INTEGRATED CIRCUITS
UNITRODE

UC1856
UC2856
UC3856

Improved Current Mode PWM Controller

FEATURES

- Pin-for-Pin Compatible With the UC3846
- 65ns Typical Delay From Shutdown to Outputs, and 50ns Typical Delay From Sync to Outputs
- Improved Current Sense Amplifier With Reduced Noise Sensitivity
- Differential Current Sense with 3V Common Mode Range
- Trimmed Oscillator Discharge Current for Accurate Deadband Control
- Accurate 1V Shutdown Threshold
- High Current Dual Totem Pole Outputs (1.5A peak)
- TTL Compatible Oscillator SYNC Pin Thresholds
- 4kV ESD Protection

DESCRIPTION

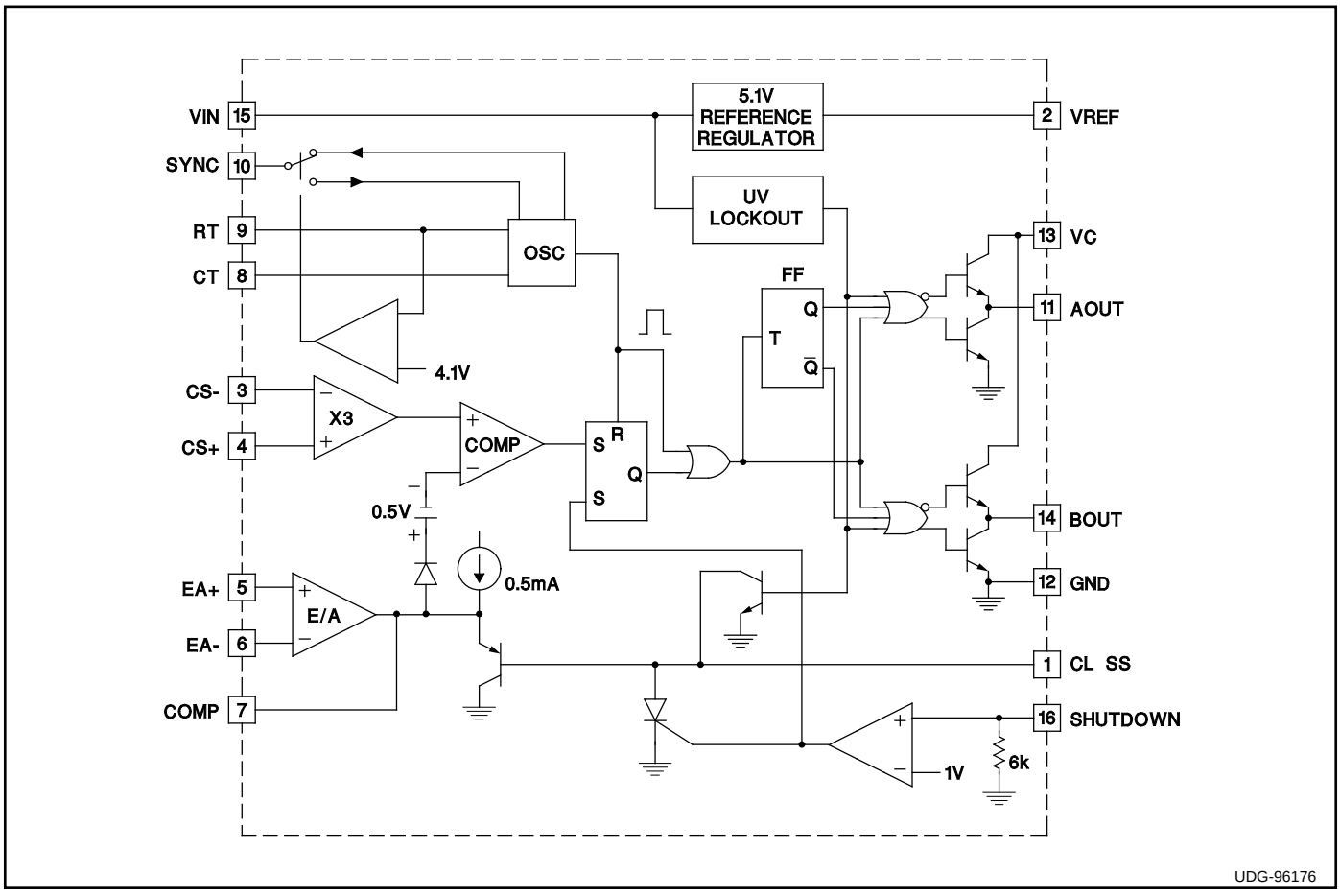
The UC3856 is a high performance version of the popular UC3846 series of current mode controllers, and is intended for both design upgrades and new applications where speed and accuracy are important. All input to output delays have been minimized, and the current sense output is slew rate limited to reduce noise sensitivity. Fast 1.5A peak output stages have been added to allow rapid switching of power FETs.

A low impedance TTL compatible sync output has been implemented with a tri-state function when used as a sync input.

Internal chip grounding has been improved to minimize internal "noise" caused when driving large capacitive loads. This, in conjunction with the improved differential current sense amplifier results in enhanced noise immunity.

Other features include a trimmed oscillator current (8%) for accurate frequency and dead time control; a 1V, 5% shutdown threshold; and 4kV minimum ESD protection on all pins.

BLOCK DIAGRAM



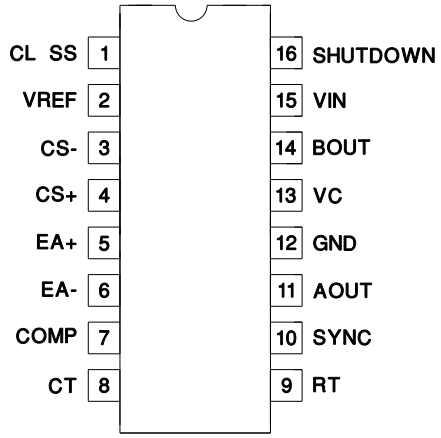
ABSOLUTE MAXIMUM RATINGS

Supply Voltage .....+40V
Collector Supply Voltage .....+40V
Output Current, Source or Sink
DC.....0.5A
Pulse (0.5µs).....2.0A
Error Amp Inputs.....–0.3V to +V_{IN}
Shutdown Input.....–0.3V to +10V
Current Sense Inputs.....–0.3V to +3V
SYNC Output Current .....±10mA
Error Amplifier Output Current .....–5mA
Soft Start Sink Current.....50mA
Oscillator Charging Current 5mA
Power Dissipation at T_A = 25°C (Note 2).....1000mW
Power Dissipation at T_C = 25°C (Note 2) 2000mW
Junction Temperature .....–55°C to +150°C
Storage Temperature Range .....–65°C to +150°C
Lead Temperature (Soldering, 10 sec.) .....+300°C

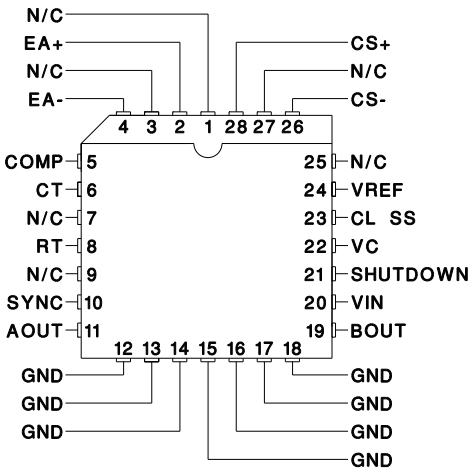
All voltages are with respect to Ground. Currents are positive into, negative out of the specified terminal. Consult packaging section of databook for thermal limitations and considerations of package.

CONNECTION DIAGRAMS

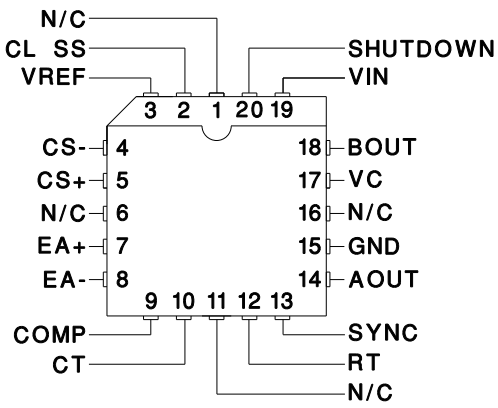
DIL–16, SOIC-16 (Top View)
J or N, DW PACKAGE



PLCC-28 (Top View)
QP PACKAGE



PLCC-20 (Top View)
Q PACKAGE



ELECTRICAL CHARACTERISTICS

Unless otherwise stated, these specifications apply for T_A = –55°C to +125°C for UC1856; – 40°C to +85°C for the UC2856; and 0°C to +70°C for the UC3856, VIN = 15V, RT = 10k, CT = 1nF, T_A = T_J.

PARAMETER	TEST CONDITIONS	UC1856/UC2856			UC3856			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Reference Section								
Output Voltage	T_J = 25°C, Io = 1mA	5.05	5.10	5.15	5.00	5.10	5.20	V
Line Regulation	VIN = 8V to 40V			20			20	mV
Load Regulation	Io = –1mA to –10mA			15			15	mV
Total Output Variation	Line, Load, and Temperature	5.00		5.20	4.95		5.25	V
Output Noise Voltage	10Hz < f < 10kHz, T_J = 25°C		50			50		µV
Long Term Stability	T_J = 125°C, 1000 Hrs (Note 2)		5	25		5	25	mV
Short Circuit Current	VREF = 0V	–25	–45	–65	–25	–45	–65	mA
Oscillator Section								
Initial Accuracy	T_J = 25°C	180	200	220	180	200	220	kHz
	Over Operating Range	170		230	170		230	kHz

ELECTRICAL CHARACTERISTICS (cont.) Unless otherwise stated, these specifications apply for T_A = –55°C to +125°C for UC1856; – 40°C to +85°C for the UC2856; and 0°C to +70°C for the UC3856, VIN = 15V, RT = 10k, CT = 1nF, $T_A = T_J$.

PARAMETER	TEST CONDITIONS	UC1856/UC2856			UC3856			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Oscillator Section (cont.)								
Voltage Stability	VIN = 8V to 40V			2			2	%
Discharge Current	T_J = 25°C, V_{CT} = 2V	7.5	8.0	8.8	7.5	8.0	8.8	mA
	V_{CT} = 2V	6.7	8.0	8.8	6.7	8.0	8.8	mA
Sync Output High Level	Io = –1mA	2.4	3.6		2.4	3.6		V
Sync Output Low Level	Io = +1mA		0.2	0.4		0.2	0.4	V
Sync Input High Level	CT = 0V, RT = VREF	2.0	1.5		2.0	1.5		V
Sync Input Low Level	CT = 0V, RT = VREF		1.5	0.8		1.5	0.8	V
Sync Input Current	CT = 0V, RT = VREF V_{SYNC} = 5V		1	10		1	10	µA
Sync Delay to Outputs	CT = 0V, RT = VREF V_{SYNC} = 0.8V to 2V		50	100		50	100	ns
Error Amplifier Section								
Input Offset Voltage	V_{CM} = 2V			5			10	mV
Input Bias Current				–1			–1	µA
Input Offset Current				500			500	nA
Common Mode Range	VIN = 8V to 40V	0		VIN – 2	0		VIN – 2	V
Open Loop Gain	Vo = 1.2V to 3V	80	100		80	100		dB
Unity Gain Bandwidth	T_J = 25°C	1	1.5		1	1.5		MHz
CMRR	V_{CM} = 0V to 38V, VIN = 40V	75	100		75	100		dB
PSRR	VIN = 8V to 40V	80	100		80	100		dB
Output Sink Current	V_{ID} = –15mV, V_{COMP} = 1.2V	5	10		5	10		mA
Output Source Current	V_{ID} = 15mV, V_{COMP} = 2.5V	–0.4	–0.5		–0.4	–0.5		mA
Output High Level	V_{ID} = 50mV, R_L (COMP) = 15k	4.3	4.6	4.9	4.3	4.6	4.9	V
Output Low Level	V_{ID} = –50mV, R_L (COMP) = 15k		0.7	1		0.7	1	V
Current Sense Amplifier Section								
Amplifier Gain	$V_{CS–}$ = 0V, CL SS Open (Notes 3,4)	2.5	2.75	3.0	2.5	2.75	3.0	V/V
Maximum Differential Input Signal ($V_{CS+} – V_{CS-}$)	CL SS Open (Note 3) R_L (COMP) = 15k	1.1	1.2		1.1	1.2		V
Input Offset Voltage	$V_{CL\ SS}$ = 0.5V COMP Open (Note 3)		5	35		5	35	mV
CMRR	V_{CM} = 0V to 3V	60			60			dB
PSRR	VIN = 8V to 40V	60			60			dB
Input Bias Current	$V_{CL\ SS}$ = 0.5V, COMP Open (Note 3)			–1	–3	–1	–3	µA
Input Offset Current	$V_{CL\ SS}$ = 0.5V, COMP Open (Note 3)			1			1	mA
Input Common Mode Range		0		3	0		3	V
Delay to Outputs	V_{EA+} = VREF, EA– = 0V CS+ – CS– = 0V to 1.5V		120	250		120	250	ns
Current Limit Adjust Section								
Current Limit Offset	V_{CS-} = 0V V_{CS+} = 0V, COMP = Open (Note 3)	0.43	0.5	0.57	0.43	0.5	0.57	V
Input Bias Current	V_{EA+} = VREF, $V_{EA–}$ = 0V		–10	–30		–10	–30	µA
Shutdown Terminal Section								
Threshold Voltage		0.95	1.00	1.05	0.95	1.00	1.05	V
Input Voltage Range		0		5	0		5	V

ELECTRICAL CHARACTERISTICS (cont.) Unless otherwise stated, these specifications apply for T_A = –55°C to +125°C for UC1856; – 40°C to +85°C for the UC2856; and 0°C to +70°C for the UC3856, VIN = 15V, RT = 10k, CT = 1nF, $T_A = T_J$.

PARAMETER	TEST CONDITIONS	UC1856/UC2856			UC3856			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Shutdown Terminal Section (cont.)								
Minimum Latching Current ($I_{CL\ SS}$)	(Note 5)	3	1.5		3	1.5		mA
Maximum Non-Latching Current ($I_{CL\ SS}$)	(Note 6)		1.5	0.8		1.5	0.8	mA
Delay to Outputs	$V_{SHUTDOWN}$ = 0 to 1.3V		65	110		65	110	ns
Output Section								
Collector-Emitter Voltage		40			40			V
Off-State Bias Current	VC = 40V			250			250	µA
Output Low Level	I_{OUT} = 20mA		0.1	0.5		0.1	0.5	V
	I_{OUT} = 200mA		0.5	2.6		0.5	2.6	V
Output High Level	I_{OUT} = –20mA	12.5	13.2		12.5	13.2		V
	I_{OUT} = –200mA	12	13.1		12	13.1		V
Rise Time	C1 = 1nF		40	80		40	80	ns
Fall Time	C1 = 1nF		40	80		40	80	ns
UVLO Low Saturation	VIN = 0V, I_{OUT} = 20mA		0.8	1.5		0.8	1.5	V
PWM Section								
Maximum Duty Cycle		45	47	50	45	47	50	%
Minimum Duty Cycle				0			0	%
Undervoltage Lockout Section								
Startup Threshold			7.7	8.0		7.7	8.0	V
Threshold Hysterisis			0.7			0.7		V
Total Standby Current								
Supply Current			18	23		18	23	mA

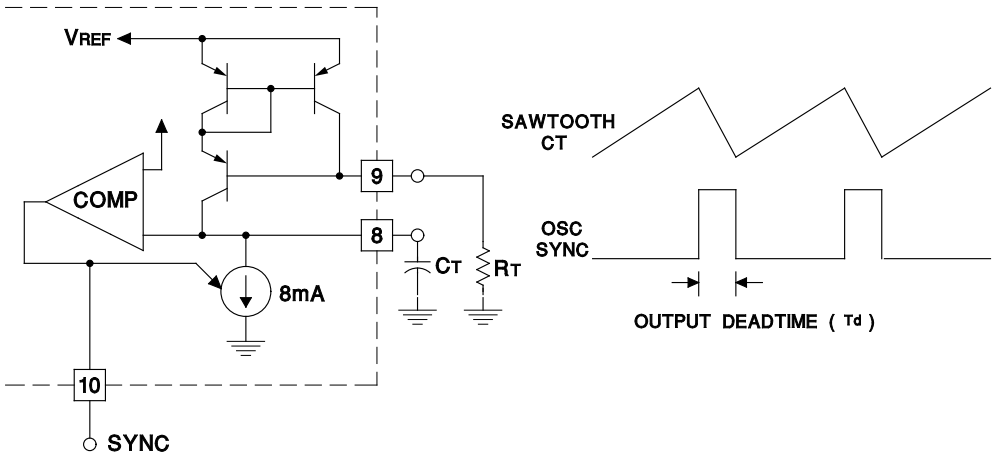
Note 1: All voltages are with respect to GND. Currents are positive into, negative out of the specified terminal.
Note 2: This parameter, although guaranteed over the recommended operating conditions is not 100% tested in production.
Note 3: Parameter measured at trip point of latch with $V_{EA}+ = VREF$, $V_{EA}- = 0V$.
Note 4: Amplifier gain defined as:

$$G = \frac{\Delta V_{COMP}}{\Delta V_{CS}+}; \qquad \Delta V_{CS}- = 0V \text{ to } 1.0V$$

Note 5: Current into CL SS guaranteed to latch circuit into shutdown state.
Note 6: Current into CL SS guaranteed not to latch circuit into shutdown state.

APPLICATIONS INFORMATION

Oscillator Circuit



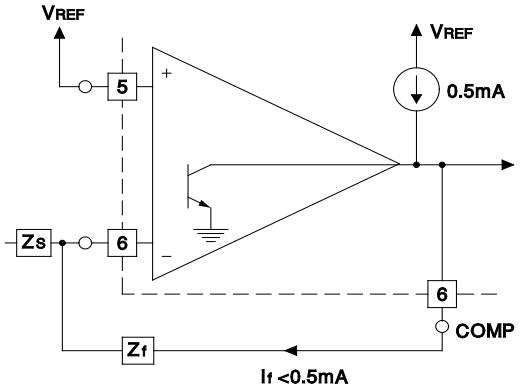
Output deadtime is determined by size of the external capacitor, C_T, according to the formula: $Td = \frac{2C_T}{8mA - \frac{3.6}{R_T}}$

For large values of R_T: $Td = 250C_T$

Oscillator frequency is approximated by the formula: $f_T = \frac{2}{R_T C_T}$

UDG-96177

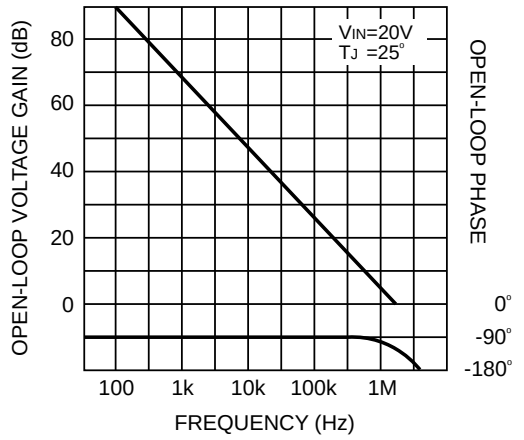
Error Amplifier Output Configuration



Error Amplifier can source up to 0.5mA.

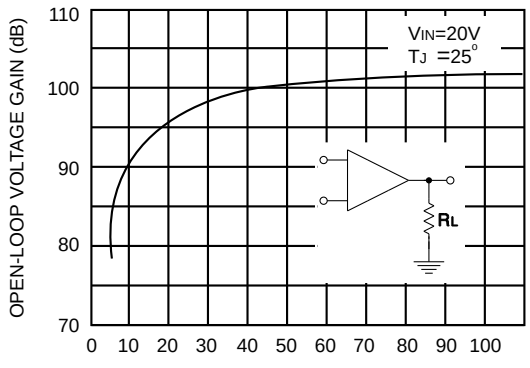
UDG-96178

Error Amplifier Gain and Phase vs Frequency



UDG-96179

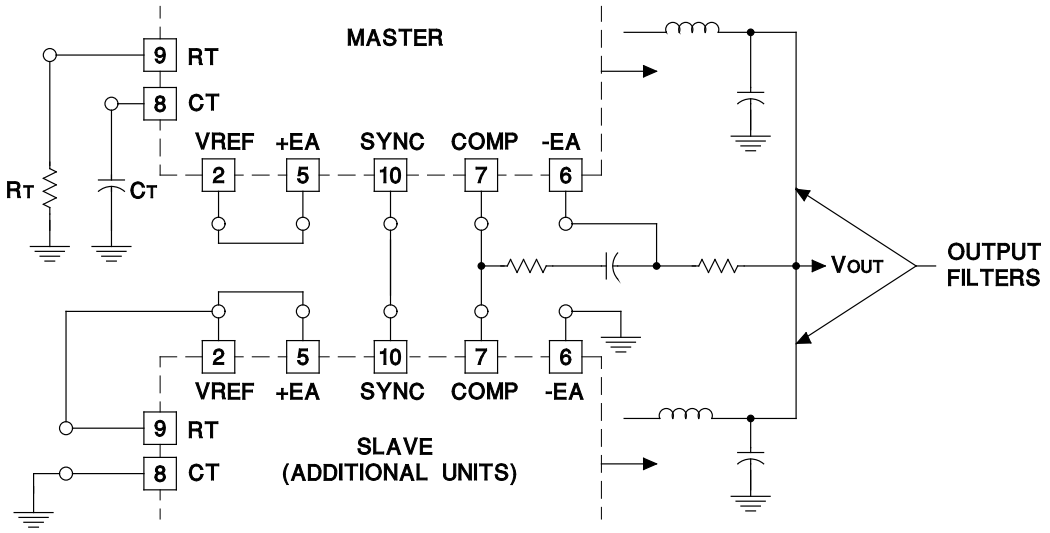
Error Amplifier Open-Loop D.C. Gain vs Load Resistance



UDG-96180

APPLICATIONS INFORMATION (cont.)

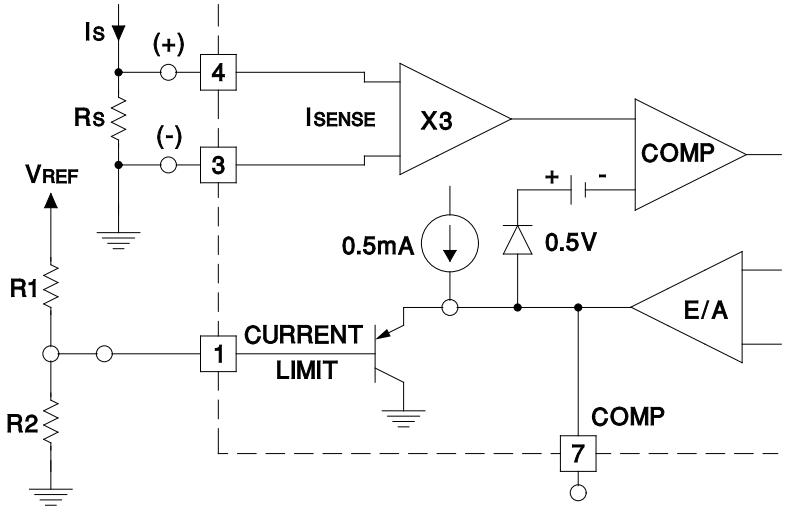
Parallel Operation



Slaving allows parallel operation of two or more units with equal current sharing.

UDG-96181

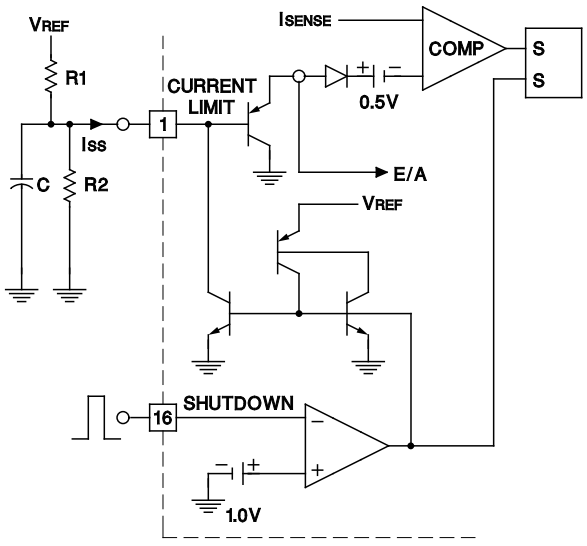
Pulse by Pulse Current Limiting



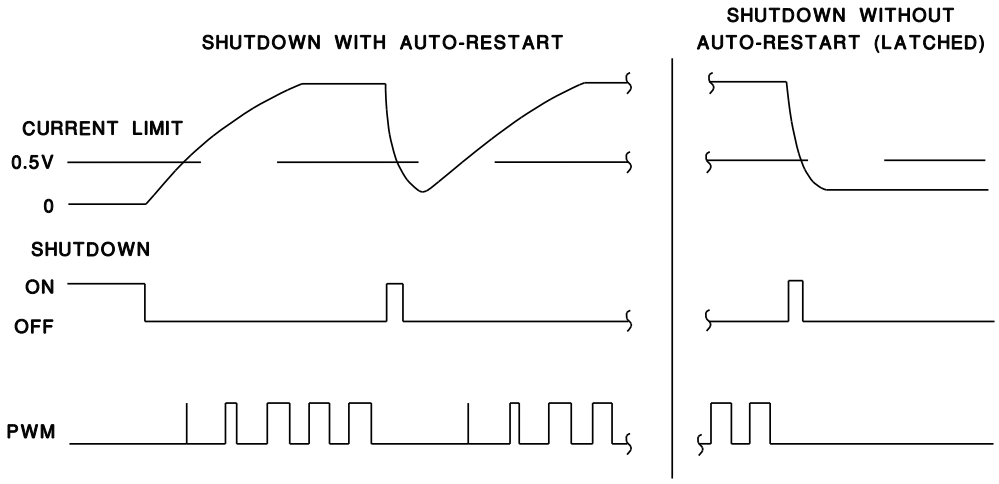
Peak current (I_S) is determined by the formula: $I_S = \dfrac{\left(\dfrac{R2\ V_{REF}}{R1 + R2}\right) - 0.5}{3R_S}$

UDG-96182

APPLICATIONS DATA (cont.)



UDG-96183

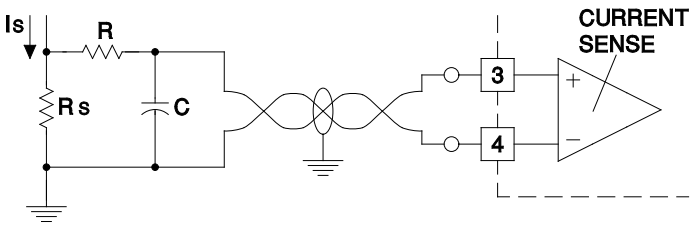


UDG-96184

If $\frac{V_{REF}}{R1} < 0.8mA$, the shutdown latch will commutate when $I_{SS} = 0.8mA$ and a restart cycle will be initiated.

If $\frac{V_{REF}}{R1} > 3mA$, the device will latch off until power is recycled.

Current Sense Amplifier Connections

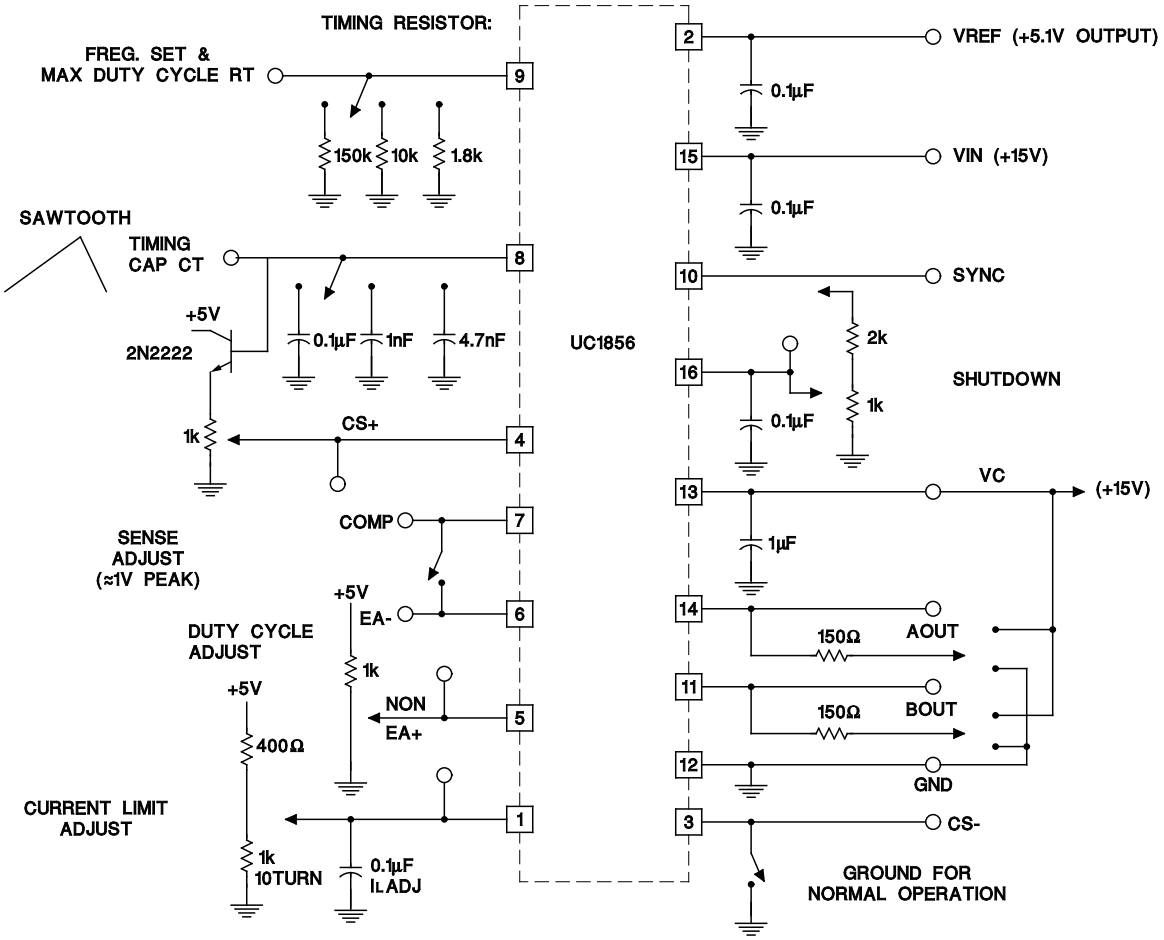


A small RC filter may be required in some applications to reduce switch transients. Differential input allows remote, noise sensing.

UDG-96185

APPLICATIONS INFORMATION (cont.)

UC1856 Open Loop Test Circuit



- BYPASS CAPS SHOULD BE LOW ESR & ESL TYPE
- SHORT E/A- & COMP FOR UNITY GAIN TESTING

THE USE OF A GROUND PLANE IS HIGHLY RECOMMENDED

UDG-96186

UNITRODE INTEGRATED CIRCUITS
7 CONTINENTAL BLVD. • MERRIMACK, NH 03054
TEL. 603-424-2410 • FAX 603-424-3460

PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
5962-9453001M2A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
5962-9453001MEA	ACTIVE	CDIP	J	16	1	TBD	A42 SNPB	N / A for Pkg Type
UC1856J	ACTIVE	CDIP	J	16	1	TBD	A42 SNPB	N / A for Pkg Type
UC1856J883B	ACTIVE	CDIP	J	16	1	TBD	A42 SNPB	N / A for Pkg Type
UC1856L	OBSOLETE	TO/SOT	L	28		TBD	Call TI	Call TI
UC1856L20	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
UC1856L20883B	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
UC1856L883B	OBSOLETE	TO/SOT	L	28		TBD	Call TI	Call TI
UC2856DW	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC2856DWG4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC2856DWTR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC2856DWTRG4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC2856J	ACTIVE	CDIP	J	16	1	TBD	A42 SNPB	N / A for Pkg Type
UC2856N	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
UC3856DW	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC3856DWG4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC3856DWTR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC3856DWTRG4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UC3856J	ACTIVE	CDIP	J	16	1	TBD	A42 SNPB	N / A for Pkg Type
UC3856N	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
UC3856NG4	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
UC3856Q	ACTIVE	PLCC	FN	20	46	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR
UC3856QG3	ACTIVE	PLCC	FN	20	46	Green (RoHS & no Sb/Br)	CU SN	Level-2-260C-1 YEAR

[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 - 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)

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

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
Low Power Wireless	www.ti.com/lpw	Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265