ADJ}			140		°C
HIGH VOLTAGE POWER MOSFET (DRAIN)						
RON of internal high voltage power MOSFET	R_{DSON}	I_{DS}=100mA		20		Ω
Breakdown voltage of internal high voltage power MOSFET	BV_{DSS}	V_{GS}=0V/I_{DS}=250uA	500			V

Notes: 1. The parameters are not 100% tested in production.
2. The minimum, maximum range of standard specification by the test to ensure, typical values by design, test or analysis to ensure.

■ APPLICATION INFORMATION

Start-up

After the system is powered on, the HV pin supplies power to the internal circuit. When the HV pin voltage is greater than 12V, the chip starts to work. When HV is lower than 6V, the chip is in UVLO state.

Critical on-mode control and output current setting

By monitoring the CS pin voltage, the **UL9024** periodically detects the peak current (peak inductance current) flowing through the internal switch MOS. When the CS terminal voltage reaches a set threshold, the power MOSFET is shut off. When the inductance current drops to zero, the circuit will restart the power MOSFET. The peak inductance current is expressed as:

$$I_{LPK} = \frac{280}{R_{CS}}(mA)$$

R_{CS} is the current sampling resistance, and the unit is ohm. The output of the CS comparator includes a 500ns leading-edge blanking time to filter out noise at the CS terminal at the on-on moment.

The calculation formula of LED output current is:

$$I_{LED} = \frac{I_{LPK}}{2} = \frac{280mV}{2 \times Rcs}(mA)$$

I_{LPK} is the peak current of inductance. According to the formula, the output LED current is only determined by the current sampling resistance RCS and the internal VREF reference voltage, and has nothing to do with the inductance.

Working frequency

The **UL9024** works in inductive current critical conduction mode. When the inductive current drops to zero, the detection circuit will re-conduct the internal switching MOS, the high voltage power MOSFET, and the inductive current rises from zero, The T_{ON} of the power MOSFET is:

$$T_{ON} = \frac{L \times I_{LPK}}{V_{IN} - V_{LED}}$$

* L is the inductance of the inductance.
* I_{LPK} is the peak current flow through the inductance.
* V_{IN} is the input DC voltage after the rectifier bridge at the input end is rectified.
* V_{LED} is the forward voltage drop on the load LED.

When the voltage on the CS pin reaches the set threshold, the power MOSFET is turned off, and the inductance is discharged to the load LED through the continuation diode until the inductance current drops to zero, and the chip will open the internal switch MOS again.

The shutdown time of the power MOSFET is:

$$T_{OFF} = \frac{L \times I_{LPK}}{V_{LED}}$$

The working frequency of the system is calculated as:

$$f = \frac{1}{T_{ON} + T_{OFF}} = \frac{V_{LED} \times \left(1 - \frac{V_{LED}}{V_{IN}}\right)}{L \times I_{LPK}}$$

■ APPLICATION INFORMATION

It can be seen from the formula that the system operating frequency of **UL9024** is related to the system input voltage V_{IN}, the forward voltage drop of the load LED V_{LED}, and the inductance L. The higher the system input voltage V_{IN}, the higher the system operating frequency. In order to give consideration to EMI and efficiency, the operating frequency range of the system is generally set between 30kHz-80kHz. Therefore, appropriate inductance value should be selected under the lowest input voltage of the system to make the system frequency meet the design requirements.

The **UL9024** sets the maximum deadline t_{OFF_MAX} to 280μs and the minimum deadline t_{OFF_MIN} to 2.5μs. According to the calculation formula of the t_{OFF}, if the inductance is very large, the t_{OFF} may exceed t_{OFF_MAX}, so that the inductance current does not fall to zero and start the next cycle charging. On the contrary, if the inductance is very small, the t_{OFF} may be less than t_{OFF_MIN}, so that when the inductance current appears to be zero, the inductance current enters the discontinuous mode, so the actual load LED current is less than the target design value. Therefore, it is necessary to select the appropriate value of inductance.

Over current protection

Once the CS pin voltage exceeds 280mV, the **UL9024** will immediately turn off the power MOSFET. This periodic over current detection method protects related components from damage, such as power MOSFET, transformer, etc.

Other protection functions

The **UL9024** also provides LED short-circuit protection and over-temperature regulation. When the chip works, it will enter the automatic monitoring state. If the LED short-circuit occurs, the chip will enter the short-circuit protection state immediately. The chip works in MAXOFF state, and the system only consumes slight power to ensure the safety of the system. When the short circuit is removed, the chip automatically returns to normal working state.

Over-temperature adjustment function

The **UL9024** internal overheating control circuit monitors the temperature of the chip. When the temperature exceeds the overheating control temperature, the system gradually reduces the output current to control the output power and temperature rise of the power supply, ensuring system reliability. The internal overheating temperature of the chip is set at 140°C.

PCB Precautions

1. Measures to reduce EMI

The area of power loop on PCB should be reduced as much as possible, such as the area of loop composed of bus capacitance, power inductance and power MOS, and the area of loop composed of power inductance, diode and output capacitance.

2. R_{CS} resistance cabling

The RCS resistance should be routed as short as possible, and the grounding end should be connected to the ground end of the bus capacitor separately. The chip ground wire needs to be led out separately from the bus ground.

3. HV pin routing

HV pins are high pressure pins that need to be as short as possible and cannot rely on other low pressure pins.

■ TYPICAL APPLICATION CIRCUIT