

## DUAL CHANNEL SYNCHRONIZED CURRENT-MODE PWM

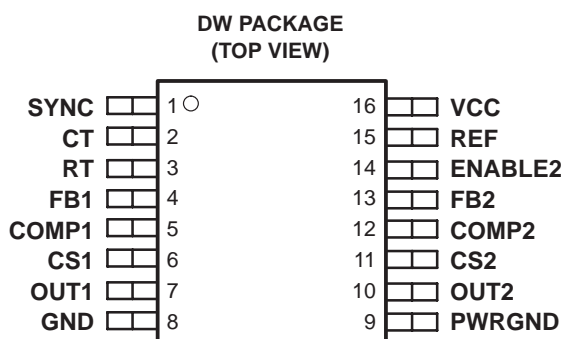
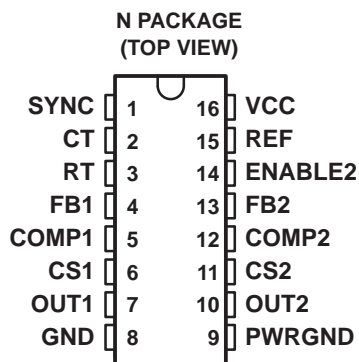
### FEATURES

- Single Oscillator Synchronizes Two PWMs
- 150- $\mu$ A Startup Supply Current
- 2-mA Operating Supply Current
- Operation to 1 MHz
- Internal Soft-Start
- Full-Cycle Fault Restart
- Internal Leading-Edge Blanking of the Current Sense Signal
- 1-A Totem Pole Outputs
- 75-ns Typical Response from Current Sense to Output
- 1.5% Tolerance Voltage Reference

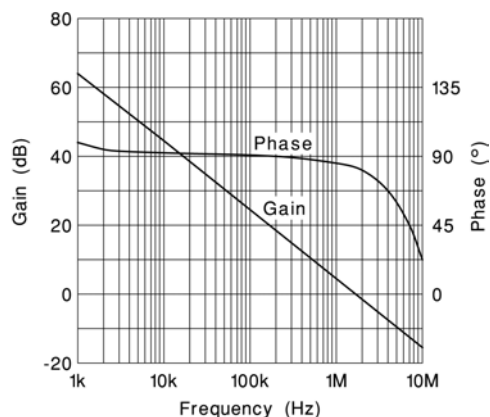
### DESCRIPTION

The UCC3810 is a high-speed BiCMOS controller integrating two synchronized pulse width modulators for use in off-line and dc-to-dc power supplies. The UCC3810 family provides perfect synchronization between two PWMs by using the same oscillator. The oscillator's sawtooth waveform can be used for slope compensation if required.

Using a toggle flip-flop to alternate between modulators, the UCC3810 ensures that one PWM does not slave, interfere, or otherwise affect the other PWM. This toggle flip-flop also ensures that each PWM is limited to 50% maximum duty cycle, insuring adequate off-time to reset magnetic elements. This device contains many of the same elements of the UC3842 current mode controller family, combined with the enhancements of the UCC3802. This minimizes power supply parts count. Enhancements include leading edge blanking of the current sense signals, full cycle fault restart, CMOS output drivers, and outputs which remain low even when the supply voltage is removed.



### ERROR AMPLIFIER GAIN AND PHASE vs FREQUENCY



ORDERING INFORMATION

T <sub>J</sub>	PACKAGED DEVICES <sup>(1)</sup>	
	SOP (DW)	PDIP (N)
–40°C to 85°C	UCC2810DW (16)	UCC2810N (16)
0°C to 70°C	UCC3810DW (16)	UCC3810N (16)

(1) All packages are available taped and reeled (indicated by the R suffix on the device type e.g., UCC2810JR)

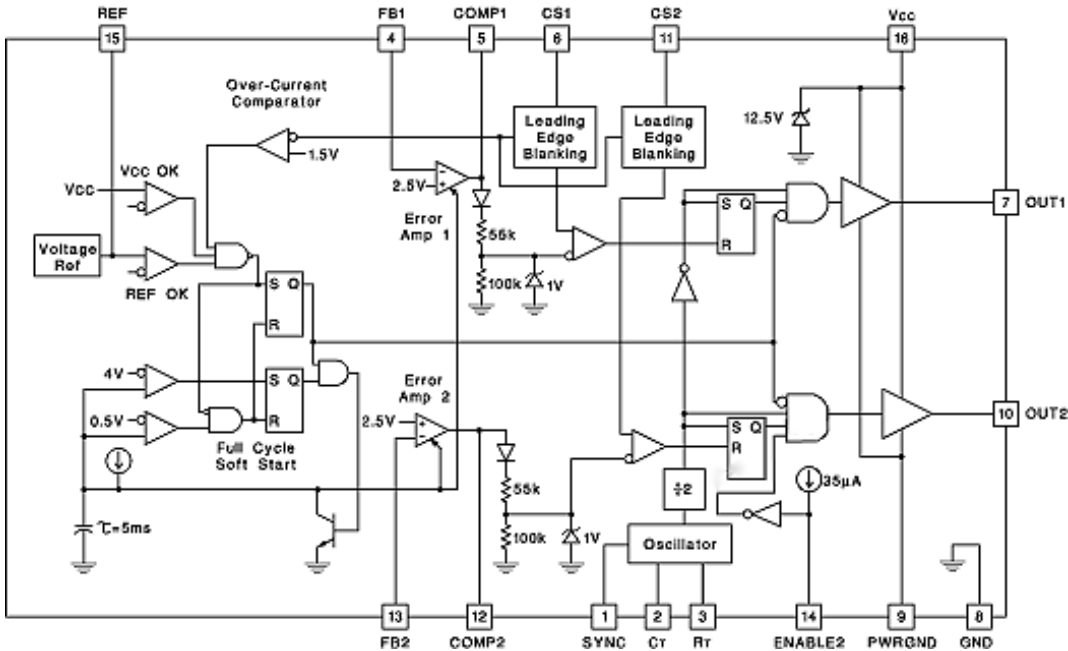
ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range unless otherwise noted<sup>(1)(3)</sup>

		UNIT
Supply voltage <sup>(2)</sup> , V <sub>CC</sub>	11	V
Supply current, I <sub>CC</sub>	20	mA
Output peak current, OUT1, OUT2, 5% duty cycle	±1	A
Output energy, OUT1, OUT2, capacitive load	20	μJ
Analog inputs, FB1, FB2, CS1, CS2, SYNC	–0.3 to 6.3	V
Operating junction temperature, T <sub>J</sub>	150	°C
Storage temperature range, T <sub>stg</sub>	–65 to 150	°C
Lead temperature (soldering, 10 sec)	300	°C

- (1) Currents are positive into, negative out of the specified terminal. All voltages are with respect to GND.
- (2) In normal operation, V<sub>CC</sub> is powered through a current-limiting resistor. Absolute maximum of 11 V applies when driven from a low impedance such that the V<sub>CC</sub> current does not exceed 20 mA.
- (3) 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.

BLOCK DIAGRAM



UDG-92062-2

**ELECTRICAL CHARACTERISTICS**

All parameters are the same for both channels,  $-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$  for the UCC2810,  $0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$  for the UCC3810,  $V_{CC} = 10\text{ V}^{(1)}$ ;  $R_T = 150\text{ k}\Omega$ ,  $C_T = 120\text{ pF}$ ; no load;  $T_A = T_J$ ; (unless otherwise specified)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>REFERENCE</b>					
$V_{CC}$ Output voltage	$T_J = 25^{\circ}\text{C}$	4.925	5.000	5.075	V
	$T_J = \text{full range, } 0\text{ mA} \leq I_{REF} \leq 5\text{ mA}$	4.85	5.00	5.10	
Load regulation	$0\text{ mA} \leq I_{REF} \leq 5\text{ mA}$		5	30	mV
Line regulation	UVLO stop threshold voltage, $0.5\text{ V} \leq V_{CC} \leq V_{SHUNT}$		12		
Output noise voltage <sup>(7)</sup>	$10\text{ Hz} < f < 10\text{ kHz, } T_J = 25^{\circ}\text{C}$		235		$\mu\text{V}$
Long term stability <sup>(7)</sup>	$T_A = 125^{\circ}\text{C, } 1000\text{ hours}$		5		mV
$I_{O(SC)}$ Output short circuit current			-8	-25	mA
<b>OSCILLATOR</b>					
$f_{OSC}$ Oscillator frequency <sup>(2)</sup>	$R_T = 30\text{ k}\Omega \quad C_T = 120\text{ pF}$	760	880	1000	kHz
	$R_T = 150\text{ k}\Omega \quad C_T = 120\text{ pF}$	190	220	250	
Temperature stability <sup>(7)</sup>			2.5%		
Peak voltage			2.5		V
Valley voltage			0.05		
Peak-to-peak amplitude		2.25	2.45	2.65	
SYNC threshold voltage		0.80	1.65	2.20	
SYNC input current	SYNC = 5 V		30		$\mu\text{A}$
<b>ERROR AMPLIFIER</b>					
$V_{FB}$ FB input voltage	COMP = 2.5 V	2.44	2.50	2.56	V
$I_{FB}$ FB input bias current				$\pm 1$	$\mu\text{A}$
Open loop voltage gain		60	73		dB
$f_{GAIN}$ Unity gain bandwidth <sup>(7)</sup>			2		MHz
$I_{SINK}$ Sink current, COMP	FB = 2.7 V, COMP = 1 V	0.3	1.4	3.5	mA
$I_{SRCE}$ Source current, COMP	FB = 1.8 V, COMP = 4 V	-0.2	-0.5	-0.8	
Minimum duty cycle	COMP = 0 V			0%	
Soft-start rise time, COMP	FB = 1.8 V, rise from 0.5 V to (REF - 1.5 V)		5		ms

(1) For UCC3810, adjust  $V_{CC}$  above the start threshold before setting at 10 V.

(2) Oscillator frequency is twice the output frequency.  $f_{OSC} = \frac{4}{R_T \times C_T}$

(3) Current sense gain A is defined by:  $A = \frac{\Delta V_{COMP}}{\Delta V_{CS}}$ ,  $0\text{ V} \leq V_{CS} \leq 0.8\text{ V}$ .

(4) Parameter measured at trip point of latch with FB = 0 V.

(5) CS blank time is measured as the difference between the minimum non-zero on-time and the CS-to-OUT delay.

(6) Start threshold voltage and  $V_{CC}$  internal zener voltage track each other.

(7) Ensured by design. Not production tested.

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PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
CURRENT SENSE							
Gain <sup>(3)</sup>				1.20	1.55	1.80	V/V
Maximum input signal <sup>(4)</sup>		COMP = 5 V		0.9	1.0	1.1	V
I <sub>CS</sub>	Input bias current, CS			±200			nA
Propagation delay time (CS to OUT)		CS steps from 0 V to 1.2 V, COMP = 2.5 V		75			ns
Blank time, CS <sup>(5)</sup>				55			
Overcurrent threshold voltage, CS				1.35	1.55	1.85	V
COMP-to-CS offset voltage		CS = 0 V		0.45	0.90	1.35	
PWM							
Maximum duty cycle <sup>(7)</sup>		R <sub>T</sub> = 150 kΩ,	C <sub>T</sub> = 120 pF	45%	49%	50%	
		R <sub>T</sub> = 30 kΩ,	C <sub>T</sub> = 120 pF	40%	45%	48%	
Minimum on-time		CS = 1.2 V,	COMP = 5 V	130			ns
OUTPUT							
V <sub>OL</sub>	Low-level output voltage	I <sub>OUT</sub> = 20 mA		0.12		0.42	V
		I <sub>OUT</sub> = 200 mA		0.48		1.10	
		I <sub>OUT</sub> = 20 mA,	V <sub>CC</sub> = 0 V	0.7		1.2	
V <sub>OH</sub>	High-level output voltage (V <sub>CC</sub> – OUT)	I <sub>OUT</sub> = –20 mA		0.15		0.42	
		I <sub>OUT</sub> = –200 mA		1.2		2.3	
t <sub>R</sub>	Rise time, OUT	C <sub>OUT</sub> = 1 nF		20		50	ns
t <sub>F</sub>	Fall time, OUT	C <sub>OUT</sub> = 1 nF		30		60	
UNDERVOLTAGE LOCKOUT (UVLO)							
Start threshold voltage				9.6	11.3	13.2	V
Stop threshold voltage				7.1	8.3	9.5	
Start-to-stop hysteresis				1.7	3.0	4.7	
ENABLE2 input bias current		ENABLE2 = 0 V		–20	–35	–55	μA
ENABLE2 input threshold voltage				0.80	1.53	2.00	V

(1) For UCC3810, adjust  $V_{CC}$  above the start threshold before setting at 10 V.

(2) Oscillator frequency is twice the output frequency.  $f_{osc} = \frac{4}{R_T \times C_T}$

(3) Current sense gain A, is defined by:  $A = \frac{\Delta V_{COMP}}{\Delta V_{CS}}$ ,  $0\text{ V} \leq V_{CS} \leq 0.8\text{ V}$ .

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PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>OVERALL</b>					
Startup current	$V_{CC} < \text{Start threshold voltage}$	0.15	0.25		mA
Operating supply current, outputs off	$V_{CC} = 10\text{ V}$ , $\text{FB} = 2.75\text{ V}$	2	3		
Operating supply current, outputs on	$V_{CC} = 10\text{ V}$ , $\text{CS} = 0\text{ V}$ , $\text{FB} = 0\text{ V}$ , $R_T = 150\text{ k}\Omega$	3.2	5.1		
	$V_{CC} = 10\text{ V}$ , $\text{CS} = 0\text{ V}$ , $\text{FB} = 0\text{ V}$ , $R_T = 30\text{ k}\Omega$	8.5	14.5		
VCC internal zener voltage <sup>(6)</sup>	$I_{CC} = 10\text{ mA}$	11.0	12.9	14.0	V
VCC internal zener voltage minus start threshold voltage		0.4	1.2		

(6) Start threshold voltage and  $V_{CC}$  internal zener voltage track each other.

**Terminal Functions**

TERMINAL		I/O	DESCRIPTION
NAME	NO.		
COMP1	5	O	Low impedance output of the error amplifiers.
COMP2	12	O	
CS1	6	I	Current sense inputs to the PWM comparators. These inputs have leading edge blanking. For most applications, no input filtering is required. Leading edge blanking disconnects the CS inputs from all internal circuits for the first 55 ns of each PWM cycle. When used with very slow diodes or in other applications where the current sense signal is unusually noisy, a small current-sense R-C filter may be required.
CS2	11	I	
CT	2	O	The timing capacitor of the oscillator. Recommended values of CT are between 100 pF and 1 nF. Connect the timing capacitor directly across CT and GND.
ENABLE2	14	I	A logic input which disables PWM 2 when low. This input has no effect on PWM 1. This input is internally pulled high. In most applications it can be left floating. In unusually noisy applications, the input should be bypassed with a 1-nF ceramic capacitor. This input has TTL compatible thresholds.
FB1	4	I	The high impedance inverting inputs of the error amplifiers.
FB2	13	I	
GND	8	–	To separate noise from the critical control circuits, this part has two different ground connections: GND and PWRGND. GND and PWRGND must be electrically connected together. However, use care to avoid coupling noise into GND.
OUT1	7	O	The high-current push-pull outputs of the PWM are intended to drive power MOSFET gates through a small resistor. This resistor acts as both a current limiting resistor and as a damping impedance to minimize ringing and overshoot.
OUT2	10	O	
PWRGND	9	–	To separate noise from the critical control circuits, this part has two different ground connections: GND and PWRGND. GND and PWRGND must be electrically connected together.
REF	15	O	The output of the 5-V reference. Bypass REF to GND with a ceramic capacitor $\geq 0.01\text{-}\mu\text{F}$ for best performance.
RT	3	O	The oscillator charging current is set by the value of the resistor connected from RT to GND. This pin is regulated to 1 V, but the actual charging current is $10\text{ V}/R_T$ . Recommended values of $R_T$ are between 10 k $\Omega$ and 470 k $\Omega$ . For a given frequency, higher timing resistors give higher maximum duty cycle and slightly lower overall power consumption.
SYNC	1	I	This logic input can be used to synchronize the oscillator to a free running oscillator in another part. This pin is edge triggered with TTL thresholds, and requires at least a 10-ns-wide pulse. If unused, this pin can be grounded, open circuited, or connected to REF.
VCC	16	I	The power input to the device. This pin supplies current to all functions including the high current output stages and the precision reference. Therefore, it is critical that VCC be directly bypassed to PWRGND with an 0.1- $\mu\text{F}$ ceramic capacitor.

## APPLICATION INFORMATION

### timing resistor

Supply current decreases with increased  $R_T$  by the relationship:

$$\Delta I_{CC} = \frac{11 \text{ V}}{R_T} \quad (1)$$

For more information, see the detailed oscillator block diagram.

### leading edge blanking and current sense

Figure 1 shows how an external power stage is connected to the UCC3810. The gate of an external power N-channel MOSFET is connected to OUT through a small current-limiting resistor. For most applications, a 10-Ω resistor is adequate to limit peak current and also practical at damping resonances between the gate driver and the MOSFET input reactance. Long gate lead length increases gate capacitance and mandates a higher series gate resistor to damp the R-L-C tank formed by the lead, the MOSFET input reactance, and the device's driver output resistance.

The UCC3810 features internal leading edge blanking of the current-sense signal on both current sense inputs. The blank time starts when OUT rises and continues for 55 ns. During that 55 ns period, the signal on CS is ignored. For most PWM applications, this means that the CS input can be connected to the current-sense resistor as shown in Figure 1. However, high speed grounding practices and short lead lengths are still required for good performance.

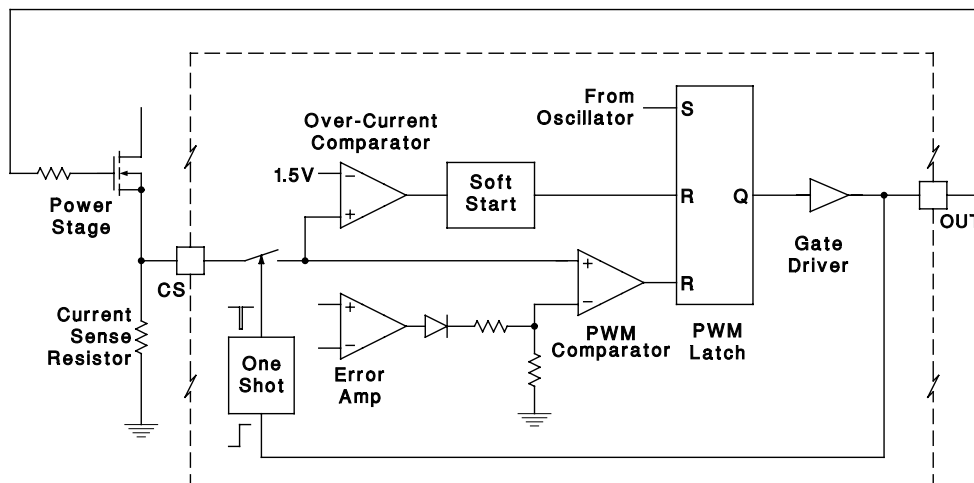


Figure 1. Detailed Block Diagram

### oscillator

The UCC3810 oscillator generates a sawtooth wave at CT. The sawtooth rise time is set by the resistor from  $R_T$  to GND. Since  $R_T$  is biased at 1 V, the current through  $R_T$  is 1 V/ $R_T$ . The actual charging current is 10 times higher. The fall time is set by an internal transistor on-resistance of approximately 100 Ω. During the fall time, all outputs are off and the maximum duty cycle is reduced to below 50%. Larger timing capacitors increase the discharge time and reduce frequency. However, the percentage maximum duty cycle is only a function of the timing resistor  $R_T$ , and the internal 100-Ω discharge resistance.

## APPLICATION INFORMATION

## error amplifier output stage

The UCC3810 error amplifiers are operational amplifiers with low-output resistance and high-input resistance. The output stage of one error amplifier is shown in Figure 3. This output stage allows the error amplifier output to swing close to GND and as high as one diode drop below 5 V with little loss in amplifier performance.

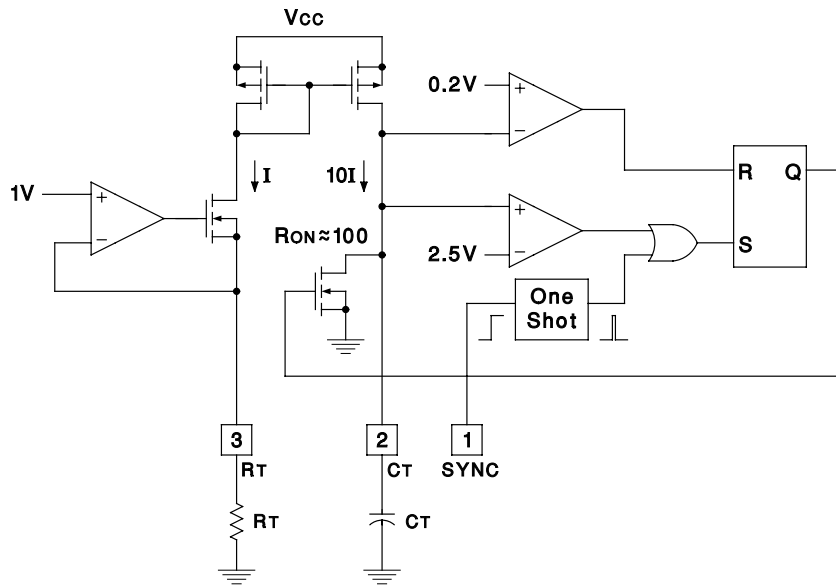


Figure 2. Oscillator

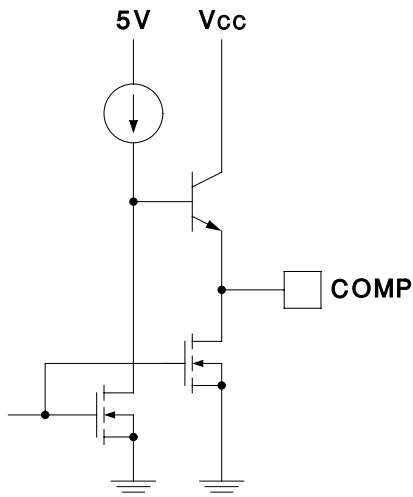


Figure 3. Error Amplifier Output Stage

TYPICAL CHARACTERISTICS

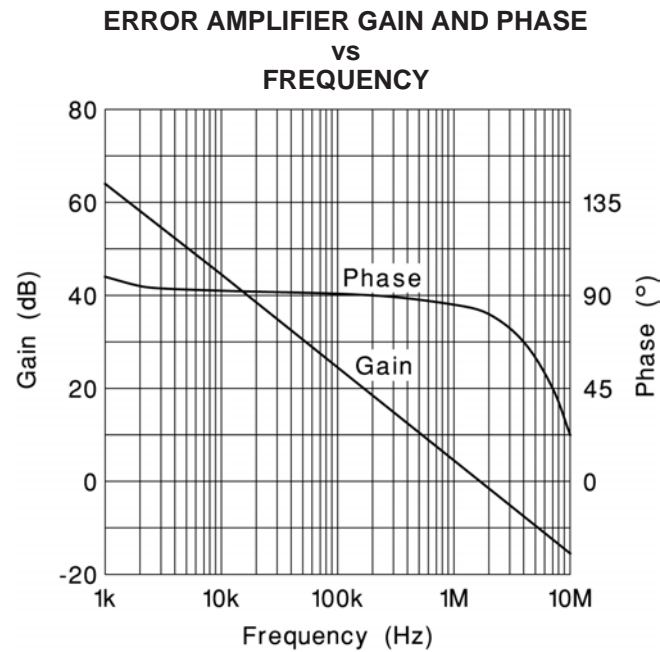


Figure 4

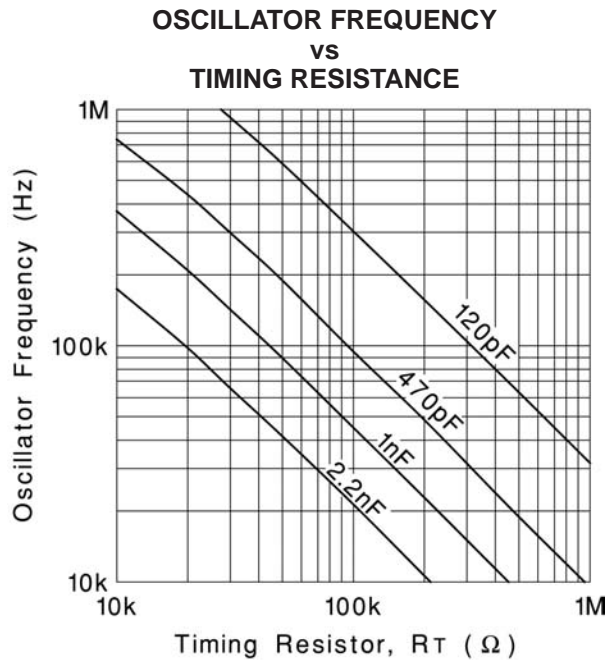


Figure 5

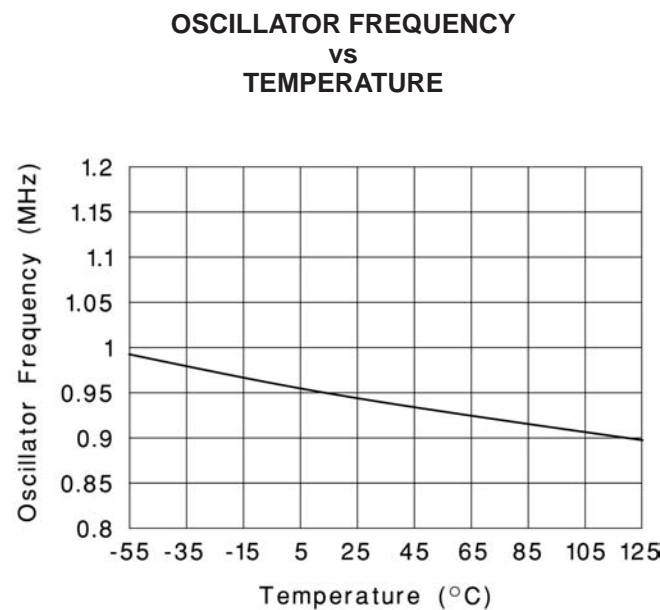


Figure 6

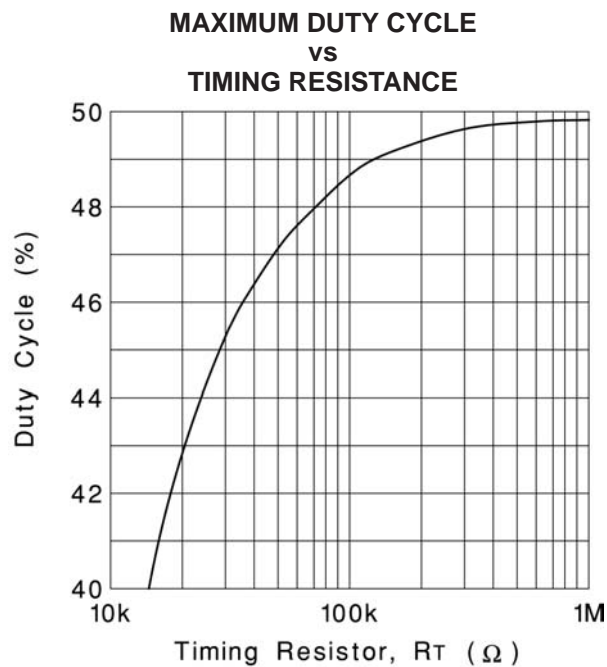


Figure 7



## TYPICAL CHARACTERISTICS

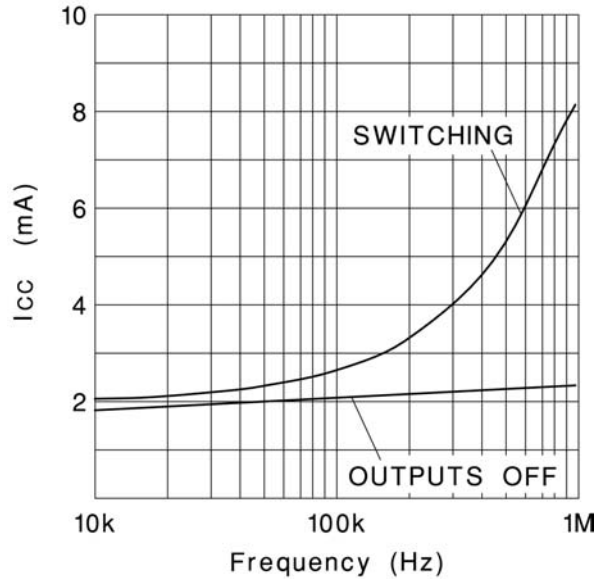
INPUT CURRENT  
vs  
OSCILLATOR FREQUENCY

Figure 8

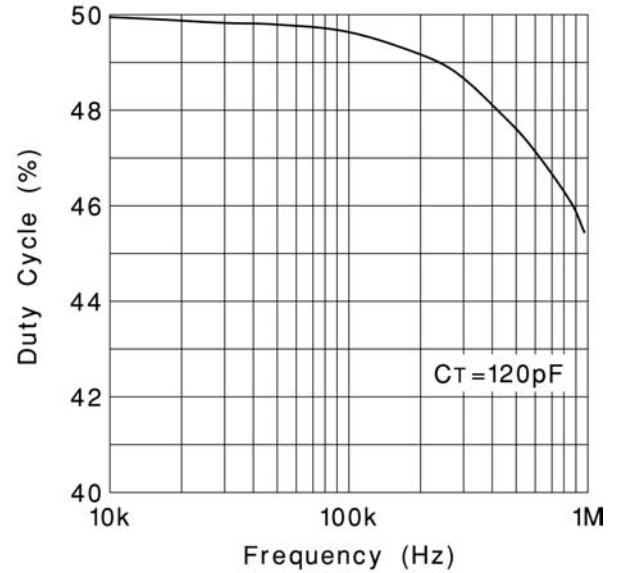
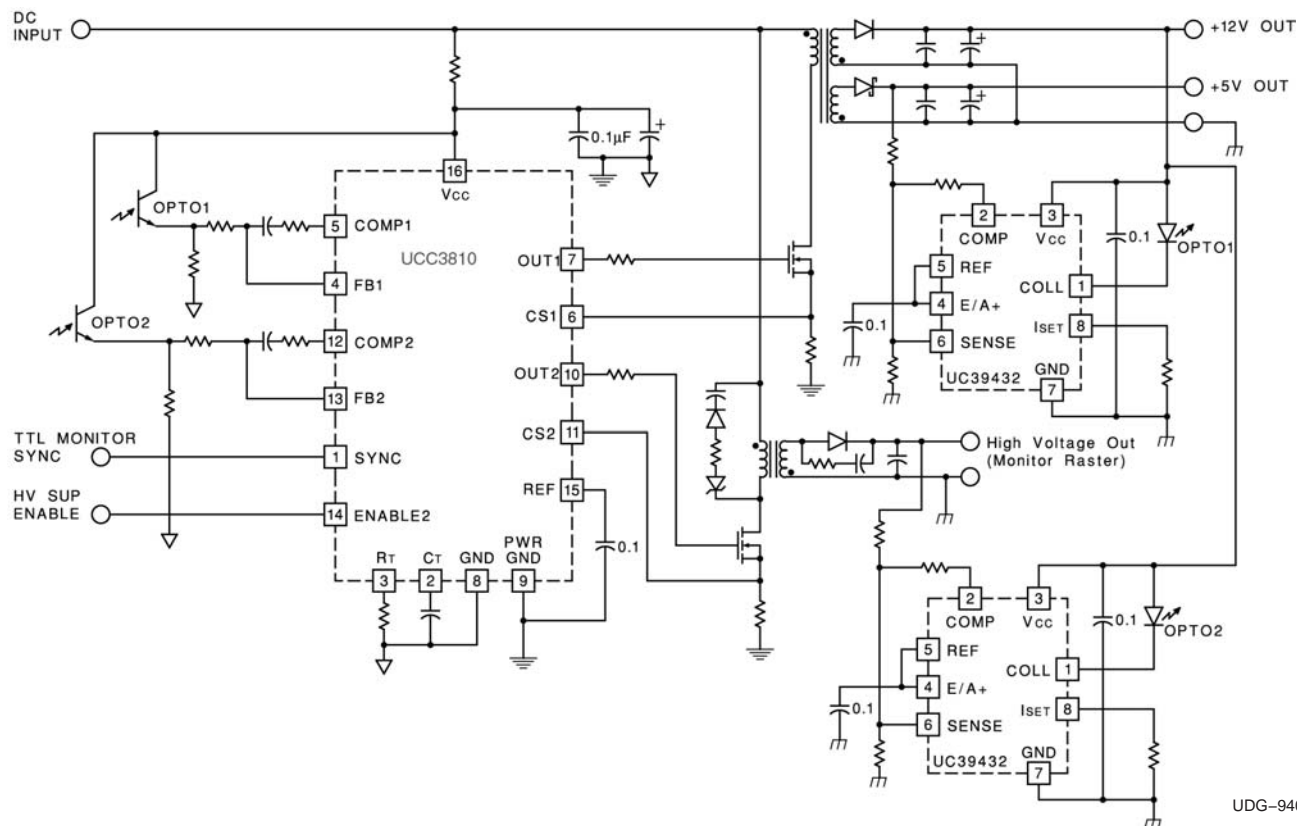
MAXIMUM DUTY CYCLE  
vs  
FREQUENCY

Figure 9



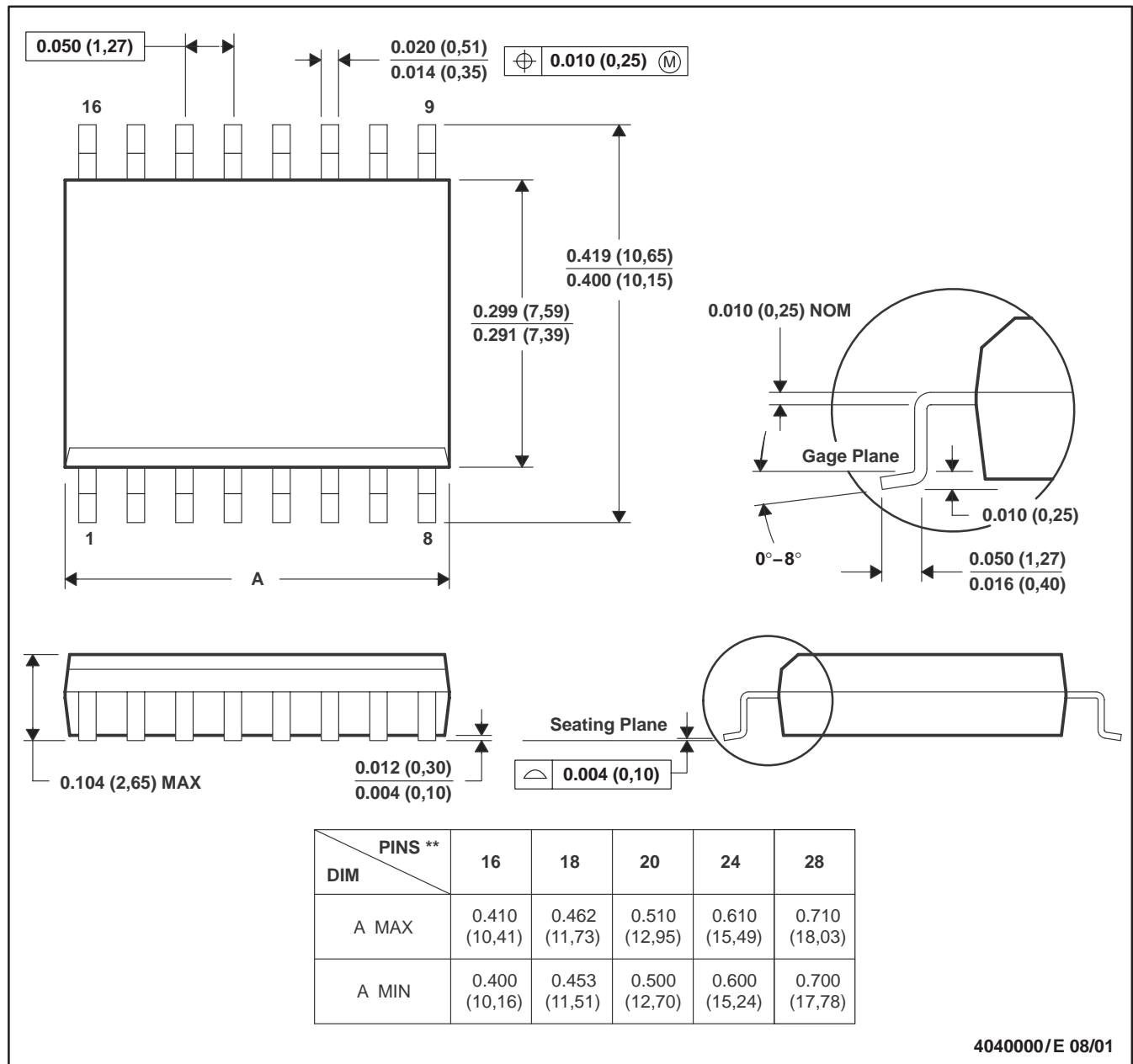
UDG-94022

Figure 10. Typical Application

DW (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

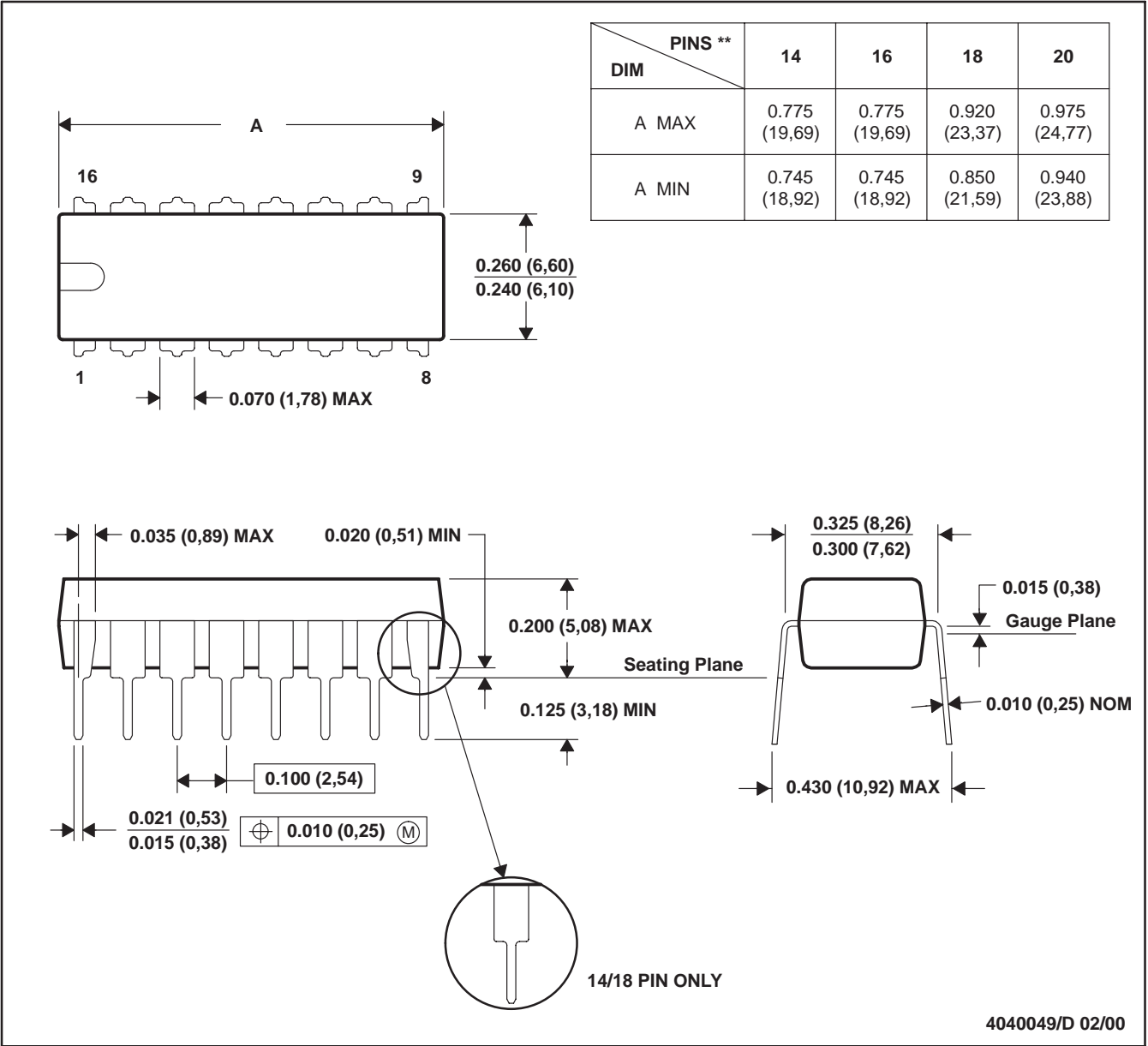
16 PINS SHOWN



- 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

N (R-PDIP-T\*\*)  
16 PINS SHOWN

PLASTIC DUAL-IN-LINE PACKAGE



NOTES: A. All linear dimensions are in inches (millimeters).  
B. This drawing is subject to change without notice.  
C. Falls within JEDEC MS-001 (20-pin package is shorter than MS-001).

## 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>
UCC2810DW	ACTIVE	SOIC	DW	16	40	None	CU NIPDAU	Level-2-220C-1 YEAR
UCC2810DWTR	ACTIVE	SOIC	DW	16	2000	None	CU NIPDAU	Level-2-220C-1 YEAR
UCC2810N	ACTIVE	PDIP	N	16	25	None	CU NIPDAU	Level-NA-NA-NA
UCC3810DW	ACTIVE	SOIC	DW	16	40	None	CU NIPDAU	Level-2-220C-1 YEAR
UCC3810DWTR	ACTIVE	SOIC	DW	16	2000	None	CU NIPDAU	Level-2-220C-1 YEAR
UCC3810DWTRG4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UCC3810N	ACTIVE	PDIP	N	16	25	None	CU NIPDAU	Level-NA-NA-NA

<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 - May not be currently available - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**None:** Not yet available Lead (Pb-Free).

**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.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean "Pb-Free" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

<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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Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>	Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>	Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
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