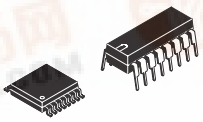
TEXAS INSTRUMENTS



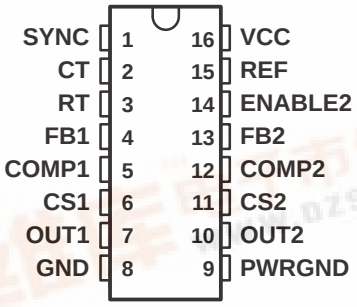
SLUS162C – FEBRUARY 1999 – REVISED NOVEMBER 2004

DUAL CHANNEL SYNCHRONIZED CURRENT-MODE PWM

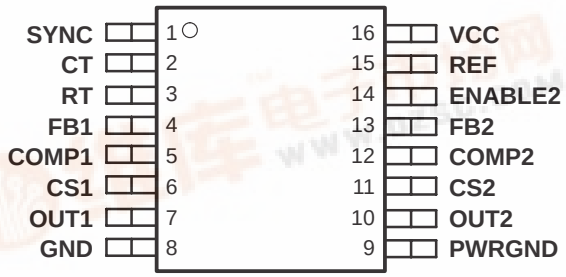
FEATURES

- Single Oscillator Synchronizes Two PWMs
- 150-μA 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

N PACKAGE
(TOP VIEW)



DW PACKAGE
(TOP VIEW)

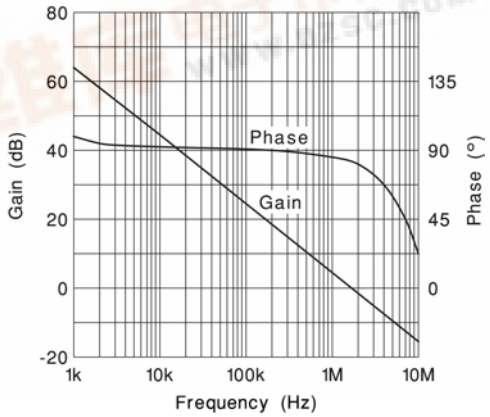


DESCRIPTION

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 usin g 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_J	PACKAGED DEVICES(1)	
	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(1)(3)

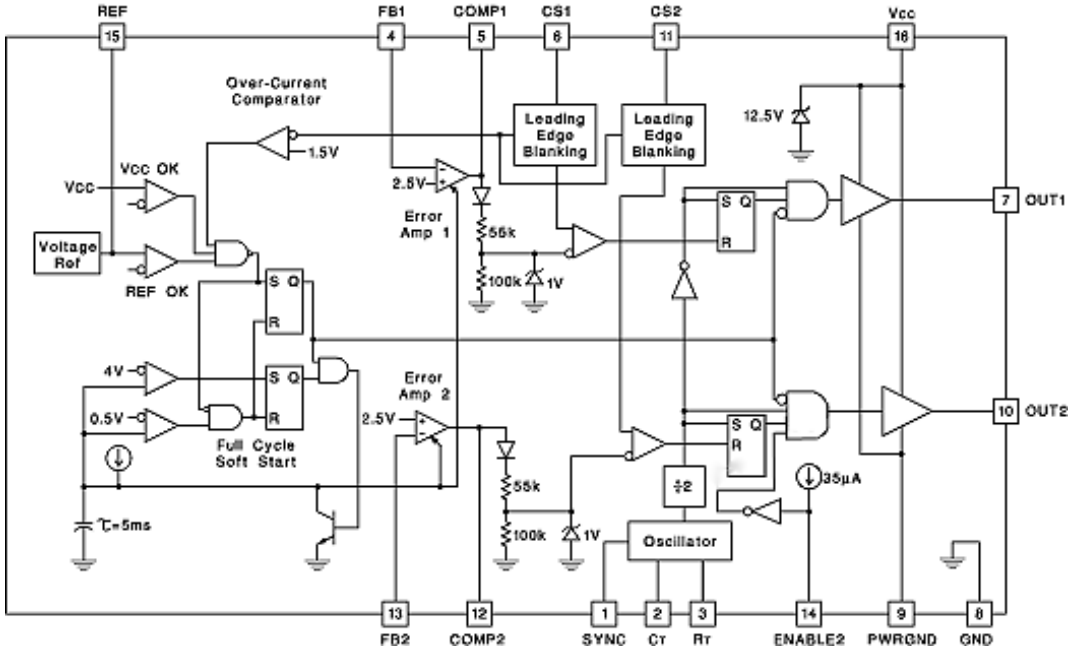
		UNIT
Supply voltage(2), V_{CC}	11	V
Supply current, I_{CC}	20	mA
Output peak current, OUT1, OUT2, 5% duty cycle	±1	A
Output energy, OUT1, OUT2, capacitive load	20	µJ
Analog inputs, FB1, FB2, CS1, CS2, SYNC	−0.3 to 6.3	V
Operating junction temperature, T_J	150	°C
Storage temperature range, T_{stg}	−65 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_{CC} is powered through a current-limiting resistor. Absolute maximum of 11 V applies when driven from a low impedance such that the V_{CC} 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°C ≤ T_A ≤ 85°C for the UCC2810, 0°C ≤ T_A ≤ 70°C for the UCC3810, V_{CC} = 10 V(1) ; R_T = 150 kΩ, C_T = 120 pF; no load; T_A = T_J; (unless otherwise specified)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
REFERENCE							
V_{CC}	Output voltage	T_J = 25°C		4.925	5.000	5.075	V
		T_J = full range,	0 mA ≤ I_{REF} ≤ 5 mA	4.85	5.00	5.10	
	Load regulation	0 mA ≤ I_{REF} ≤ 5 mA			5	30	mV
	Line regulation	UVLO stop threshold voltage, 0.5 V ≤ V_{CC} ≤ V_{SHUNT}			12		
	Output noise voltage(7)	10 Hz < *f* < 10 kHz,	T_J = 25°C		235		μV
	Long term stability(7)	T_A = 125°C,	1000 hours		5		mV
$I_{O(SC)}$	Output short circuit current				−8	−25	mA
OSCILLATOR							
f_{OSC}	Oscillator frequency(2)	R_T = 30 kΩ	C_T = 120 pF	760	880	1000	kHz
		R_T = 150 kΩ	C_T = 120 pF	190	220	250	
	Temperature stability(7)				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		μA
ERROR AMPLIFIER							
V_{FB}	FB input voltage	COMP = 2.5 V		2.44	2.50	2.56	V
I_{FB}	FB input bias current					±1	μA
	Open loop voltage gain			60	73		dB
f_{GAIN}	Unity gain bandwidth(7)				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 V ≤ V_{CS} ≤ 0.8 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.

ELECTRICAL CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
CURRENT SENSE							
	Gain(3)			1.20	1.55	1.80	V/V
	Maximum input signal(4)	COMP = 5 V		0.9	1.0	1.1	V
I_{CS}	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(5)				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(7)	R_T = 150 kΩ,	C_T = 120 pF	45%	49%	50%	
		R_T = 30 kΩ,	C_T = 120 pF	40%	45%	48%	
	Minimum on-time	CS = 1.2 V,	COMP = 5 V		130		ns
OUTPUT							
V_{OL}	Low-level output voltage	I_{OUT} = 20 mA			0.12	0.42	V
		I_{OUT} = 200 mA			0.48	1.10	
		I_{OUT} = 20 mA,	V_{CC} = 0 V		0.7	1.2	
V_{OH}	High-level output voltage (V_{CC} − OUT)	I_{OUT} = −20 mA			0.15	0.42	
		I_{OUT} = −200 mA			1.2	2.3	
t_R	Rise time, OUT	C_{OUT} = 1 nF			20	50	ns
t_F	Fall time, OUT	C_{OUT} = 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: $A = \frac{\Delta V_{COMP}}{\Delta V_{CS}}$, $0 V \le V_{CS} \le 0.8 V$.

(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.

ELECTRICAL CHARACTERISTICS

All parameters are the same for both channels, −40°C ≤ T_A ≤ 85°C for the UCC2810, 0°C ≤ T_A ≤ 70°C for the UCC3810, V_{CC} = 10 V(1) ; R_T = 150 kΩ, C_T = 120 pF; no load; T_A = T_J; (unless otherwise specified)

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

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

Terminal Functions

TERMINAL NAME	TERMINAL NO.	I/O	DESCRIPTION
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 ≥ 0.01-μF 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 V/R_T. Recommended values of R_T are between 10 kΩ and 470 kΩ. 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-μF ceramic capacitor.

APPLICATION INFORMATION

timing resistor

Supply current decreases with increased R_T by the relationship:

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

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.

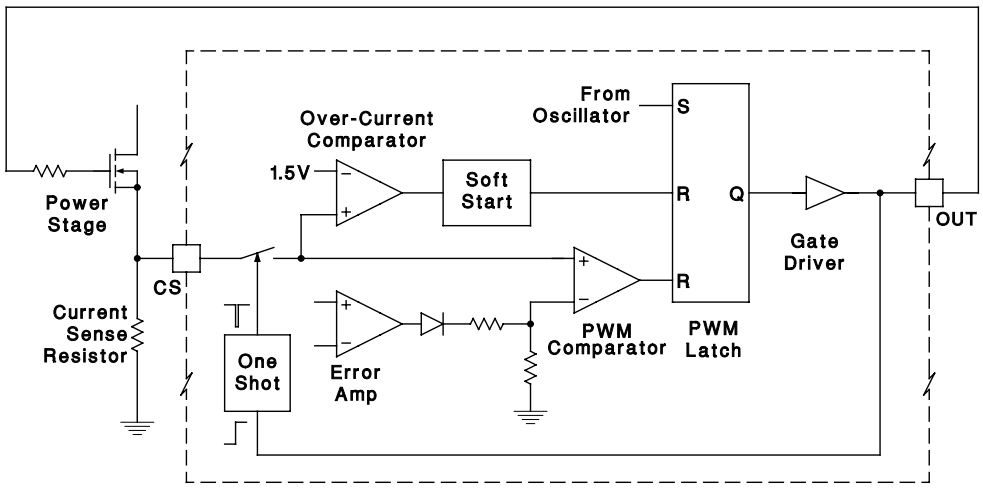


Figure 1. Detailed Block Diagram

oscillator

The UCC3810 oscillator generates a sawtooth wave at CT. The sawtooth rise time is set by the resistor from RT 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.

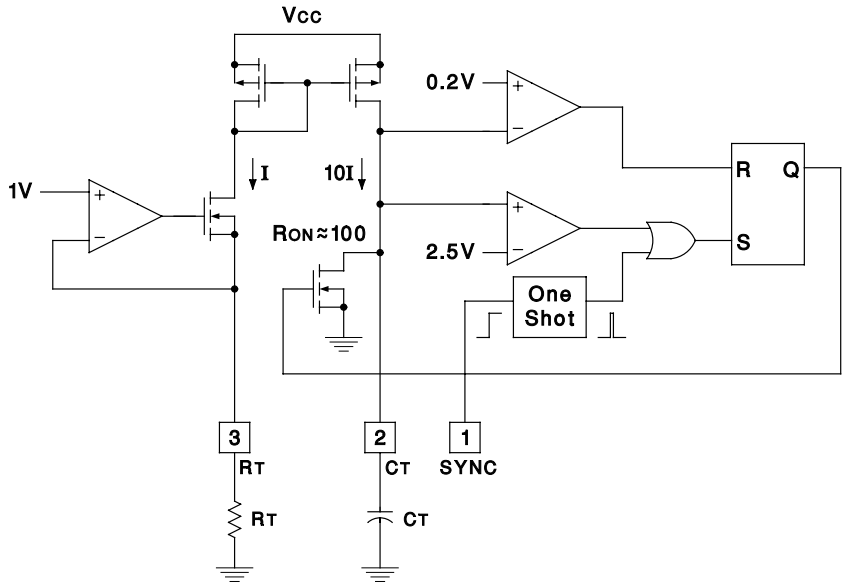


Figure 2. Oscillator

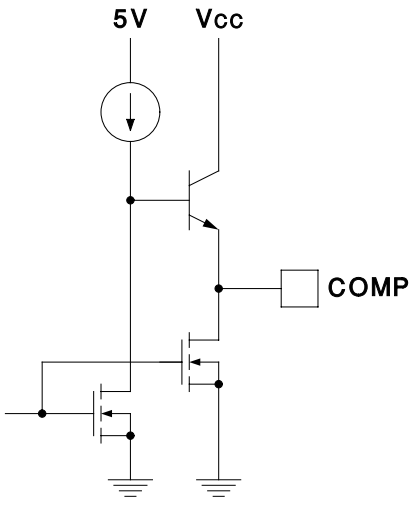


Figure 3. Error Amplifier Output Stage

TYPICAL CHARACTERISTICS

ERROR AMPLIFIER GAIN AND PHASE vs FREQUENCY

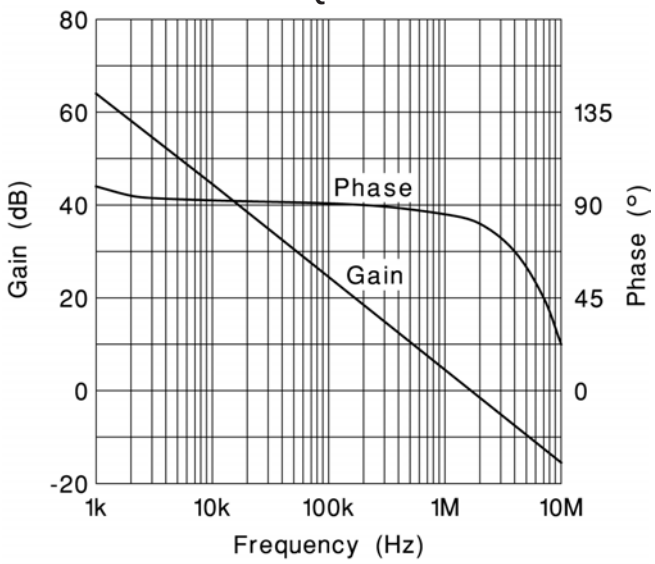


Figure 4

OSCILLATOR FREQUENCY vs TIMING RESISTANCE

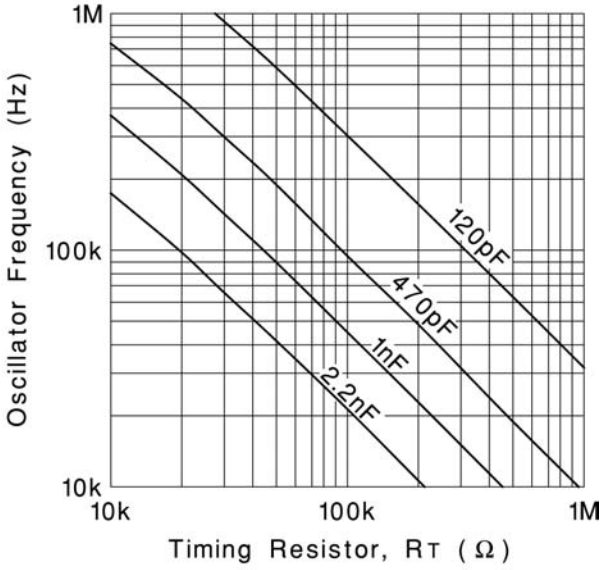


Figure 5

OSCILLATOR FREQUENCY vs TEMPERATURE

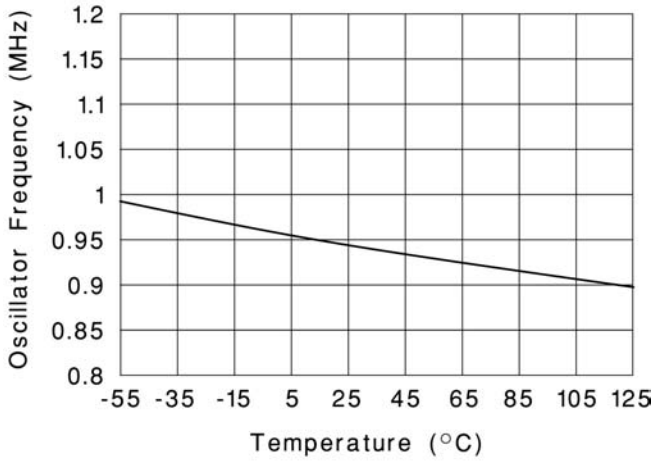


Figure 6

MAXIMUM DUTY CYCLE vs TIMING RESISTANCE

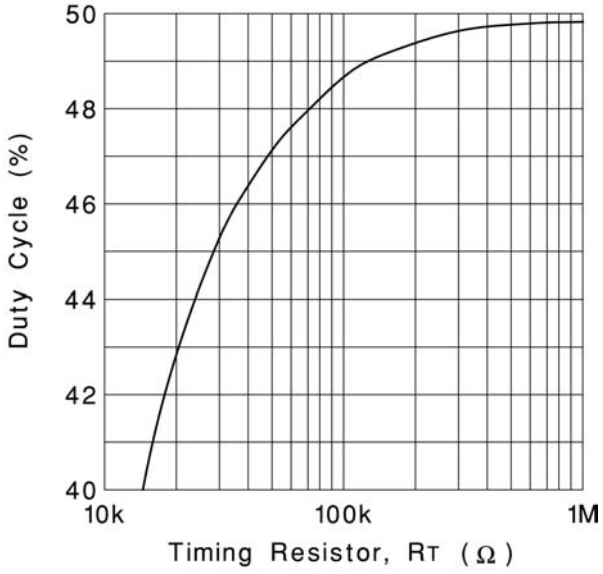


Figure 7

TYPICAL CHARACTERISTICS

INPUT CURRENT vs OSCILLATOR FREQUENCY

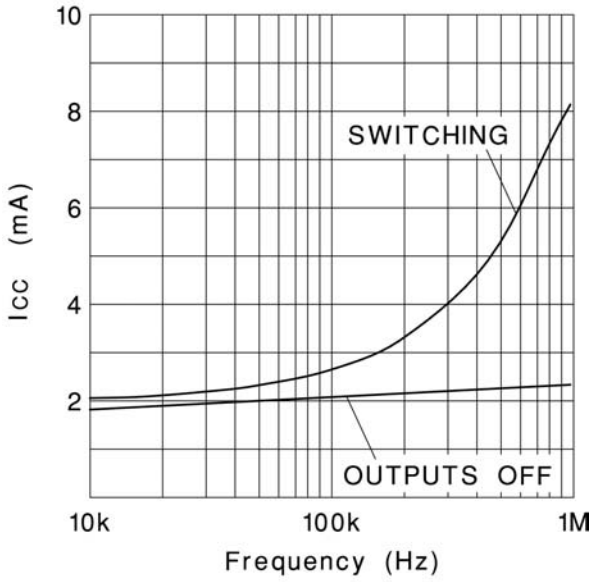


Figure 8

MAXIMUM DUTY CYCLE vs FREQUENCY

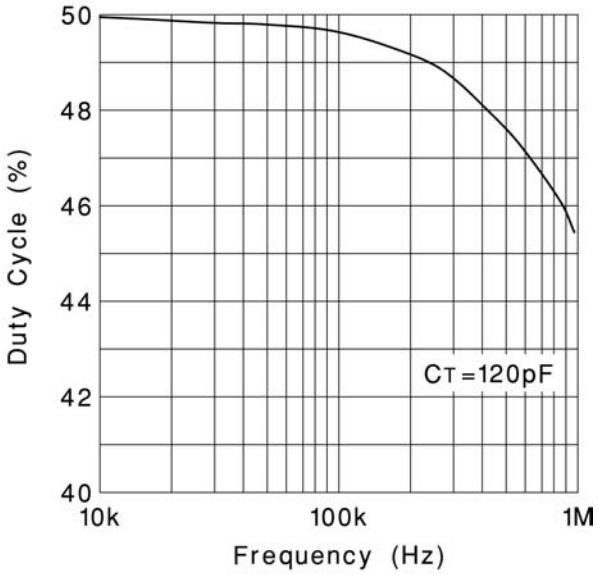


Figure 9

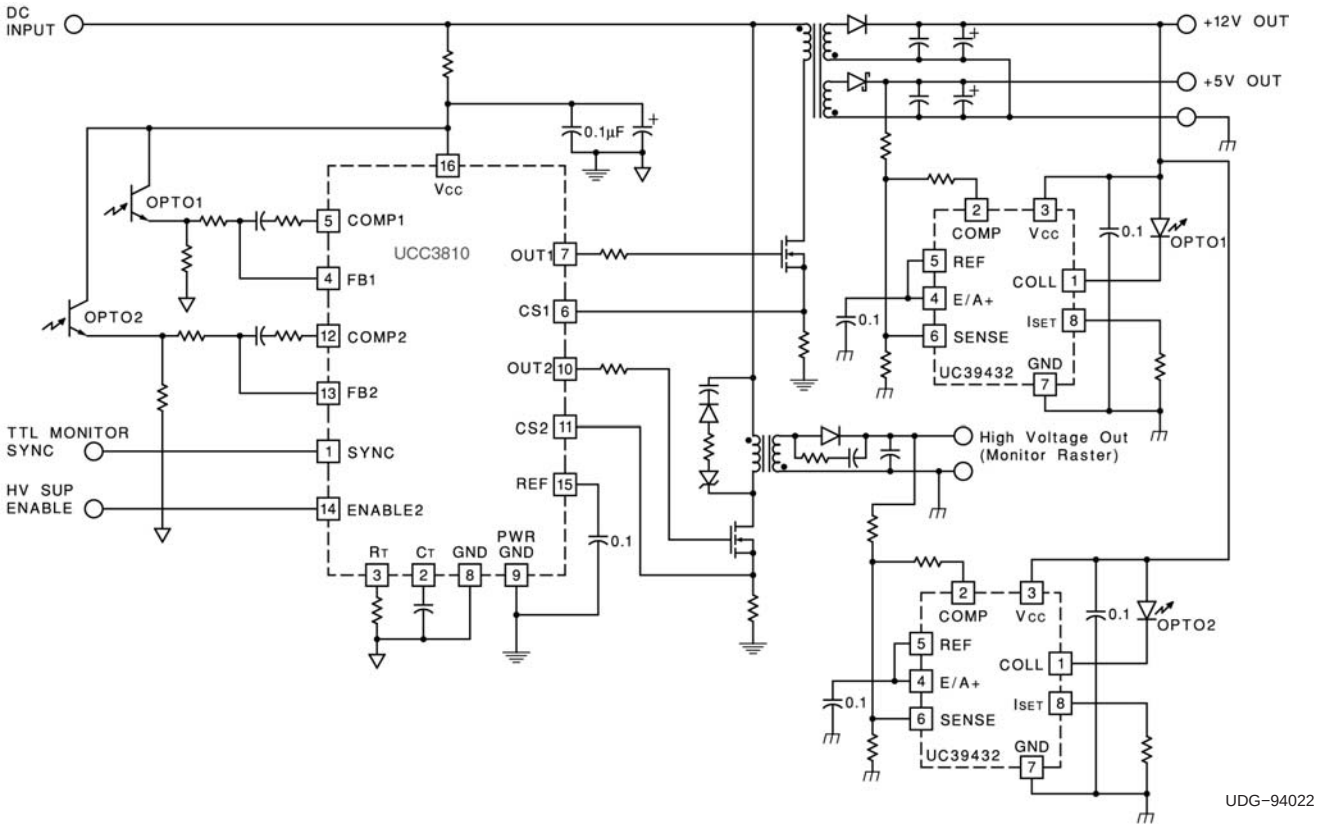
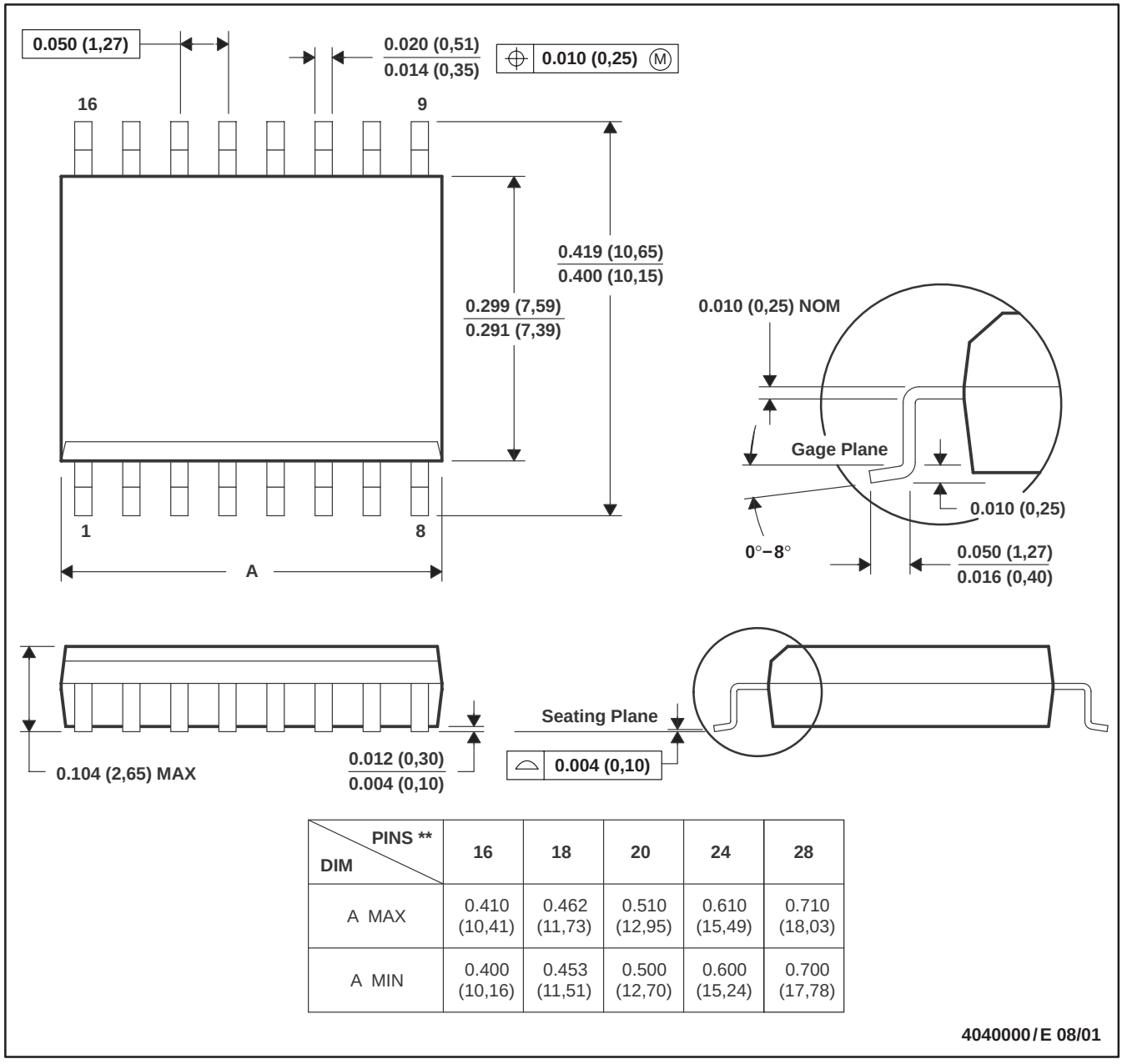


Figure 10. Typical Application

DW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

16 PINS SHOWN



DIM \ PINS **	16	18	20	24	28
A MAX	0.410 (10,41)	0.462 (11,73)	0.510 (12,95)	0.610 (15,49)	0.710 (18,03)
A MIN	0.400 (10,16)	0.453 (11,51)	0.500 (12,70)	0.600 (15,24)	0.700 (17,78)

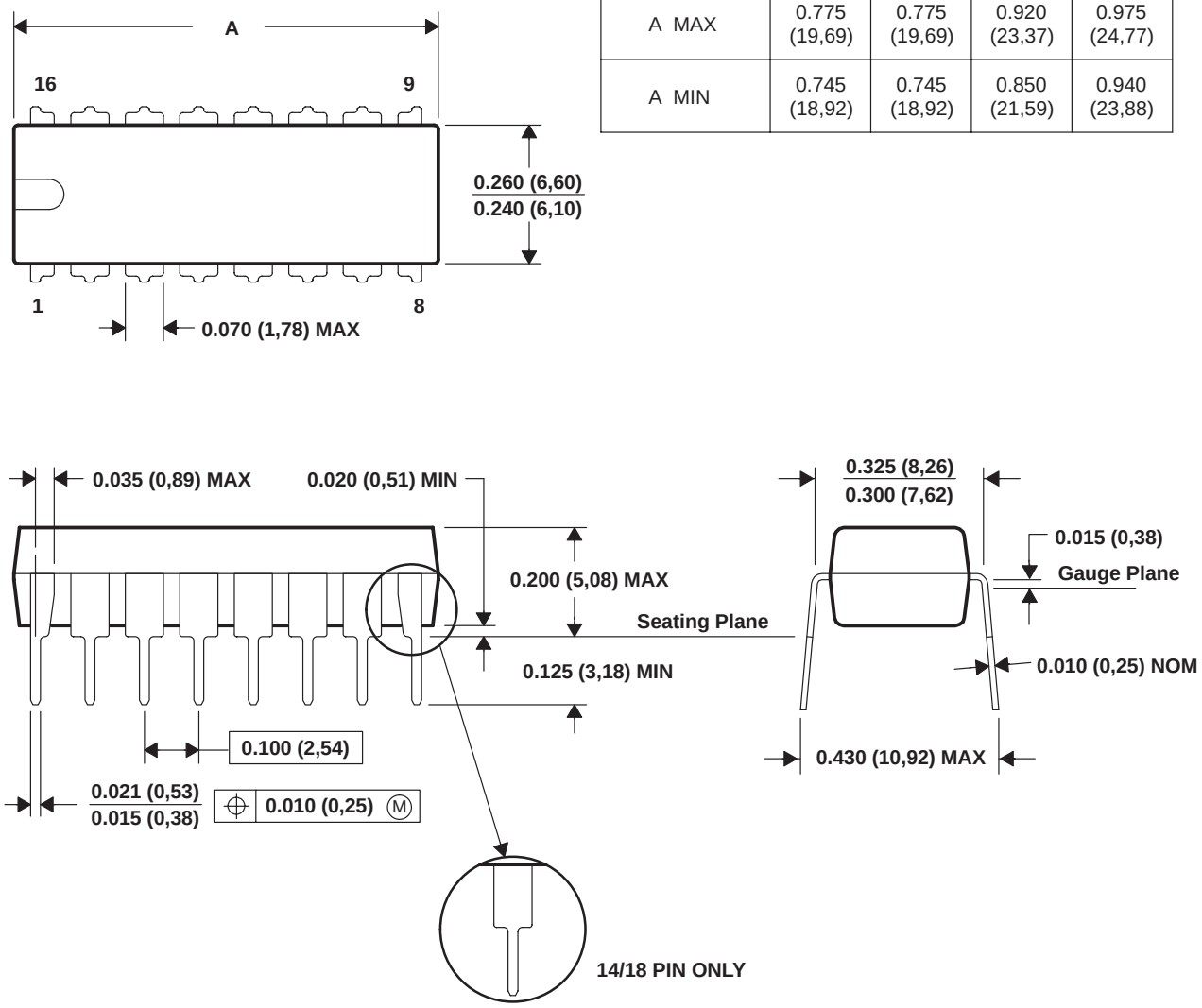
4040000/E 08/01

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**) PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN

DIM \ PINS **	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	0.975 (24,77)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)



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 [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
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

[1] 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.

[2] 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.

[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDECindustry standard classifications, and peak solder temperature.

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