

## DUAL COLD CATHODE FLUORESCENT LAMP CONTROLLER

### FEATURES

- Synchronous or Nonsynchronous Operation
- Dual Output and Control Stages
- BiCMOS Technology
- Accurate Current Control with 2-mA Typical Supply Current
- Analog or Digital Low-Frequency Dimming Capability
- Open Lamp Protection with Voltage Clamp
- 4.5-V to 25-V Operation
- PWM Frequencies Synchronized to External Resonant Tanks
- TSSOP-16 (PW) Package

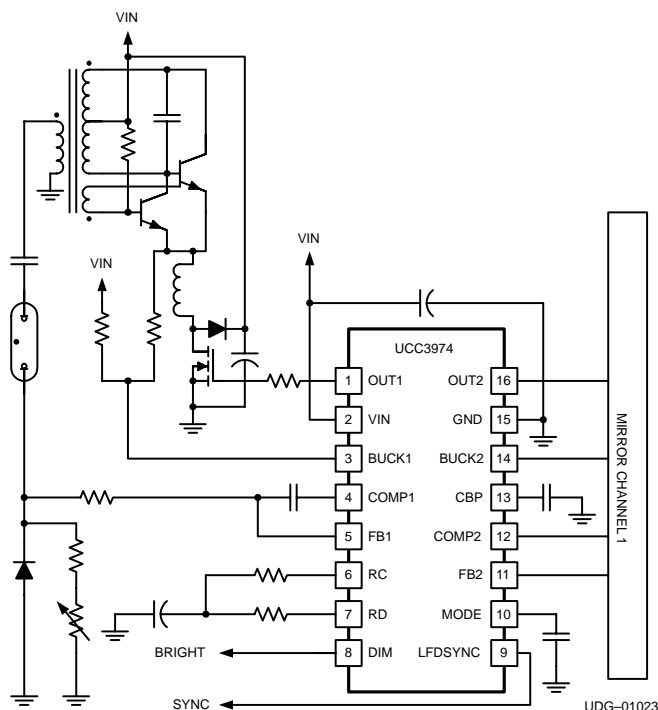
### APPLICATIONS

- Portable PCs
- Desktop LCD Monitors
- Internet Appliances

### DESCRIPTION

Design goals for a cold cathode fluorescent lamp (CCFL) converter used for a liquid crystal display (LCD) monitor application include small size, high efficiency, and low cost. The UCC2974/UCC3974 CCFL controllers provide the necessary circuit blocks to implement a highly efficient LCD monitor backlight supply in a small 16-pin TSSOP package. The device features two control stages for operating independent resonant tanks for multi-lamp designs. The BiCMOS controller typically consumes less than 2-mA of operating current, improving overall system efficiency. External parts count is minimized and system cost is reduced by integrating such features as dual PWM driver stages, open lamp protection, overvoltage clamp, and synchronization circuitry between the buck and push-pull stages. The device operates in both analog and low-frequency dimming modes.

### TYPICAL APPLICATION



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

# UCC2974 UCC3974

SLUS485A – JULY 2001 – REVISED NOVEMBER 2001

## absolute maximum ratings over operating free-air temperature (unless otherwise noted)†

Supply voltage range, V <sub>BAT</sub> .....	27 V
Input voltage range, BUCK .....	-5 V to V <sub>BAT</sub>
MODE .....	-0.3 V to 4.3 V
Mode maximum forced current .....	300 $\mu$ A
Operating virtual junction temperature range, T <sub>J</sub> .....	-55°C to 150°C
Storage temperature range, T <sub>stg</sub> .....	-65°C to 150°C
Lead temperature soldering 1,6 mm (1/16 inch) from case for 10 seconds .....	260°C

† 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 under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

‡ Unless otherwise specified, all voltages are with respect to GND.

### AVAILABLE OPTIONS

T <sub>J</sub>	PACKAGE
	PW§ (SSOP)
-40°C to 85°C	UCC2974PW
0°C to 70°C	UCC3974PW

§ This package is available taped and reeled. To order this packaging option, add an R suffix to the part number. (e.g. UCC2974PWR)

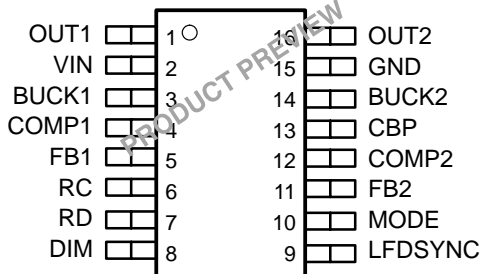
### DISSIPATION RATING TABLE

PACKAGE	T <sub>A</sub> ≤ 25°C	DERATING FACTOR	T <sub>A</sub> = 70°C	T <sub>A</sub> = 85°C
16-pin PW with solder	775 mW	6.2 mW/°C	495 mW	402 mW

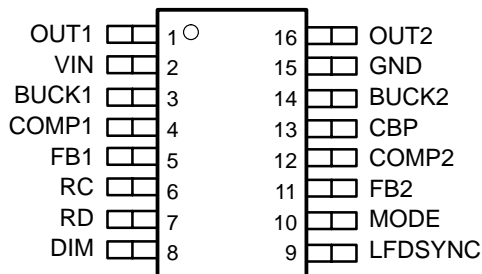
## recommended operating conditions


	MIN	NOM	MAX	UNIT
Supply voltage, V <sub>IN</sub>	4.5		25	V
Mode voltage	0		4.3	V
DIM voltage	0		3.5	V
LFDSYNC amplitude	0		4.5	V

**UCC2974  
PW PACKAGE  
(TOP VIEW)**



**UCC3974  
PW PACKAGE  
(TOP VIEW)**



  
ACTUAL SIZE  
(5,10mm x 6,60mm)

electrical characteristics over recommended operating virtual junction temperature range,  $T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$  for the UCC3974,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ , for the UCC2974,  $T_A = T_J$ .  
 $V_{IN} = V_{BUCK} = 12\text{ V}$ ,  $\text{MODE} = \text{OPEN}$  (unless otherwise noted)

**supply current**

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{IN}$	$V_{IN}$ supply current	$12\text{ V} \leq V_{IN} \leq 25\text{ V}$		1.7	3	mA
		$V_{IN} = 12\text{ V}$ , MODE < 0.425 V		300	500	$\mu\text{A}$
	UVLO threshold voltage	LOW to HIGH	3.6	4	4.4	V
	UVLO hysteresis voltage		35	120	200	mV

**output**

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
	High-level output voltage	$12\text{ V} \leq V_{IN} \leq 25\text{ V}$	8	10.5	13	V
	Low-level output voltage	MODE = 0.5 V, $I_{SINK} = 1\text{ mA}$		50	200	mV
	Rise time	$C_L = 1\text{ nF}$		170	350	ns
	Fall time	$C_L = 1\text{ nF}$		140	300	

**oscillator**

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
	Free-running oscillator frequency	$12\text{ V} \leq V_{IN} \leq 25\text{ V}$ , BUCK = $V_{IN}$	30	45	60	kHz
	Free-running synchronizable oscillator frequency	$12\text{ V} \leq V_{IN} \leq 25\text{ V}$ , BUCK = $V_{IN}-3$			220	
	Maximum duty cycle	FB = 1 V	100%			
	Minimum duty cycle	FB = 2 V			0%	
	BUCK input bias current	BUCK = $V_{IN} = 12\text{ V}$		3	10	$\mu\text{A}$
		BUCK = $V_{IN} = 25\text{ V}$		3	10	
	Zero detect threshold voltage	Measured at BUCK with respect to $V_{IN}$ , $12\text{ V} \leq V_{IN} \leq 25\text{ V}$	-2.4	-1.7	-1.1	V

**error amplifier**

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
	Input voltage	COMP = FB, $0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$	1.465	1.5	1.535	V
		COMP = FB, $-40^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$	1.455	1.5	1.545	
	Line regulation voltage	$12\text{ V} \leq V_{IN} \leq 25\text{ V}$		1	5	mV
	Input bias current			100	250	nA
	Open loop gain		60	80		dB
	High-level output voltage	FB = 1 V, $I_{SOURCE} = 50\text{ }\mu\text{A}$	3.5	3.7	4.2	V
	Low-level output voltage	FB = 2 V, $I_{SINK} = 50\text{ }\mu\text{A}$		0.15	0.35	
	Output source current	FB = 1 V, COMP = 2 V		-1.2	-0.3	mA
	Output sink current	FB = 2 V, COMP = 2 V	45	90		$\mu\text{A}$
	Unity gain bandwidth	$T_J = 25^\circ\text{C}$ , See Note 1	2	5		MHz

NOTE 1: Ensured by design, not production tested.

# UCC2974 UCC3974

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electrical characteristics over recommended operating virtual junction temperature range,  $T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$  for the UCC3974,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ , for the UCC2974,  $T_A = T_J$ .  
 $V_{IN} = V_{BUCK} = 12\text{ V}$ , MODE = OPEN (unless otherwise noted)

## mode select

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Enable threshold voltage		0.425	0.500	0.575	V
Output enable threshold voltage		0.85	1.00	1.15	
Open lamp detect enable voltage threshold		2.75	3	3.25	
Low-frequency dimming (LFD) voltage threshold		3.8	4.0	4.1	
MODE output current	MODE = 0.5 V	3.3	5.0	6.8	$\mu\text{A}$
MODE clamp voltage	MODE = OPEN	4.0	4.2	4.4	V

## low-frequency dimming

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Duty cycle	$R_C = 400\text{ k}\Omega$ , $C_{LFD} = 10\text{ nF}$ , $R_D = 20\text{ k}\Omega$ , DIM < 0.5 V	6%	10%	12%	
Maximum duty cycle	$R_C = 400\text{ k}\Omega$ , $C_{LFD} = 10\text{ nF}$ , $R_D = 20\text{ k}\Omega$ , DIM > 3.1 V	100%			
Free-running oscillator frequency	$R_C = 400\text{ k}\Omega$ , $C_{LFD} = 10\text{ nF}$ , $R_D = 20\text{ k}\Omega$		200		Hz
Synchronized oscillator frequency	$R_C = 400\text{ k}\Omega$ , $C_{LFD} = 10\text{ nF}$ , FLFDSYNC = 400 Hz at $V_{LFDSYNC} = 2.25\text{ V}$		400		

## open lamp

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Open lamp detect threshold voltage	$V_{IN} = 12\text{ V}$ , Measured at VBUCK wrt $V_{IN}$	-8.5	-7.8	-7.0	V
	$V_{IN} = 25\text{ V}$ , Measured at VBUCK wrt $V_{IN}$	-8.6	-7.8	-6.9	
Voltage clamp detect threshold voltage	Measured at VBUCK	-9.6	-8.75	-8.0	

NOTES: 1: Ensured by design, not production tested.

## Terminal Functions

TERMINAL NAME		NO.	I/O	DESCRIPTION
BUCK1		3	I	Voltage sense for the resonant tank.
BUCK2		14	I	
CBP		13	O	Internally generated low-voltage supply. Bypass to GND with 0.1- $\mu$ F bypass coordinator.
COMP1		4	O	Outputs of the error amplifiers for the two channels.
COMP2		12	O	
DIM		8	I	Reference signal applied to the LFD PWM that determines the LFD duty cycle.
FB1		5	I	Inverting inputs of the error amplifiers.
FB2		11	I	
GND		15	–	Power supply return.
LFDSYNC		9	I	2.5-V logic-compatible pin used to synchronize the LFD oscillator.
MODE		10	I	Start-up timing control.
OUT1		1	O	FET drive outputs for the two channels. The pin is driven between GND and internal voltage (typically 12 V).
OUT2		16	O	
RC		6	O	Connection for the low-frequency dimming (LFD) charge resistor. The other terminal of the resistor is connected to the LFD capacitor, $C_{LFD}$ .
RD		7	O	Connection for low-frequency dimming (LFD) discharge resistor, $R_D$ . The other terminal of the resistor is connected to the LFD capacitor, $C_{LFD}$ . LFD frequency us user programmable by varying $R_C$ , $R_D$ and $C_{FLD}$ .
VIN		2	I	Power supply input. 4.5 V to 25 V.

### detailed pin descriptions

**DIM** – The range is approximately 0.5 V to 3 V for the programmed minimum 100% duty cycle. If the LFDSYNC pin is pulled above 2.25 V before MODE crosses the LFD enable threshold and is held high, the function of DIM changes from an analog voltage, which determines the LFD duty cycle, to a digital signal (2.5-V logic compatible) which turns the lamps on or off directly. This allows users to implement their own LFD solution and easily interface it to the UCC3974. Pulling this pin above 3.0 V (weak internal pull-up device is provided) causes the LFD section of the device to provide 100% LFD duty cycle.

**LFDSYNC** – This 2.5-V logic compatible pin is used to synchronize the LFD oscillator. A positive pulse restarts the LFD ramp. Weak internal pull-down device provided. This pin must be set high when digital LFD mode control is required.

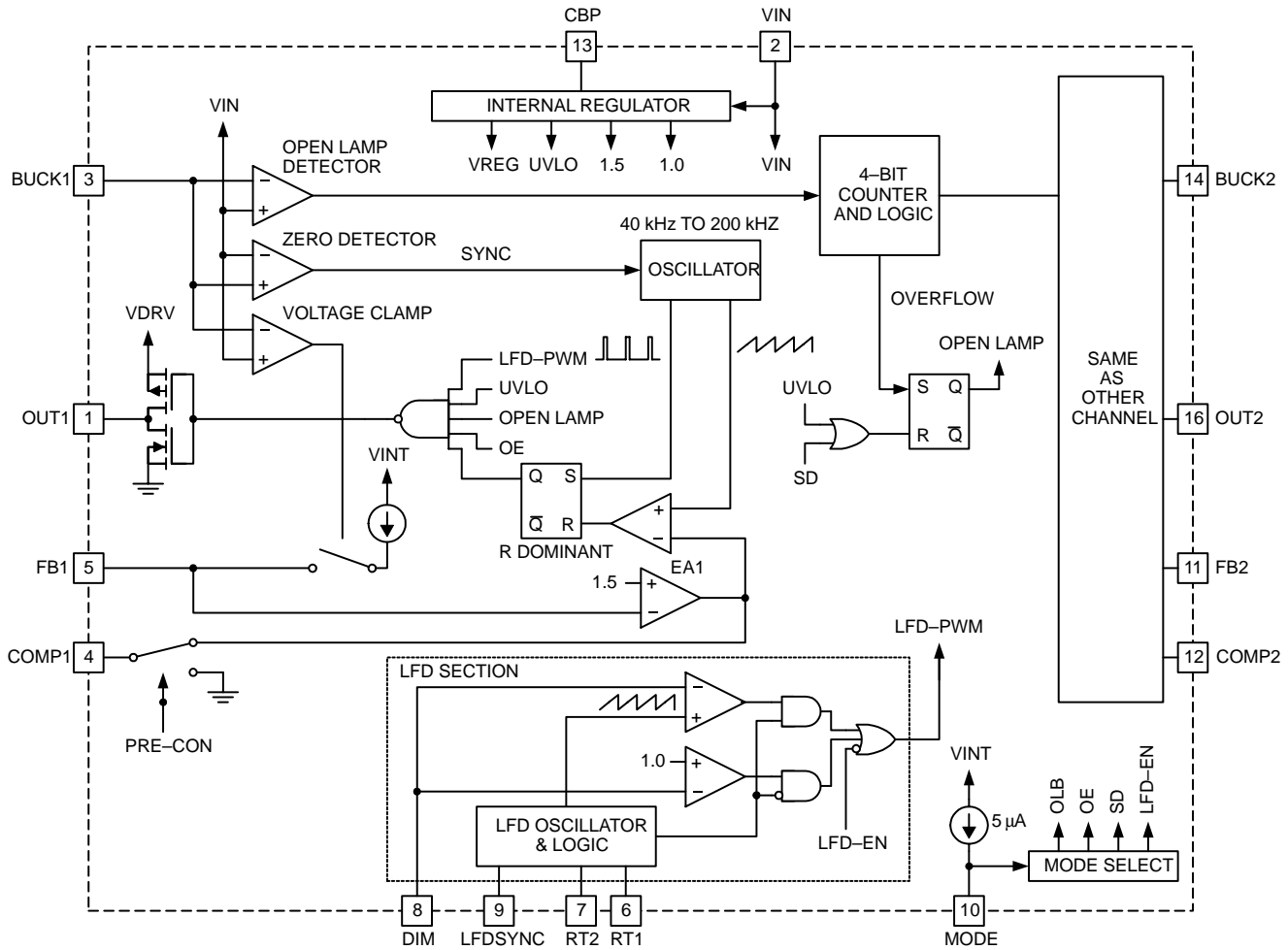
**MODE** – This pin controls the start-up timing for the device. A capacitor is connected from this pin to ground and has a constant current forced into it. The pin voltage controls the state of the device. When the system has a power cycle, the pin is discharged to ground..

MODE PIN VOLTAGE	FUNCTION
$V_{MODE} < 0.5 \text{ V}$	All circuitry is disabled.
$V_{MODE} > 0.5 \text{ V}$	Internal circuitry is enabled.
$V_{MODE} > 1.0 \text{ V}$	Output driver is enabled.
$V_{MODE} > 3.0 \text{ V}$	Enable open lamp detection circuitry.
$V_{MODE} > 4.0 \text{ V}$	Enable low-frequency dimming (LFD).

**BUCK1/BUCK2** – These pins are used to sense the voltage on the resonant tank. This voltage is used for synchronizing the internal high-frequency oscillators with the resonant tanks. This voltage is also used to detect an open lamp condition when MODE is above 3 V.

**APPLICATION INFORMATION**

**functional block diagram**

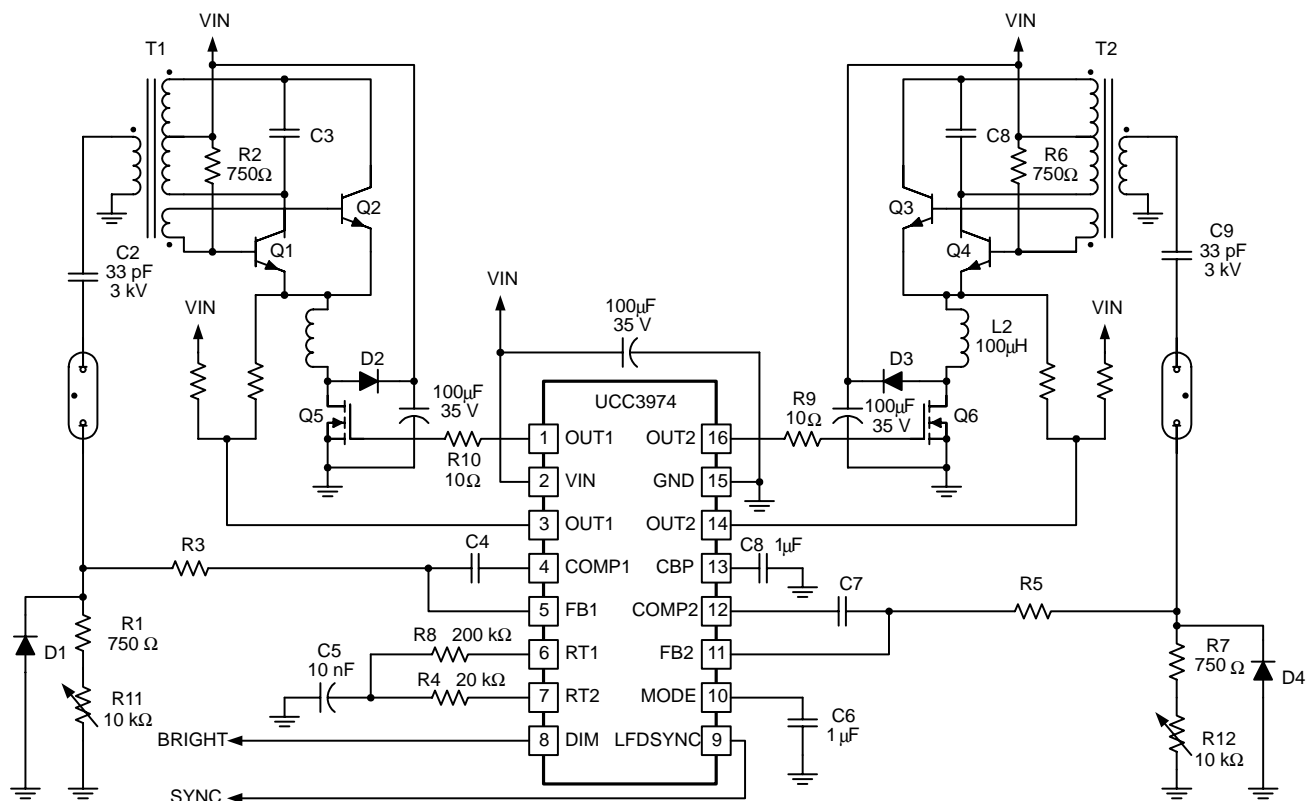


UDG-01021

**general description**

The UCC3974 extends the capabilities of the UCC3972 and UCC3973 backlight controllers. The basic functionality is the same as that for the UCC3972; a buck controlled current source feeding a royer oscillator CCFL circuit. As such the application information for the UCC3972 that pertains to the royer oscillator, buck controller and CCFL circuit in general apply to the UCC3974. Also, this device implements a voltage clamping scheme, similar to that of the UCC3973, using an internal current source to bias up the FB pin and thereby limiting the current available to the royer stage. This limits the voltage to which the secondary side of the transformer is exposed.

The extensions this device provides are two separately controlled channels to be used with two separate royer stages, and integrated low-frequency dimming (LFD) control .



UDG-01020

**Figure 1. Typical Dual-Channel Application**

### low-frequency dimming (LFD)

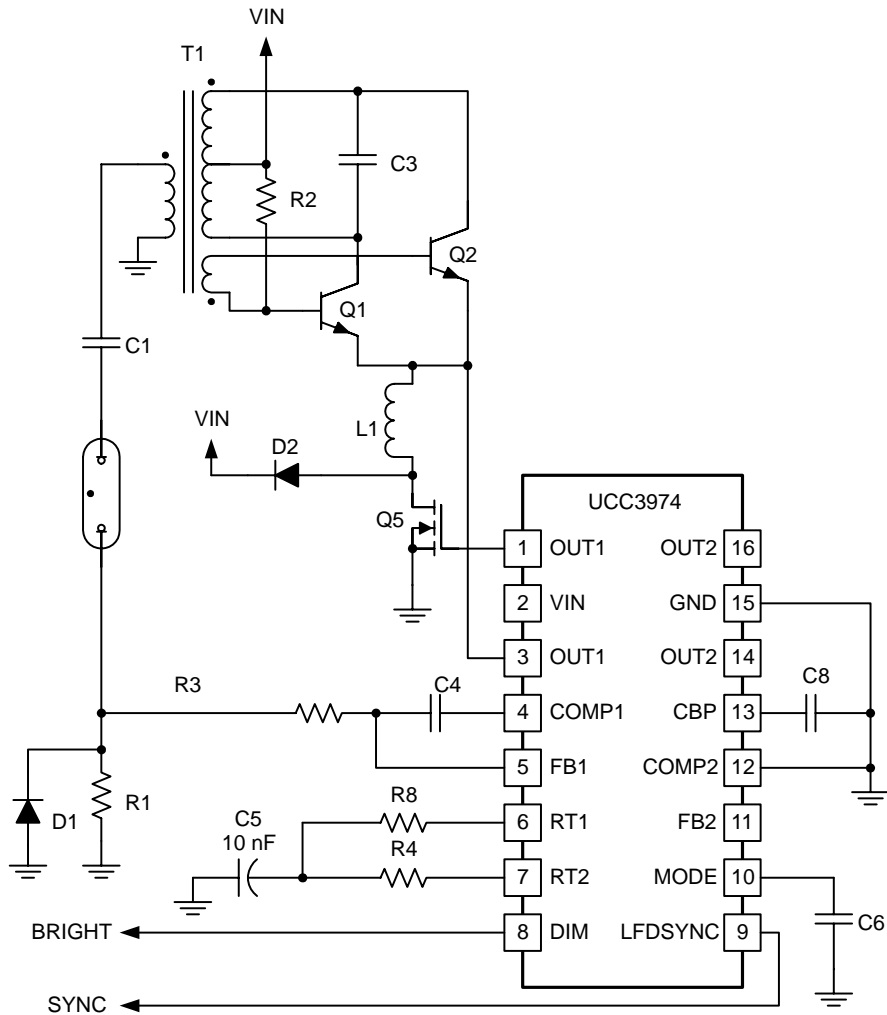
The low-frequency dimming section of the device is implemented as either a low frequency pulse width modulator (PWM) or as a direct digital input. In either case, the DIM pin is the controlling input. The type of DIM input is determined at startup. As the MODE pin transitions through the LFD\_ENABLE threshold, the LFDSYNC pin is observed. When this pin is high, the DIM pin is a 2.5-V compatible logic input. When the DIM pin is high, the output is enabled. When it is low the output is disabled. The user is required to provide the correct frequency and duty ratio to the DIM pin in this mode. To change the mode of operation without power cycling the device, the MODE pin must be brought below the LFD\_ENABLE threshold and then brought above it with the LFDSYNC pin held in the desired state.

To use DIM as an analog input, the LFDSYNC pin must be low when mode crosses the LFD\_ENABLE threshold. In this mode, DIM becomes an analog input that varies the amount of time that the lamp is on during the period of the LFD oscillator. From 0.5 V to 3 V applied to the DIM pin varies the lamp on duty cycle from the programmed minimum to 100%.

**NOTE:** The analog dimming signal is sensitive to coupled noise from the lamps. Noise on this line will be seen as lamp flicker. It is highly recommended that precautions be taken to prevent noise coupling to this signal for optimum results.

Applying a pulse train to the LFDSYNC pin will synchronize the LFD oscillator to that pulse train. The frequency of the applied pulse train must be higher than the free running frequency of the oscillator.

**APPLICATION INFORMATION**



UDG-01022

**Figure 2. Typical Single-Channel Application**



**APPLICATION INFORMATION**

**low-frequency dimming oscillator**

The oscillator for the LFD section of the device is an R-C relaxation oscillator with programmable upslope and downslope on its timing ramp. Figure 3 shows a simplified LFD oscillator diagram that illustrates the principle. The charge time for the timing capacitor,  $C_T$  is the time it takes to charge that capacitor from 0.5 V to 3 V from a 4.2-V source through RC. This time is:

$$t_c = 1.126 \times R_C \times C_T \tag{1}$$

The discharge time is the time it takes to discharge the  $C_T$  capacitor from 3 V to 0.5 V through  $R_D$  connected to GND. This time is:

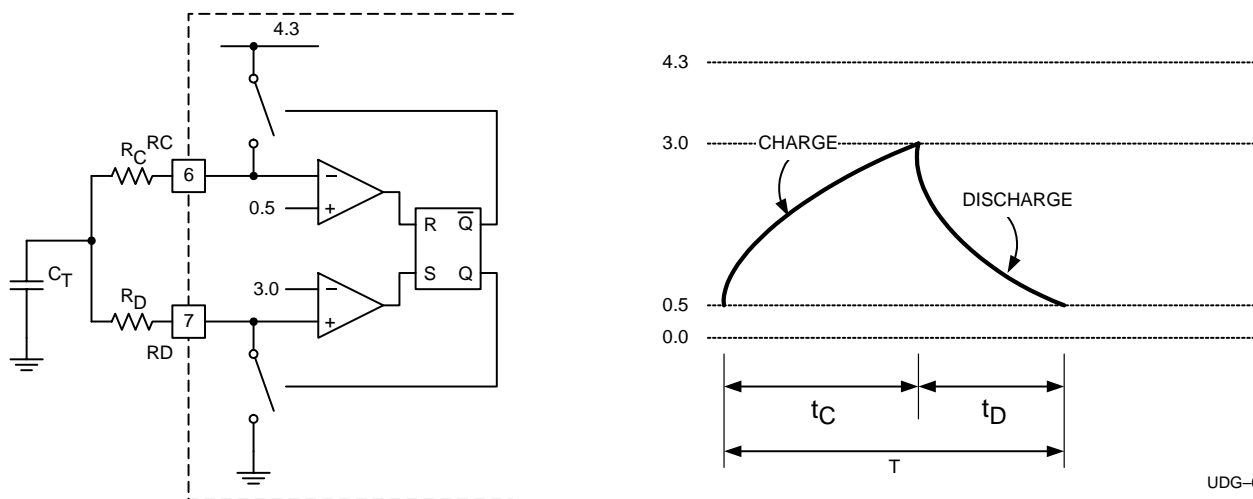
$$t_d = 1.792 \times R_D \times C_T \tag{2}$$

The period of the LFD oscillator is simply the sum of the charge and discharge times, or

$$T = C_T (1.126 \times R_C + 1.792 \times R_D) \tag{3}$$

The minimum duty cycle of the LFD PWM when operating in this mode is:

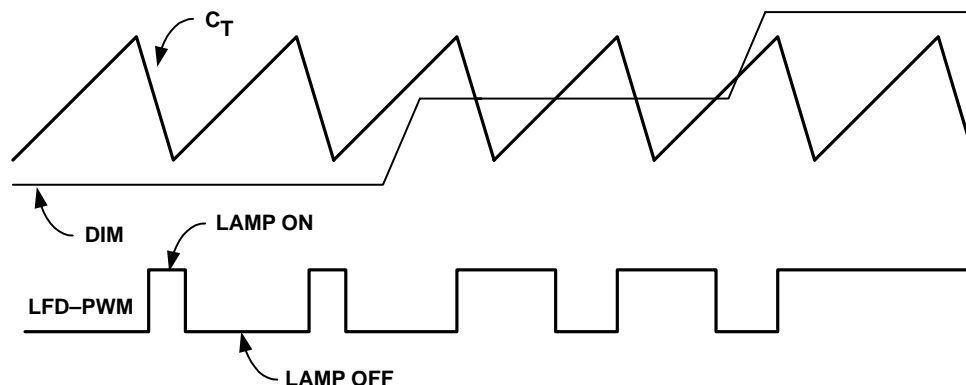
$$d_{\min} = \frac{t_d}{T} \tag{4}$$



UDG-01025

**Figure 3. LFD Oscillator**

**APPLICATION INFORMATION**



UDG-01024

**Figure 4. LFD Waveforms**

Note from the Figure 4 that the LFD-PWM output is turned on at the start of the discharge cycle and is turned off when  $C_T$  crosses the DIM signal or at the start of the charge cycle if DIM is less than the valley voltage of 0.5 V.

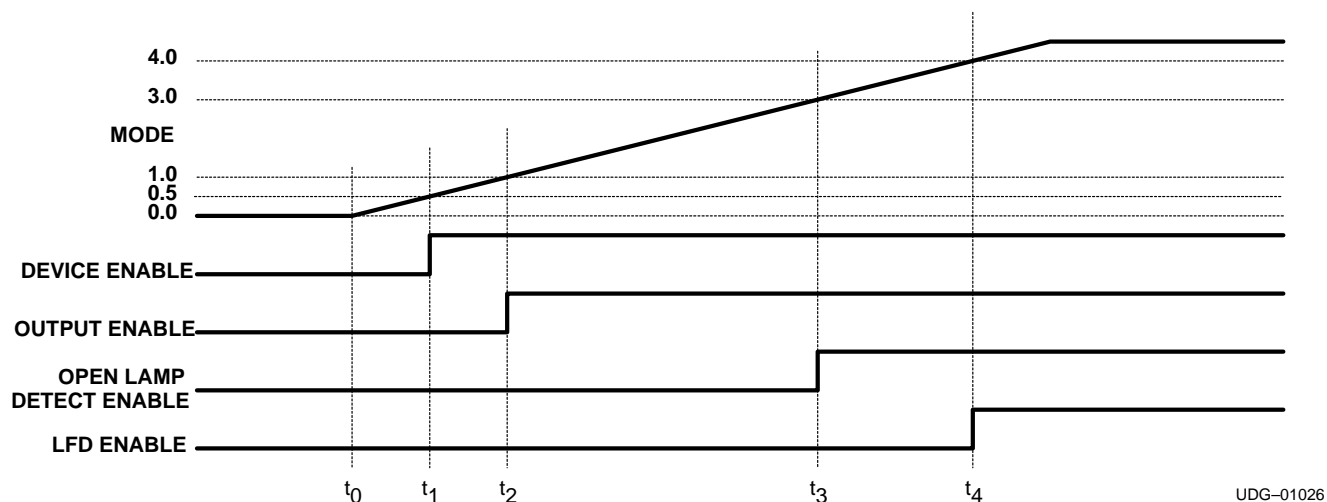
The LFD oscillator runs free at some frequency determined by the external timing components. The LFD oscillator can be synchronized to a system clock signal by applying this clock signal to the LFDSYNC pin. The signal must not be applied during power up since the MODE pin's crossing of the LFD\_ENABLE threshold determines the function DIM takes on. If the synchronization signal is applied during power up, unpredictable results may occur. The synchronization frequency should be fairly close to (but higher than) the free run frequency of the oscillator. The operating range for the DIM signal is reduced when synchronizing the LFD oscillator just as with any other PWM. A synchronization pulse causes termination of the current charge cycle and starts a discharge. The ratio of free run to synchronization frequencies is the reduction factor for DIM's operating range.

For instance if the free-run frequency is 90% of the synchronization frequency, DIM is active over the 0.5-V to 2.75-V range instead of the 0.5-V to 3-V range. As a general recommendation, the free-run frequency should be kept within the 100-Hz to 1-kHz range, and synchronization should be limited to 120% of the free-run frequency to preserve control range on DIM.

**output driver**

The OUT1 and OUT2 pins are designed to directly drive small power MOSFETs. Output drive capability is limited by the 50-Ω maximum resistance of the driver. For large FETs where this drive level is insufficient, a separate driver is required. Note also that the output drive level is limited to approximately 12 V if the input voltage exceeds that level. For input voltages below 12 V, the driver drives to slightly below the input voltage.

**startup sequence**



**Figure 5. Start-Up Sequence**

Figure 5 describes what happens during a typical startup sequence. At  $t_0$ , power is applied to the system. A constant current source begins charging the external capacitor connected to the MODE pin. Until the voltage on the MODE pin reaches 0.5 V ( $t_1$ ), the internal circuitry on the device is disabled and nothing happens at the outputs. As the voltage crosses 0.5 V, the internal circuitry is powered up. When the voltage crosses 1 V at  $t_2$ , the outputs are enabled, allowing the buck stages to begin to charge up and to supply current to the royer stages.

During the period from  $t_2$  to  $t_3$ , the open lamp detection circuitry is disabled, preventing a false trip of the open lamp detector circuit when the lamp is trying to ignite for the first time. As a precaution against severe overvoltage on the high-voltage secondary of the transformer, a clamp circuit is included in the UCC3974. The function of the clamp circuit is to monitor the voltage on the BUCK pins and prevent that voltage to drop more than 8.7-V below the input rail. This is accomplished by sourcing a current from the FB pin when the BUCK voltage drops more than 8.7 V.

The magnitude of the current sourced from this pin is proportional to the excess drop of the BUCK voltage beyond 8.7 V. The maximum current sourced from this pin is approximately 200  $\mu$ A. Consequently, the impedance at the FB pin affects the speed at which this clamp becomes effective. A small capacitor and large resistors in the feedback network increases the effectiveness of this feature. From  $t_3$  onward, the open lamp detector circuit is enabled. Each time the BUCK pin drops more than 7.8-V below  $V_{IN}$ , a 4-bit counter is clocked. If the counter reaches a count of 16 (4 bits) it declares an open lamp fault and shuts down the device. Resetting the device requires a power cycle. The counter in the open lamp detector is an up/down counter. If the BUCK pin only occasionally dips below the 7.8-V threshold, an open lamp condition is not declared since the counter is clocked down on each cycle in which BUCK does not cross the 7.8-V threshold. At time  $t_4$ , LFD is enabled. Depending on the state of LFDSYNC when this threshold is crossed, DIM is either an analog input or a digital one.

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
UCC3974PW	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UCC3974PWG4	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UCC3974PWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UCC3974PWRG4	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

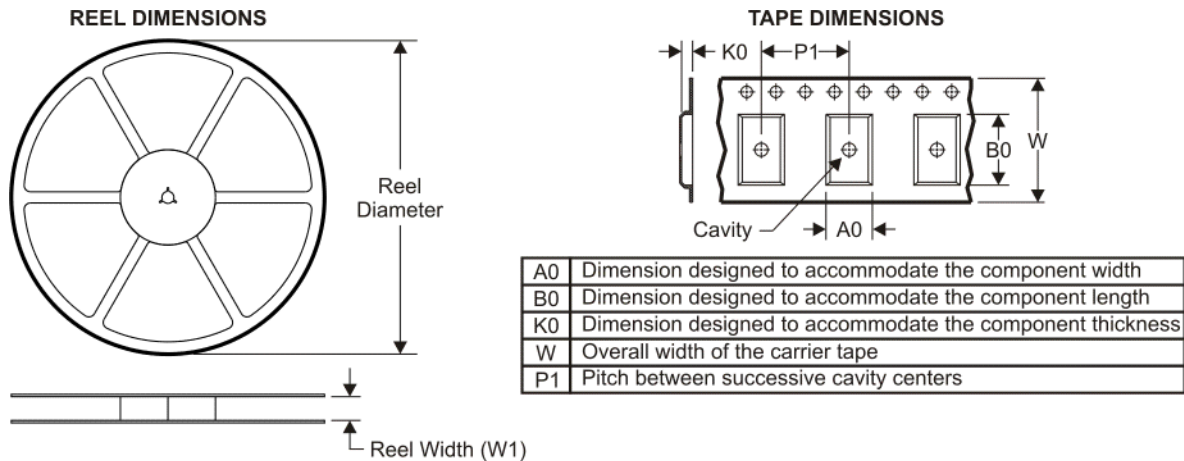
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

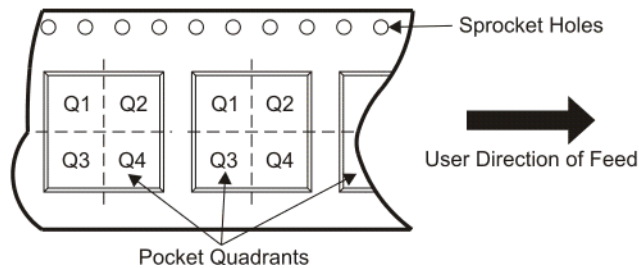
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## TAPE AND REEL INFORMATION



### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
UCC3974PWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
UCC3974PWR	TSSOP	PW	16	2000	346.0	346.0	29.0

## IMPORTANT NOTICE

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