

## HIGH-SPEED PWM CONTROLLER

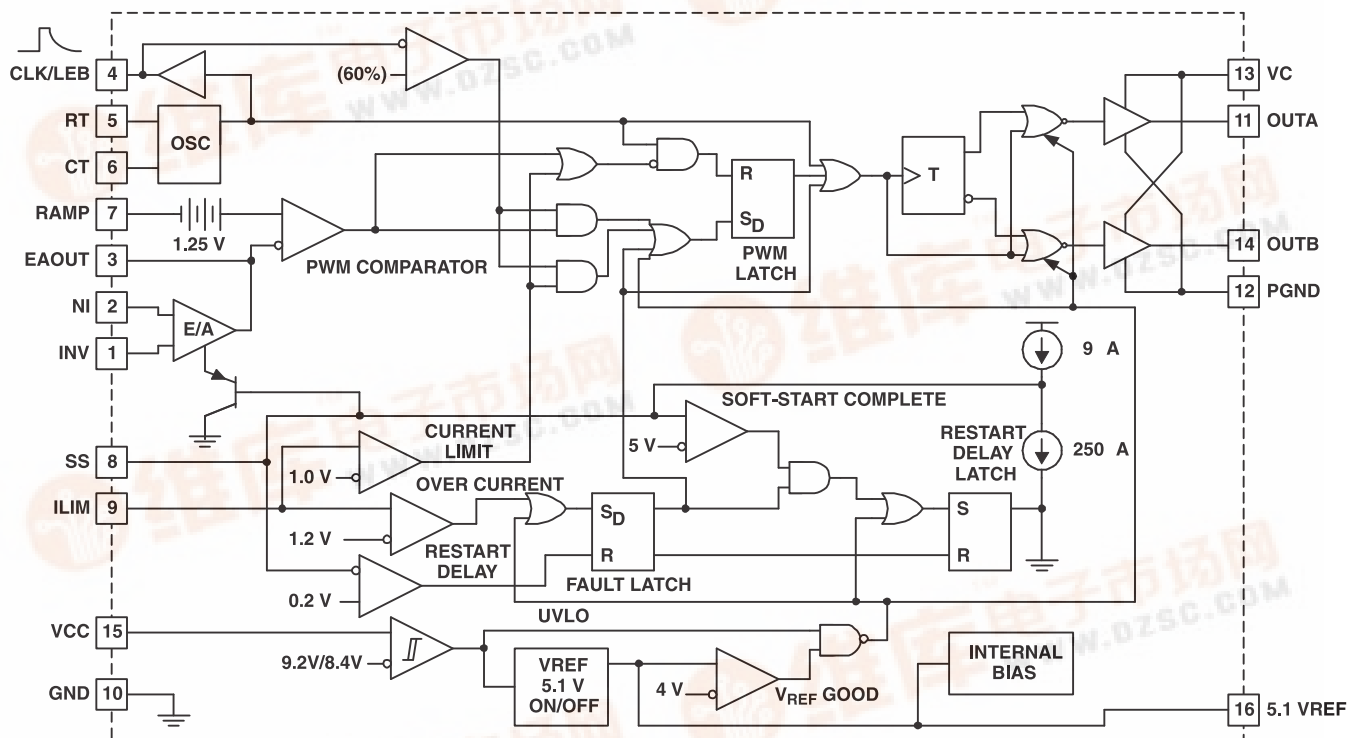
### FEATURES

- Qualified for Automotive Applications
- Improved Version of the UC3825 PWM
- Compatible With Voltage-Mode or Current-Mode Control Methods
- Practical Operation at Switching Frequencies to 1 MHz
- 50-ns Propagation Delay to Output
- High-Current Dual Totem-Pole Outputs: 2 A (Peak)
- Trimmed Oscillator Discharge Current
- Low 100- $\mu$ A Startup Current
- Pulse-by-Pulse Current-Limiting Comparator
- Latched Overcurrent Comparator With Full-Cycle Restart

### DESCRIPTION

The UC2825A pulse-width modulation (PWM) controller is an improved versions of the standard UC3825. Performance enhancements have been made to several of the circuit blocks. Error amplifier gain bandwidth product is 12 MHz, while input offset voltage is 2 mV. Current limit threshold is specified to a tolerance of 5%. Oscillator discharge current is specified at 10 mA for accurate dead-time control. Frequency accuracy is improved to 6%. Startup supply current, typically 100  $\mu$ A, is ideal for off-line applications. The output drivers are redesigned to actively sink current during undervoltage lockout (UVLO) at no expense to the startup current specification. In addition, each output is capable of 2-A peak currents during transitions.

### BLOCK DIAGRAM



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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.

## DESCRIPTION (CONTINUED)

Functional improvements have also been implemented. The shutdown comparator is now a high-speed overcurrent comparator with a threshold of 1.2 V. The overcurrent comparator sets a latch that ensures full discharge of the soft-start capacitor before allowing a restart. While the fault latch is set, the outputs are in the low state. In the event of continuous faults, the soft-start capacitor is fully charged before discharge to insure that the fault frequency does not exceed the designed soft start period. The CLOCK pin has become CLK/LEB. This pin combines the functions of clock output and leading edge blanking adjustment and has been buffered for easier interfacing.

The UC2825A has dual alternating outputs and the same pin configuration of the UC3825. "A" version parts have UVLO thresholds identical to the original UC3825.

See the application report, *The UC3823A,B and UC3825A,B Enhanced Generation of PWM Controllers (SLUA125)* for detailed technical and application information.

## ORDERING INFORMATION<sup>(1)</sup>

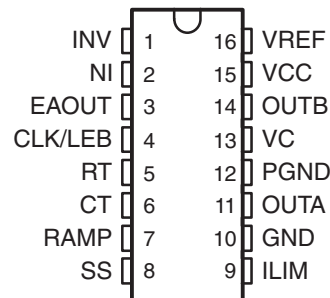
T <sub>J</sub>	MAXIMUM DUTY CYCLE	UVLO	PACKAGE <sup>(2)</sup>		ORDERABLE PART NUMBER	TOP-SIDE MARKING
-40°C to 125°C	<50%	9.2 V/8.4 V	SOIC – DW	Reel of 2000	UC2825AQDWRQ1	UC2825AQDW

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at [www.ti.com](http://www.ti.com).

(2) Package drawings, thermal data, and symbolization are available at [www.ti.com/packaging](http://www.ti.com/packaging).

## PIN ASSIGNMENTS

DW PACKAGE  
(TOP VIEW)



**TERMINAL FUNCTIONS**

TERMINAL		I/O	DESCRIPTION
NAME	NO.		
CLK/LEB	4	O	Output of the internal oscillator
CT	6	I	Timing capacitor connection for oscillator frequency programming. The timing capacitor should be connected to the device ground using minimal trace length.
EAOUT	3	O	Output of the error amplifier for compensation
GND	10		Analog ground return
ILIM	9	I	Input to the current limit comparator
INV	1	I	Inverting input to the error amplifier
NI	2	I	Noninverting input to the error amplifier
OUTA	11	O	High-current totem-pole output A of the on-chip drive stage
OUTB	14	O	High-current totem-pole output B of the on-chip drive stage
PGND	12		Ground return for the output driver stage
RAMP	7	I	Noninverting input to the PWM comparator with 1.25-V internal input offset. In voltage-mode operation, this serves as the input voltage feed-forward function by using the CT ramp. In peak current-mode operation, this serves as the slope compensation input.
RT	5	I	Timing resistor connection for oscillator frequency programming
SS	8	I	Soft-start input and the maximum duty cycle clamp
VC	13		Power supply for the output stage. This pin should be bypassed with a 0.1- $\mu$ F monolithic ceramic low ESL capacitor with minimal trace lengths.
VCC	15		Power supply for the device. This pin should be bypassed with a 0.1- $\mu$ F monolithic ceramic low ESL capacitor with minimal trace lengths
VREF	16	O	5.1-V reference. For stability, the reference should be bypassed with a 0.1- $\mu$ F monolithic ceramic low ESL capacitor and minimal trace length to the ground plane.

**ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>**

over operating free-air temperature range unless otherwise noted

			VALUE
$V_{IN}$	Supply voltage	VC, VCC	22 V
$I_O$	Source or sink current, dc	OUTA, OUTB	0.5 A
$I_O$	Source or sink current, pulse (0.5 $\mu$ s)	OUTA, OUTB	2.2 A
	Analog inputs	INV, NI, RAMP	–0.3 V to 7 V
		ILIM, SS	–0.3 V to 6 V
	Power ground	PGND	$\pm$ 0.2 V
$I_{CLK}$	Clock output current	CLK/LEB	–5 mA
$I_{O(EA)}$	Error amplifier output current	EAOUT	5 mA
$I_{SS}$	Soft-start sink current	SS	20 mA
$I_{OSC}$	Oscillator charging current	RT	–5 mA
$T_J$	Operating virtual junction temperature range		–55°C to 150°C
$T_{stg}$	Storage temperature range		–65°C to 150°C
	Lead temperature 1,6 mm (1/16 in) from case for 10 s		300°C

- (1) 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.

**ELECTRICAL CHARACTERISTICS**
 $T_J = -40^\circ\text{C}$  to  $125^\circ\text{C}$ ,  $R_T = 3.65\text{ k}\Omega$ ,  $C_T = 1\text{ nF}$ ,  $V_{CC} = 12\text{ V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>Reference, <math>V_{REF}</math></b>						
$V_O$	Output voltage	$T_J = 25^\circ\text{C}$ , $I_O = 1\text{ mA}$	5.05	5.1	5.15	V
	Line regulation	$12\text{ V} \leq V_{CC} \leq 20\text{ V}$		2	15	mV
	Load regulation	$1\text{ mA} \leq I_O \leq 10\text{ mA}$		5	20	mV
	Total output variation	Line, load, temperature	5.03		5.17	V
	Temperature stability <sup>(1)</sup>	$T_{(min)} < T_J < T_{(max)}$		0.2	0.4	mV/ $^\circ\text{C}$
	Output noise voltage <sup>(1)</sup>	$10\text{ Hz} < f < 10\text{ kHz}$		50		$\mu\text{V}_{\text{RMS}}$
	Long term stability <sup>(1)</sup>	$T_J = 125^\circ\text{C}$ , 1000 hours		5	25	mV
	Short circuit current	$V_{REF} = 0\text{ V}$	30	60	90	mA
		$T_J = 125^\circ\text{C}$	30		110	
<b>Oscillator</b>						
$f_{\text{OSC}}$	Initial accuracy <sup>(1)</sup>	$T_J = 25^\circ\text{C}$	375	400	425	kHz
		$R_T = 6.6\text{ k}\Omega$ , $C_T = 220\text{ pF}$ , $T_J = 25^\circ\text{C}$	0.9	1	1.1	
	Total variation <sup>(1)</sup>	Line, temperature	350		450	kHz
		$R_T = 6.6\text{ k}\Omega$ , $C_T = 220\text{ pF}$	0.85		1.15	
	Voltage stability	$12\text{ V} < V_{CC} < 20\text{ V}$			1	%
	Temperature stability <sup>(1)</sup>	$T_{(min)} < T_J < T_{(max)}$		$\pm 5$		%
	High-level output voltage, clock		3.7	4		V
	Low-level output voltage, clock			0	0.2	V
	Ramp peak		2.6	2.8	3	V
	Ramp valley		0.7	1	1.25	V
	Ramp valley to peak		1.6	1.8	2	V
		$T_J = -40^\circ\text{C}$	1.55		2	
$I_{\text{OSC}}$	Oscillator discharge current	$R_T = \text{Open}$ , $V_{CT} = 2\text{ V}$	9	10	11	mA
		$T_J = 125^\circ\text{C}$	8		11	
<b>Error Amplifier</b>						
	Input offset voltage			2	10	mV
	Input bias current			0.6	3	$\mu\text{A}$
	Input offset current			0.1	1	$\mu\text{A}$
	Open loop gain	$1\text{ V} < V_O < 4\text{ V}$	60	95		dB
CMRR	Common-mode rejection ratio	$1.5\text{ V} < V_{CM} < 5.5\text{ V}$	75	95		dB
PSRR	Power-supply rejection ratio	$12\text{ V} < V_{CC} < 20\text{ V}$	85	110		dB
$I_{O(\text{sink})}$	Output sink current	$V_{EAOUT} = 1\text{ V}$	1	2.5		mA
$I_{O(\text{src})}$	Output source current	$V_{EAOUT} = 4\text{ V}$	-0.5	-1.3		mA
	High-level output voltage	$I_{EAOUT} = -0.5\text{ mA}$	4.5	4.7	5	V
	Low-level output voltage	$I_{EAOUT} = -1\text{ mA}$	0	0.5	1	V
	Gain bandwidth product	$f = 200\text{ kHz}$	6	12		MHz
	Slew rate <sup>(1)</sup>		6	9		V/ $\mu\text{s}$

(1) Specified by design

**ELECTRICAL CHARACTERISTICS (continued)**
 $T_J = -40^\circ\text{C}$  to  $125^\circ\text{C}$ ,  $R_T = 3.65\text{ k}\Omega$ ,  $C_T = 1\text{ nF}$ ,  $V_{CC} = 12\text{ V}$  (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>PWM Comparator</b>						
$I_{BIAS}$	Bias current, RAMP	$V_{RAMP} = 0\text{ V}$		-1	-8	$\mu\text{A}$
	Minimum duty cycle				0	%
	Maximum duty cycle		85			%
$t_{LEB}$	Leading edge blanking time	$R_{LEB} = 2\text{ k}\Omega$ , $C_{LEB} = 470\text{ pF}$	300	375	450	ns
$R_{LEB}$	Leading edge blanking resistance	$V_{CLK/LEB} = 3\text{ V}$	8	10	12	$\text{k}\Omega$
$V_{ZDC}$	Zero dc threshold voltage, EAOUT	$V_{RAMP} = 0\text{ V}$	1.10	1.25	1.4	V
$t_{DELAY}$	Delay-to-output time <sup>(2)</sup>	$V_{EAOUT} = 2.1\text{ V}$ , $V_{ILIM} = 0\text{ V}$ to $2\text{ V}$ step		50	80	ns
<b>Current Limit / Start Sequence / Fault</b>						
$I_{SS}$	Soft-start charge current	$V_{SS} = 2.5\text{ V}$	8	14	20	$\mu\text{A}$
$V_{SS}$	Full soft-start threshold voltage		4.3	5		V
$I_{DSCH}$	Restart discharge current	$V_{SS} = 2.5\text{ V}$	100	250	350	$\mu\text{A}$
$I_{SS}$	Restart threshold voltage			0.3	0.5	V
$I_{BIAS}$	ILIM bias current	$V_{ILIM} = 0\text{ V}$ to $2\text{ V}$ step			15	A
$I_{CL}$	Current limit threshold voltage		0.95	1	1.05	V
	Overcurrent threshold voltage		1.14	1.2	1.26	V
$t_d$	Delay-to-output time, ILIM <sup>(1)</sup>	$V_{ILIM} = 0\text{ V}$ to $2\text{ V}$ step		50	80	ns
<b>Output</b>						
	Low-level output saturation voltage	$I_{OUT} = 20\text{ mA}$		0.25	0.4	V
		$I_{OUT} = 200\text{ mA}$		1.2	2.2	
	High-level output saturation voltage	$I_{OUT} = -20\text{ mA}$		1.9	2.9	V
		$I_{OUT} = -200\text{ mA}$		2	3	
$t_r$ , $t_f$	Rise/fall time <sup>(2)</sup>	$C_L = 1\text{ nF}$		20	45	ns
<b>Undervoltage Lockout (UVLO)</b>						
	Start threshold voltage		8.4	9.2	9.6	V
	UVLO hysteresis		0.4	0.8	1.2	V
<b>Supply Current</b>						
$I_{SU}$	Startup current	$V_C = V_{CC} = V_{TH} = -0.5\text{ V}$		100	300	$\mu\text{A}$
$I_{CC}$	Input current			28	36	mA

(2) Specified by design

**APPLICATION INFORMATION**

The oscillator is a sawtooth. The rising edge is governed by a current controlled by the RT pin and value of capacitance at the CT pin ( $C_{CT}$ ). The falling edge of the sawtooth sets dead time for the outputs. Selection of RT should be done first, based on desired maximum duty cycle. CT can then be chosen based on the desired frequency (RT) and  $D_{MAX}$ . The design equations are:

$$R_T = \frac{3V}{(10\text{ mA}) \times (1 - D_{MAX})} \quad C_T = \frac{(1.6 \times D_{MAX})}{(R_T \times f)} \tag{1}$$

Recommended values for  $R_T$  range from 1 kΩ to 100 kΩ. Control of  $D_{MAX}$  less than 70% is not recommended.

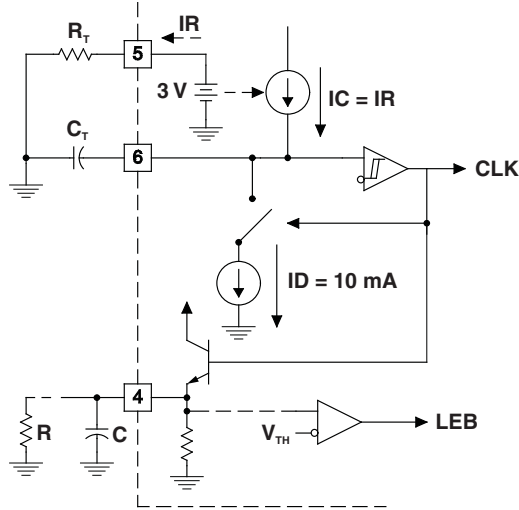


Figure 1. Oscillator

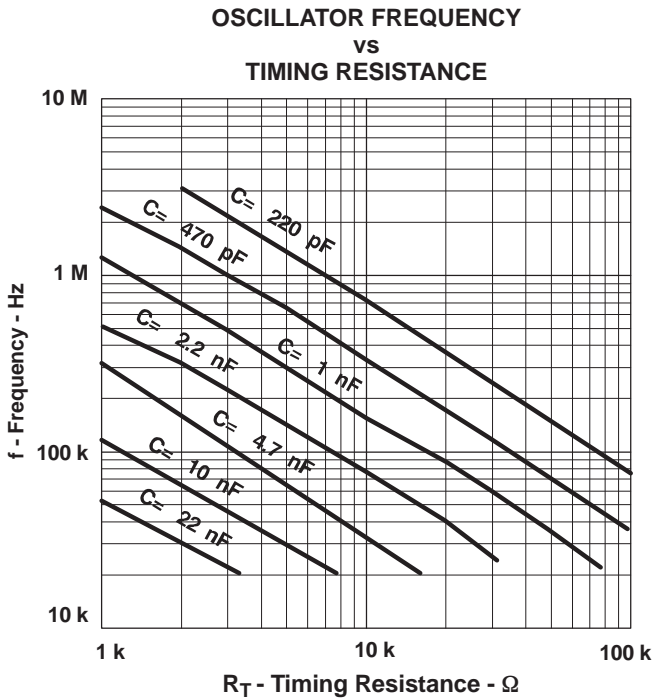


Figure 2.

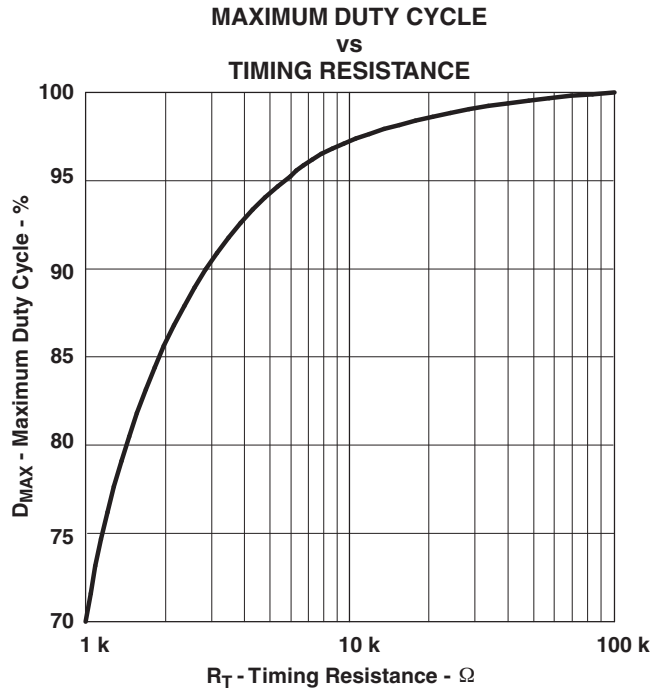


Figure 3.

## Leading Edge Blanking (LEB)

The UC2825A performs fixed-frequency PWM control. The outputs are alternately controlled. During every other cycle, one output is off. Each output then switches at one-half the oscillator frequency, varying in duty cycle from 0% to less than 50%.

To limit maximum duty cycle, the internal clock pulse blanks both outputs low during the discharge time of the oscillator. On the falling edge of the clock, the appropriate output(s) is driven high. The end of the pulse is controlled by the PWM comparator, current limit comparator, or the overcurrent comparator.

Normally the PWM comparator senses a ramp crossing a control voltage (error amplifier output) and terminates the pulse. LEB causes the PWM comparator to be ignored for a fixed amount of time after the start of the pulse. This allows noise inherent with switched mode power conversion to be rejected. The PWM ramp input may not require any filtering as result of LEB.

To program a LEB period, connect a capacitor, C, to CLK/LEB. The discharge time set by C and the internal 10-k $\Omega$  resistor determines the blanked interval. The 10-k $\Omega$  resistor has a 10% tolerance. For more accuracy, an external 2-k $\Omega$  1% resistor (R) can be added, resulting in an equivalent resistance of 1.66 k $\Omega$  with a tolerance of 2.4%. The design equation is:

$$t_{LEB} = 0.5 \times (R \parallel 10 \text{ k}\Omega) \times C \quad (2)$$

Values of R less than 2 k $\Omega$  should not be used.

LEB is also applied to the current limit comparator. After LEB, if the ILIM pin exceeds the 1-V threshold, the pulse is terminated. The overcurrent comparator, however, is not blanked. It catches catastrophic overcurrent faults without a blanking delay. Any time the ILIM pin exceeds 1.2 V, the fault latch is set and the outputs driven low. For this reason, some noise filtering may be required on the ILIM pin.

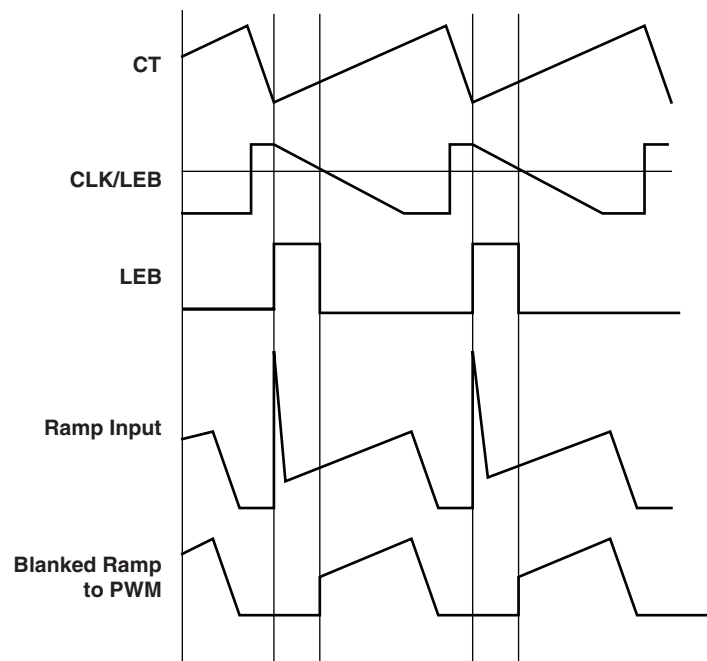


Figure 4. Leading Edge Blanking Operational Waveforms

### UVLO, Soft Start, and Fault Management

Soft start is programmed by a capacitor on the SS pin. At power up, SS is discharged. When SS is low, the error amplifier output is also forced low. While the internal 9- $\mu\text{A}$  source charges the SS pin, the error amplifier output follows until closed loop regulation takes over.

Anytime ILIM exceeds 1.2 V, the fault latch is set and the output pins are driven low. The soft-start capacitor is then discharged by a 250- $\mu\text{A}$  current sink. No more output pulses are allowed until the soft-start capacitor is fully discharged and ILIM is below 1.2 V. At this time, the fault latch resets and the chip executes a soft start.

Should the fault latch get set during soft start, the outputs are immediately terminated, but the soft-start capacitor does not discharge until it has been fully charged first. This results in a controlled hiccup interval for continuous fault conditions.

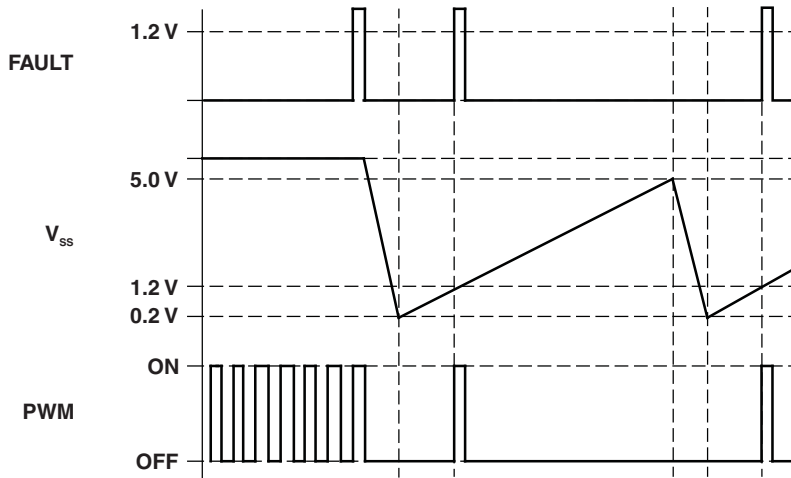
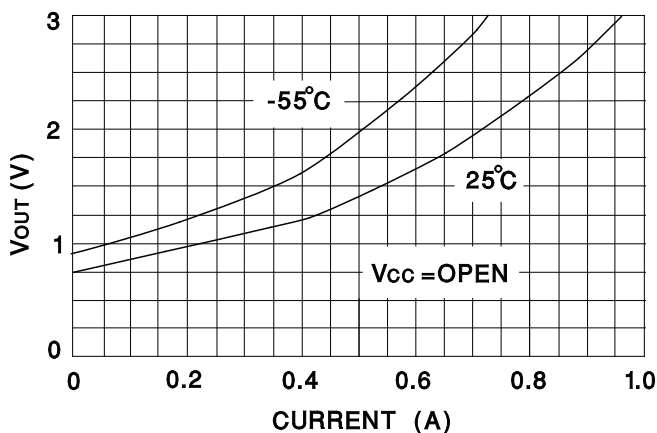


Figure 5. Soft-Start and Fault Waveforms

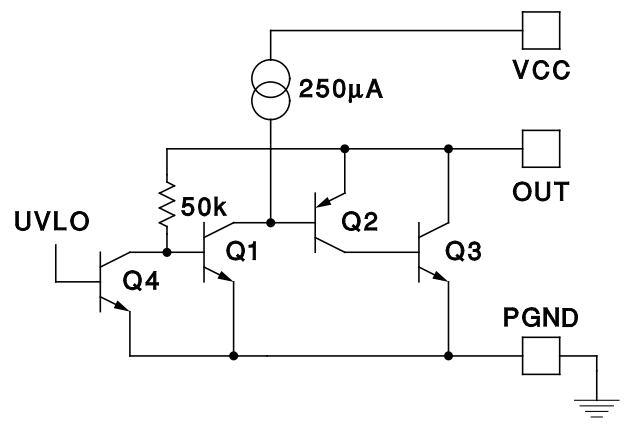
### Active-Low Outputs During UVLO

The UVLO function forces the outputs to be low and considers both VCC and VREF before allowing the chip to operate.



UDG-95108

Figure 6. Output Voltage vs Output Current



UDG-95106

Figure 7. Output Voltage and Current During UVLO



## Control Methods

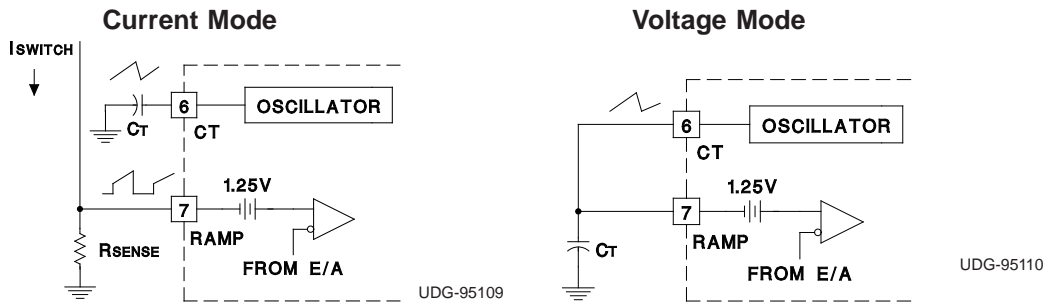


Figure 8. Control Methods

## Synchronization

The oscillator can be synchronized by an external pulse inserted in series with the timing capacitor. Program the free-running frequency of the oscillator to be 10% to 15% slower than the desired synchronous frequency. The pulse width should be greater than 10 ns and less than half the discharge time of the oscillator. The rising edge of the CLK/LEB pin can be used to generate a synchronizing pulse for other chips. Note that the CLK/LEB pin no longer accepts an incoming synchronizing signal.

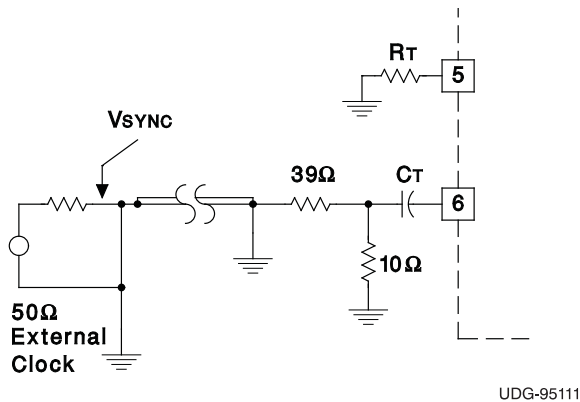


Figure 9. General Oscillator Synchronization

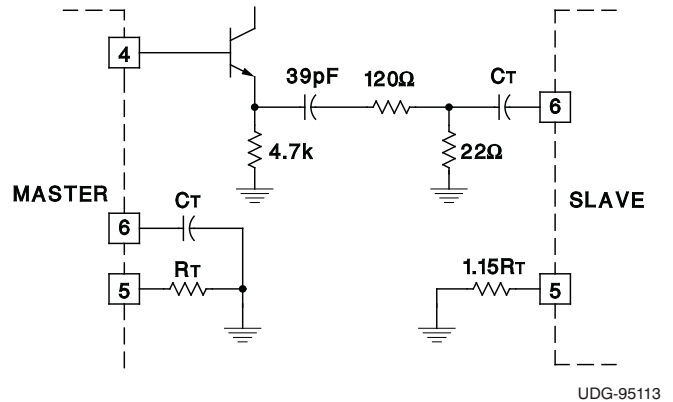
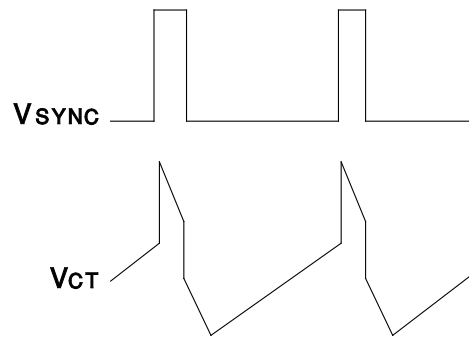


Figure 10. Two Unit Interface



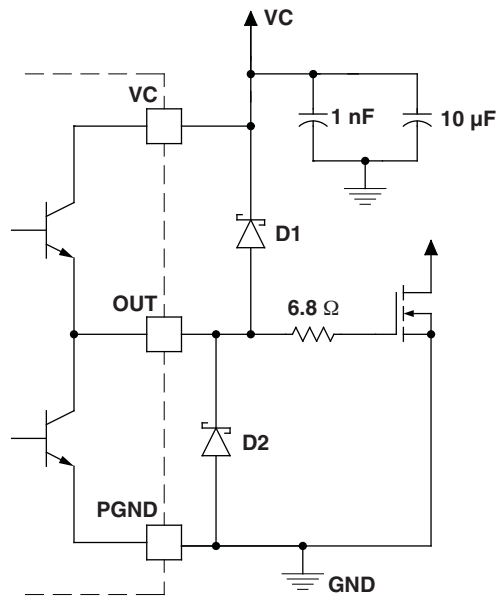
UDG-95112

Figure 11. Operational Waveforms

## High-Current Outputs

Each totem pole output can deliver a 2-A peak current into a capacitive load. The output can slew a 1000-pF capacitor by 15 V in approximately 20 ns. Separate collector supply (VC) and power ground (PGND) pins help decouple the device's analog circuitry from the high-power gate drive noise. The use of 3-A Schottky diodes (1N5120, USD245, or equivalent) (see Figure 13) from each output to both VC and PGND are recommended. The diodes clamp the output swing to the supply rails, necessary with any type of inductive/capacitive load, typical of a MOSFET gate. Schottky diodes must be used because a low forward voltage drop is required. Do not use standard silicon diodes.

Although they are single-ended devices, two output drivers are available on the UC2825A. These can be paralleled by the use of a 0.5- $\Omega$  (noninductive) resistor connected in series with each output for a combined peak current of 4 A.



D1, D2 = 1N5820

**Figure 12. Power MOSFET Drive Circuit**

## Ground Planes

Each output driver of these devices is capable of 2-A peak currents. Careful layout is essential for correct operation of the chip. A ground plane must be employed. A unique section of the ground plane must be designated for high di/dt currents associated with the output stages. This point is the power ground to which the PGND pin is connected. Power ground can be separated from the rest of the ground plane and connected at a single point, although this is not necessary if the high di/dt paths are well understood and accounted for. VCC should be bypassed directly to power ground with a good high-frequency capacitor. The sources of the power MOSFET should connect to power ground, as should the return connection for input power to the system and the bulk input capacitor. The output should be clamped with a high-current Schottky diode to both VCC and PGND. Nothing else should be connected to power ground.

VREF should be bypassed directly to the signal portion of the ground plane with a good high-frequency capacitor. Low ESR/ESL ceramic 1-mF capacitors are recommended for both VCC and VREF. All analog circuitry should, likewise, be bypassed to the signal ground plane.

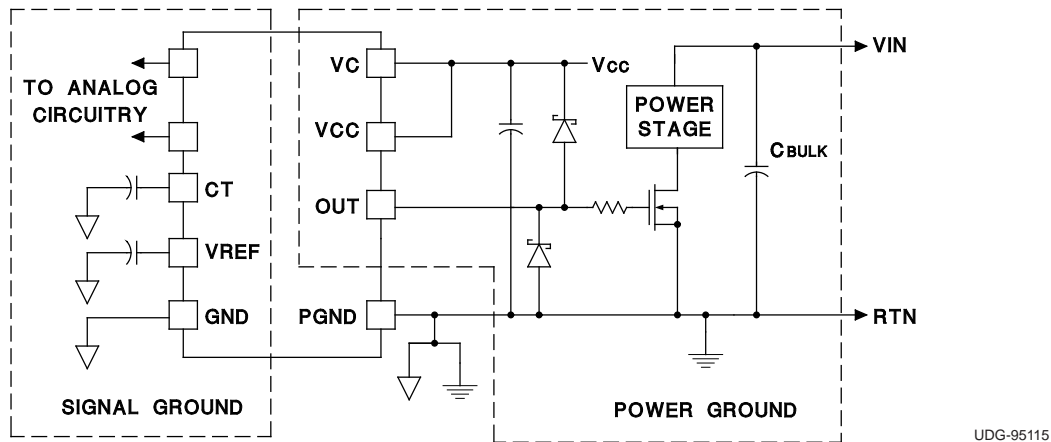


Figure 13. Ground Planes Diagram

### Open-Loop Test Circuit

This test fixture is useful for exercising many functions of this device family and measuring their specifications. As with any wideband circuit, careful grounding and bypass procedures should be followed. The use of a ground plane is highly recommended.

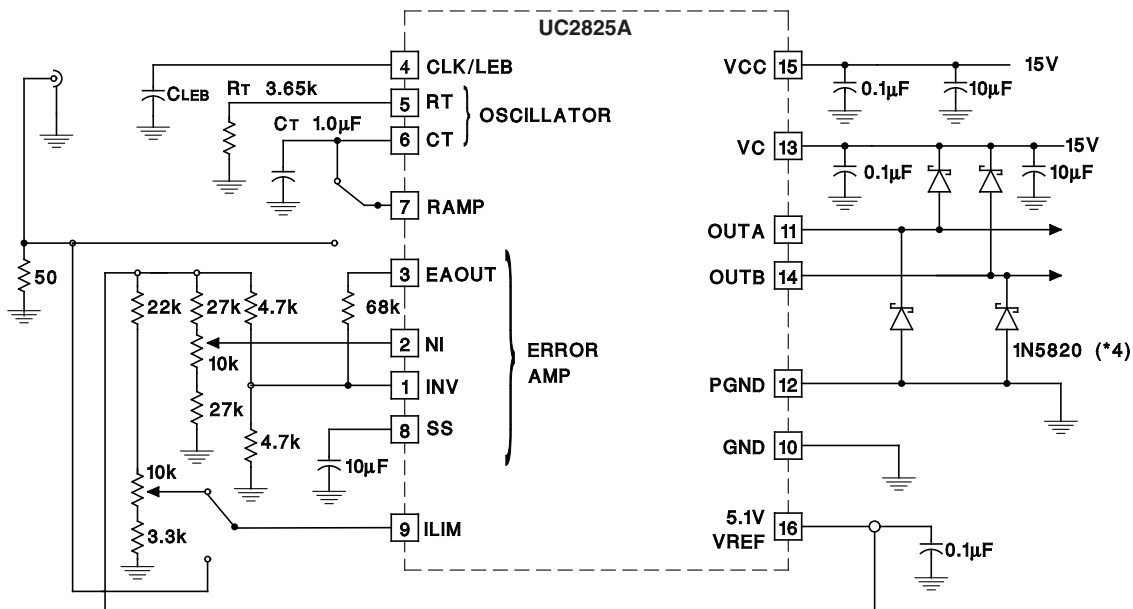


Figure 14. Open-Loop Test Circuit Schematic

**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>
UC2825AQDWRQ1	ACTIVE	SOIC	DW	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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**OTHER QUALIFIED VERSIONS OF UC2825A-Q1 :**

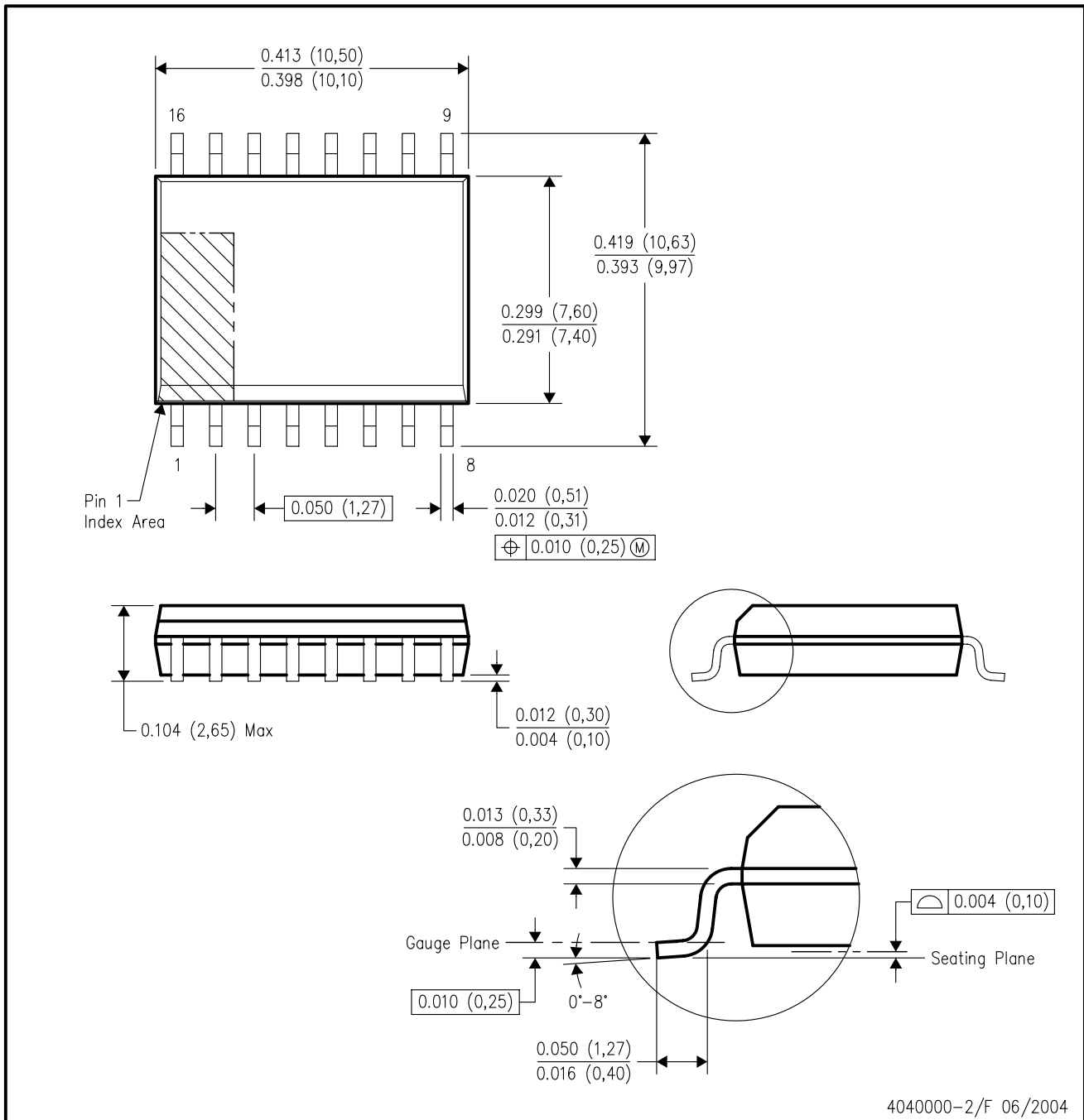
- Catalog: [UC2825A](#)
- Enhanced Product: [UC2825A-EP](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

DW (R-PDSO-G16)

PLASTIC SMALL-OUTLINE PACKAGE



4040000-2/F 06/2004

- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - D. Falls within JEDEC MS-013 variation AA.

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