UNITRODE

UCC1839
UCC2839
UCC3839

Secondary Side Average Current Mode Controller

PRELIMINARY

FEATURES

- Practical Secondary Side Control of Isolated Power Supplies
- Provides a Self Regulating Bias Supply From a High Input Voltage Using an External N-Channel Depletion Mode FET
- Onboard Precision, Fixed Gain, Differential Current Sense Amplifier
- Wide Bandwidth Current Error Amplifier
- 5V Reference
- High Current, Programmable Gm Amplifier Optimized to Drive Opto-couplers

DESCRIPTION

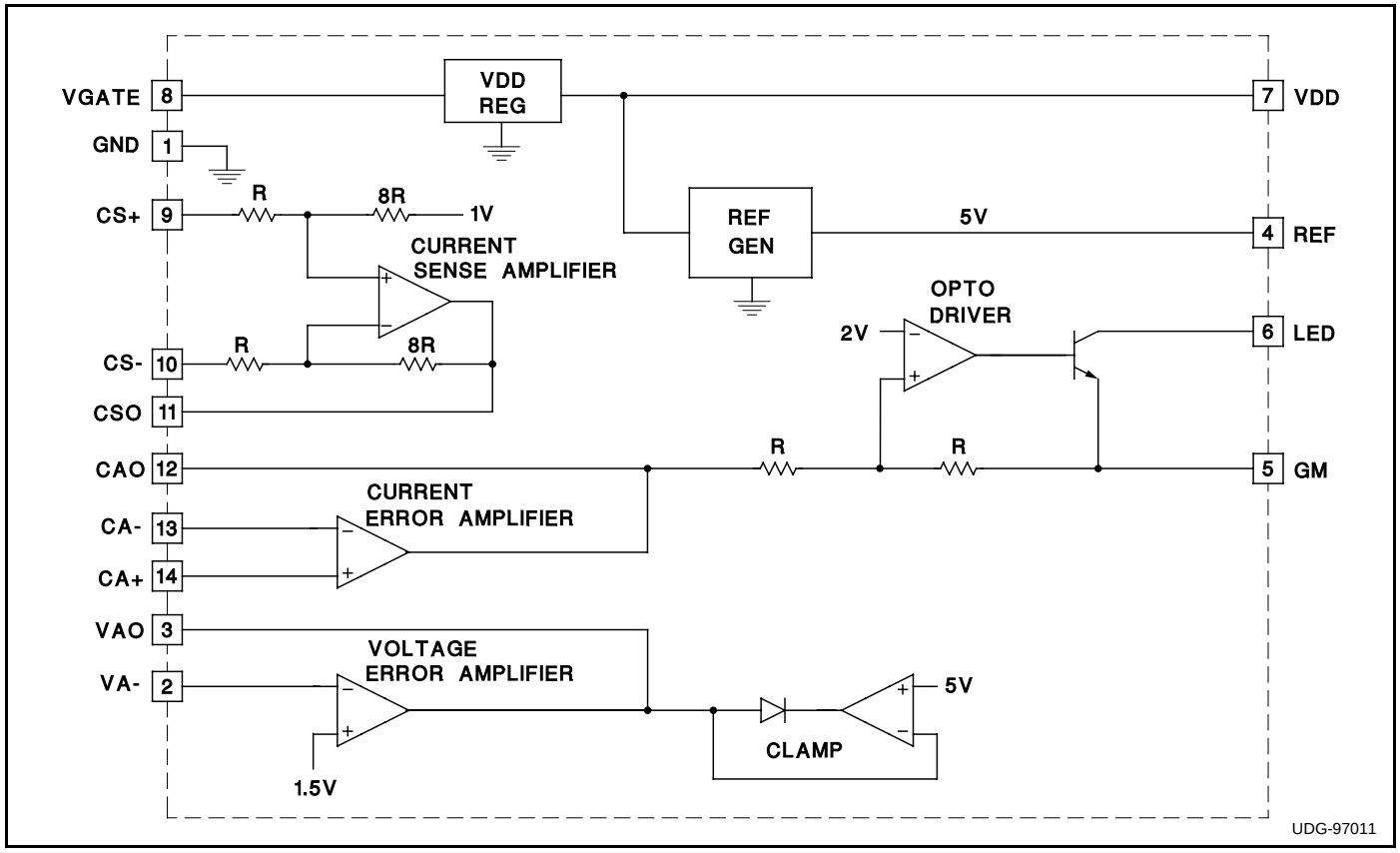
The UCC3839 provides the control functions for secondary side average current mode control in isolated power supplies. Start up, pulse width modulation and MOSFET drive must be accomplished independently on the primary side. Communication from secondary to primary side is anticipated through an opto-isolator.

Accordingly, the UCC3839 contains a fixed gain current sense amplifier, voltage and current error amplifiers, and a Gm type buffer/driver amplifier for the opto-isolator. Additional housekeeping functions include a precision 5V reference and a bias supply regulator.

Power for the UCC3839 can be generated by peak rectifying the voltage of the secondary winding of the isolation transformer. From this unregulated voltage, the UCC3839's bias supply regulator will generate its own 7.5V bias supply using an external, N-channel, depletion mode FET.

The UCC3839 can be configured for traditional average current mode control where the output of the voltage error amplifier commands the current error amplifier. It can also be configured for output voltage regulation with average current mode short circuit current limiting, employing two parallel control loops regulating the output voltage and output current independently.

BLOCK DIAGRAM



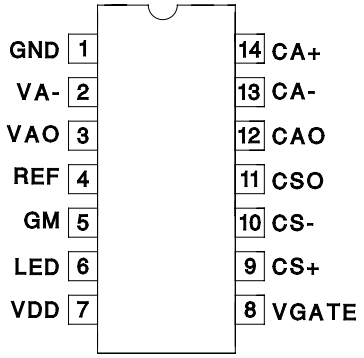
ABSOLUTE MAXIMUM RATINGS

Supply Voltage 15V
Supply Current
(LED not connected) 2mA
(LED connected) 14mA
Analog Inputs . . . . . –0.3V to 15V
Power Dissipation at T_A = 60°C
(LED not connected) 20mW
(LED connected) 55mW
Storage Temperature . . . . . –65°C to +150°C
Junction Temperature . . . . . –55°C to +150°C
Lead Temperature (Soldering, 10sec.) . . . . . +300°C

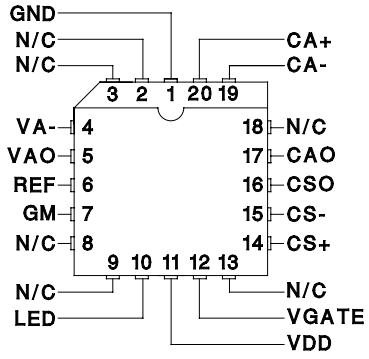
Currents are positive into, negative out of the specified terminal. Consult Packaging Section of Databook for thermal limitations and considerations of package.

CONNECTION DIAGRAM

DIL-14, SOIC-14 (Top View)
J or N Package, D Package



PLCC-20 (Top View)
Q Packages



ELECTRICAL CHARACTERISTICS: Unless otherwise specified, 0°C to 70°C for the UCC3839, –40°C to 85° for the UCC2839 and –55°C to 125°C for the UCC1839. V_{LINE} = 10V, RG = 400Ω. $T_A = T_J$.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Current Error Amplifier					
VIO				10	mV
AVOL		60			dB
CMRR	V_{CM} = 0.5V to 5.5V	60			dB
PSRR	V_{LINE} = 10V to 20V	60			dB
CAO High	CA– = 1V, CA+ = 1.1V, I_{CAO} = –100uA	4.8		7	V
I_{CAO}	CA– = 1V, CA+ = 1.1V, CAO = 0.5V	–500		–250	µA
CAO Low	CA– = 1V, CA+ = 0.9V, I_{CAO} = 500µA		0.2	0.4	V
GBW	F = 100kHz, T_A = 25°C	3	5		MHz
Voltage Error Amplifier					
VA–		1.475	1.5	1.525	V
AVOL		60			dB
PSRR	V_{LINE} = 10V to 20V	60			dB
VAO High	I_{VAO} = –100µA to 100µA	4.8	5	5.2	V
I_{VAO}	VA– = 1.45V, VAO = 0.5V	–500		–250	µA
VAO Low	VA– = 1.55V, VAO = 0.5V, I_{VAO} = 500µA		0.2	0.4	V
GBW	(Note 1)	3	5		MHz
Current Sense Amplifier					
CSO Zero	CS+ = CS– = –0.3V to 5.5V, I_{CSO} = –100µA to 100µA	0.95	1	1.05	V
AV	CS+ = 0, CS– = 0mV to –200mV	7.8	8	8.2	V/V

ELECTRICAL CHARACTERISTICS (cont.): Unless otherwise specified, 0°C to 70°C for the UCC3839, –40°C to 85° for the UCC2839 and –55°C to 125°C for the UCC1839. V_{LINE} = 10V, RG = 400Ω. $T_A = T_J$.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Current Sense Amplifier (cont.)					
Slew Rate	CS+ = 0, CS– = 0mV to –0.5V	2	4		V/µs
CSO	CS+ = –200mV, CS– = –700mV	4.8	5	5.2	V
LED Driver					
I_{LED}	LED = 5.5V, CA– = 1V, CA+ = 1.1V, RG = 400		0	10	µA
	LED = 5.5V, CA– = 1V, CA+ = 0.9V, RG = 400	9	10	11	mA
Gm	LED = 5.5V, CAO = 1V to 3V, RG = 400	2.25	2.5	2.75	mS
Slew Rate	CAO = 2V to 2.5V, LED = 400Ω to 5.5V, RG = 400	2	4		V/µs
Precision Reference					
REF	T_J = 25°C	4.95	5	5.05	V
	I_{REF} = 0mA to 1mA, V_{LINE} = 10V to 20V	4.925		5.075	V
VA+/REF		0.298	0.3	0.302	V/V
VDD Regulator					
VDD	IDD = 0mA to –15mA, V_{LINE} = 10V to 40V	7	7.5	8	V
I_{VDD}	V_{LINE} = 10V to 40V, CA– = 0V, CA+ = 1V, VA– = 2.9V, CS+ = CS– = 0, I_{REF} = 0		1.3	2	mA

Note 1: Guaranteed by design. Not 100% tested in production.

PIN DESCRIPTIONS

CA–: Current Error Amplifier Negative Input.

CAO: Current Error Amplifier Output. Output source current is limited, and output sink current is guaranteed to be greater than the VAO output source current. Current loop compensation components are generally connected to CAO and CA–.

CA+: Current Error Amplifier Positive Input.

CS–: Current Sense Amplifier Negative Input

CSO: Current Sense Amplifier Output. Internally set gain V_{OUT}/V_{IN} = 8 V_{IN} = 0V results in CSO = 1V.

CS+: Current Sense Amplifier Positive Input.

GM: Gm (transconductance) Programming Pin. Resistor R_{GM} = 400Ω to GND.

GND: Chip Ground.

LED: Output of LED Driver. Connect LED from VDD pin to LED.

REF: 5V Precision Reference Buffer Output. Minimum Decoupling Capacitance = 0.01µF

VA–: Voltage Error Amplifier Negative Input. Voltage Error Amplifier is internally referenced to 1.5V

VAO: Voltage Error Amplifier Output. In a two loop average current mode control configuration, VAO is connected to CA+ and is the current command signal. VAO is internally clamped not to exceed 5V for short circuit control. In a single loop voltage mode control configuration with a parallel average short circuit current control loop, VAO is connected directly to CAO. Output source current is limited, and output sink current is guaranteed to be greater than the CAO output source current.

VDD: 7.5V Regulator output. Supply for most of the chip. Minimum Decoupling Capacitance = 0.01µF

VGATE: External FET Gate Control Voltage.

APPLICATION INFORMATION

Figure 1 shows a typical secondary side average current mode controller configuration using the UCC3839. In this configuration, output voltage is sensed and regulated by the voltage error amplifier. Its output, VAO provides the reference for the current error amplifier at the CA+ pin. VAO can be connected to CA+ directly or through a resistive divider depending on the particular application requirements.

Average current mode control needs accurate output current information which is provided by a low value current sense resistor. The voltage proportional to the converter's output current is sensed and amplified by the precision current sense amplifier of the chip. The onboard current sense amplifier has a gain of 8 and is intended for differential sensing of the shunt voltage with a common mode voltage range from 0V up to 5V. The output of the current sense amplifier, CSO is 1V for zero input which guarantees that the circuit can control currents down to 0A.

APPLICATION INFORMATION (cont.)

The CSO signal is fed to the CA– input of the current error amplifier through a resistor. The current error amplifier takes the VAO and CSO signals and generates the error signal for the pulse width modulator.

Since the PWM function is located on the primary side of the power converter the CAO signal must be sent across the safety isolation boundary. The UCC3839 anticipates an opto-coupler to provide isolation between primary and secondary. Therefore, CAO drives a transconductance amplifier that controls LED current in an opto-isolator. During start up and when CAO exceeds 4V, the current in the LED drops to zero. Maximum LED current is obtained during normal operation as CAO reaches its lowest potential. Its value is determined by the programming resistor value from the GM pin to circuit GND.

An alternative secondary side controller configuration is introduced in Figure 2. In this circuit, the voltage and current control loops of the UCC3839 are connected parallel. It can be achieved by connecting the VAO and CAO pins together. The error amplifier with the lower output voltage controls the current in the opto-coupler providing the feedback signal for the PWM section on the primary side. Voltage regulation is still maintained by the voltage error amplifier until a user programmable output current is reached. At this time CAO will take control over the Gm amplifier and the output current of the converter will be regulated while the output voltage falls below its nominal value. This current level is set at the CA+ input by a resistive divider from the 5V reference of the chip.

Since the chip is powered from a peak rectifier which maintains the bias supply for the UCC3839 even under short circuit conditions, both of these techniques can be used to eliminate the short circuit runaway problem in isolated power supplies using peak current mode control on the primary side.

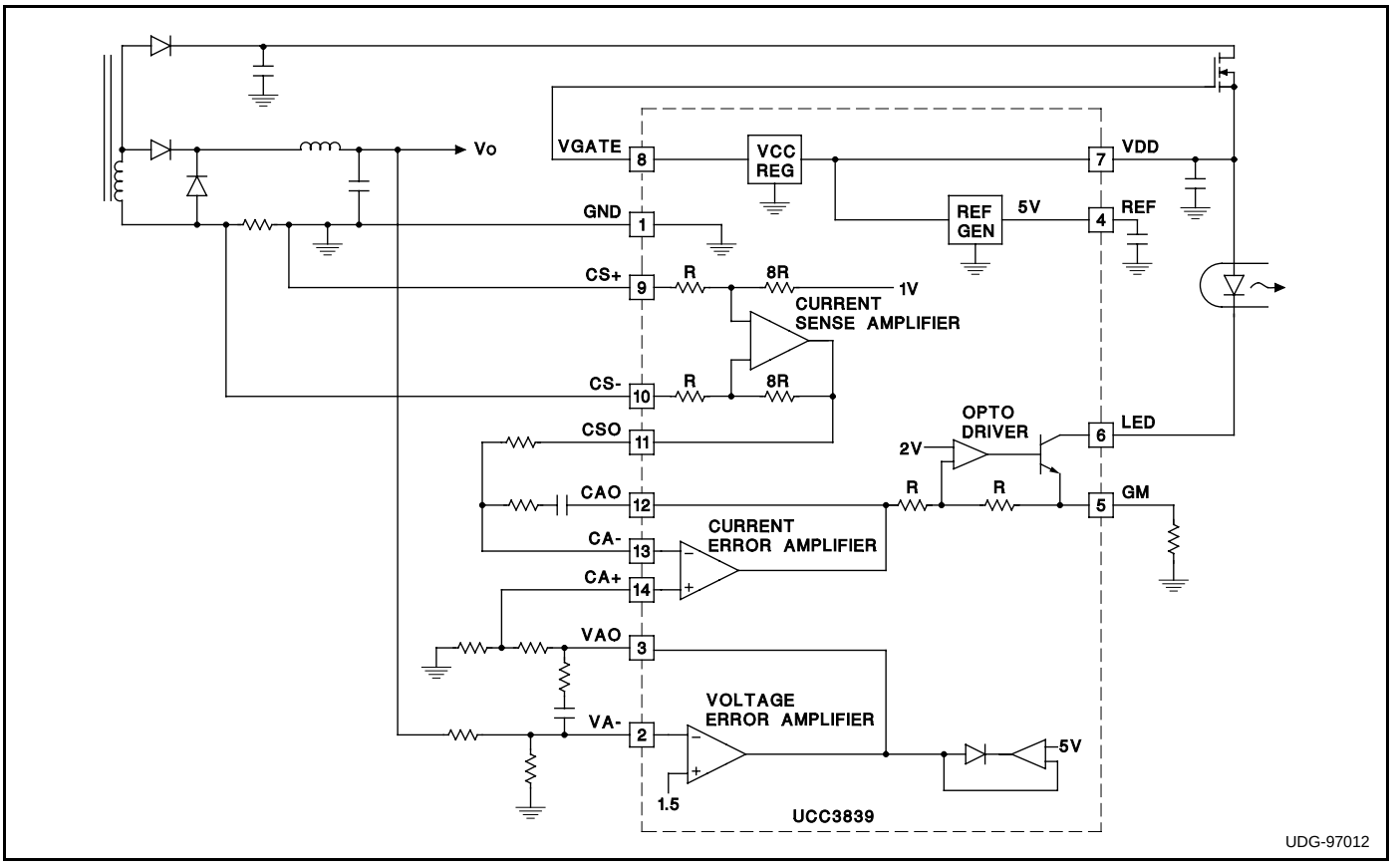


Figure 1. Secondary Side Average Current Mode Controller

APPLICATION INFORMATION (cont.)

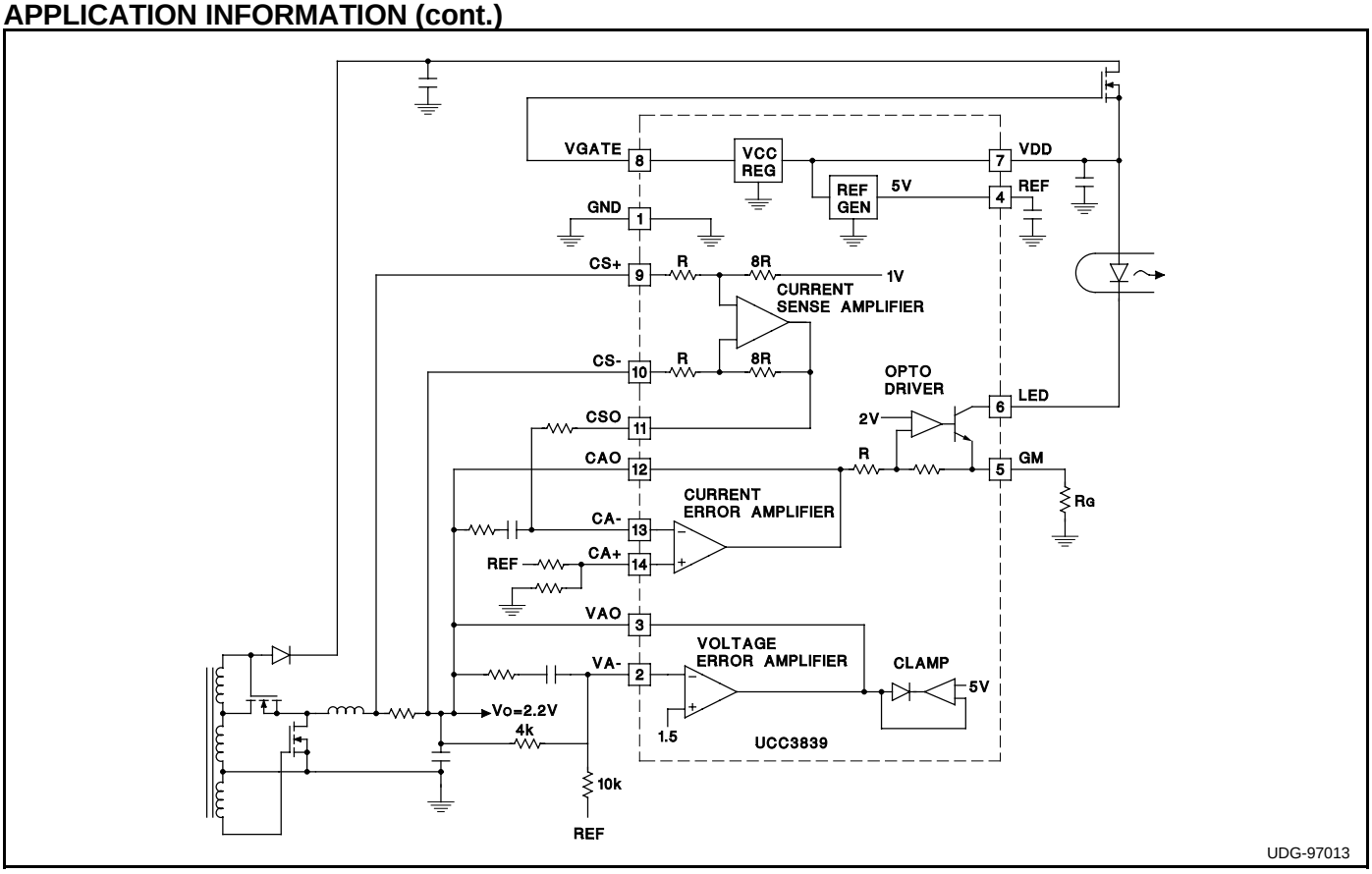


Figure 2. Voltage Mode with Average Current Short Circuit Limit

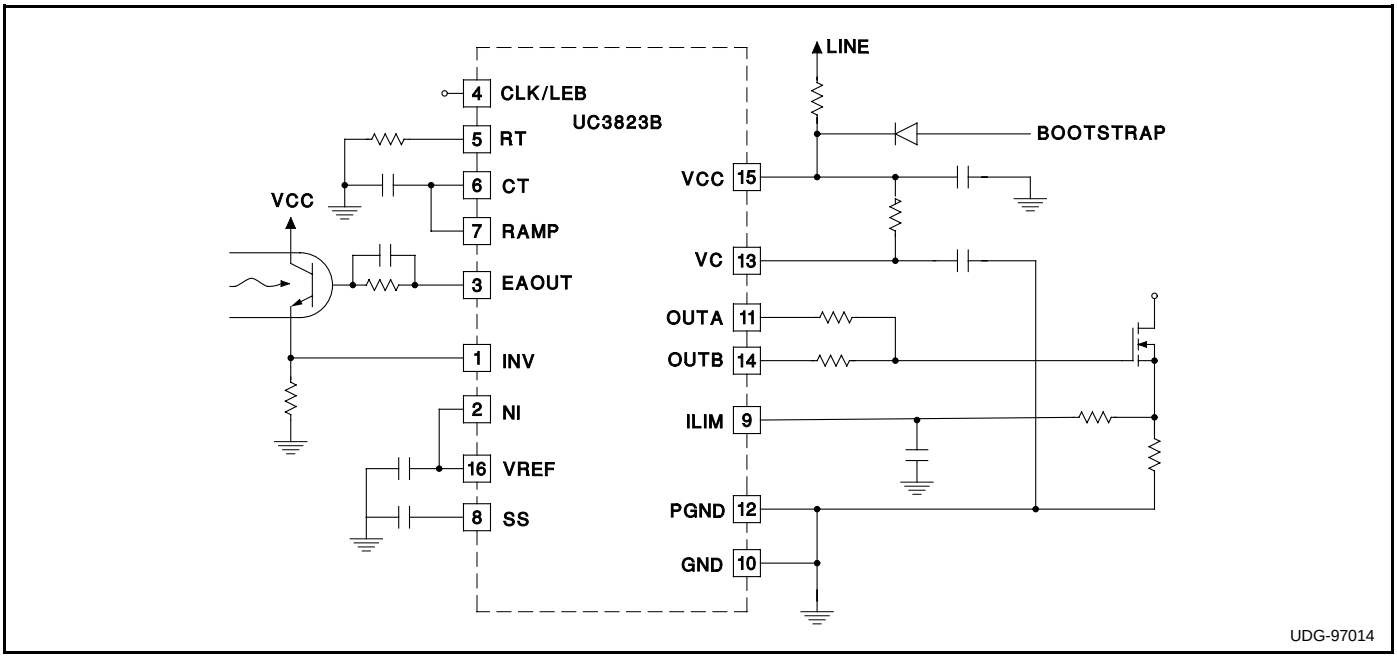


Figure 3. Typical Primary Side Circuit For Use With Secondary Side Average Current Mode Controller

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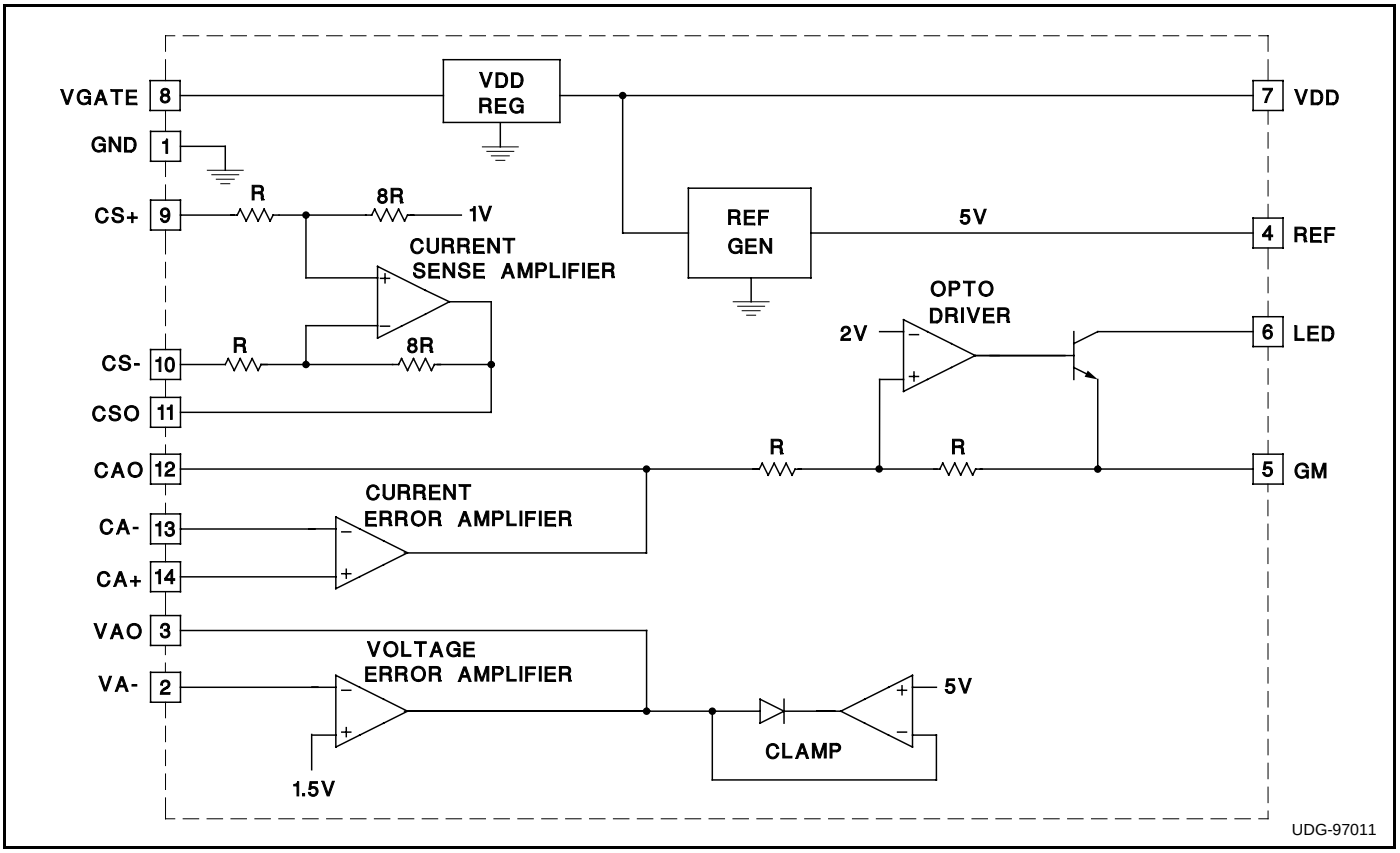

ABSOLUTE MAXIMUM RATINGS

Supply Voltage 15V
Supply Current
(LED not connected) 2mA
(LED connected) 14mA
Analog Inputs . . . . . –0.3V to 15V
Power Dissipation at T_A = 60°C
(LED not connected) 20mW
(LED connected) 55mW
Storage Temperature . . . . . –65°C to +150°C
Junction Temperature . . . . . –55°C to +150°C
Lead Temperature (Soldering, 10sec.) . . . . . +300°C

Currents are positive into, negative out of the specified terminal. Consult Packaging Section of Databook for thermal limitations and considerations of package.

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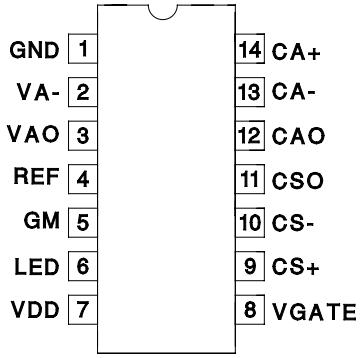
J or N Package, D Package



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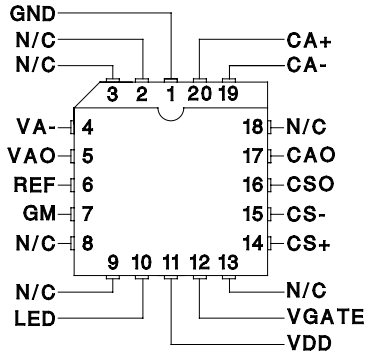

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PSRR	V_{LINE} = 10V to 20V	60			dB
CAO High	CA– = 1V, CA+ = 1.1V, I_{CAO} = –100uA	4.8		7	V
I_{CAO}	CA– = 1V, CA+ = 1.1V, CAO = 0.5V	–500		–250	µA
CAO Low	CA– = 1V, CA+ = 0.9V, I_{CAO} = 500µA		0.2	0.4	V
GBW	F = 100kHz, T_A = 25°C	3	5		MHz
Voltage Error Amplifier					
VA–		1.475	1.5	1.525	V
AVOL		60			dB
PSRR	V_{LINE} = 10V to 20V	60			dB
VAO High	I_{VAO} = –100µA to 100µA	4.8	5	5.2	V
I_{VAO}	VA– = 1.45V, VAO = 0.5V	–500		–250	µA
VAO Low	VA– = 1.55V, VAO = 0.5V, I_{VAO} = 500µA		0.2	0.4	V
GBW	(Note 1)	3	5		MHz
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CSO Zero	CS+ = CS– = –0.3V to 5.5V, I_{CSO} = –100µA to 100µA	0.95	1	1.05	V
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LED Driver					
I_{LED}	LED = 5.5V, CA– = 1V, CA+ = 1.1V, RG = 400		0	10	µA
	LED = 5.5V, CA– = 1V, CA+ = 0.9V, RG = 400	9	10	11	mA
Gm	LED = 5.5V, CAO = 1V to 3V, RG = 400	2.25	2.5	2.75	mS
Slew Rate	CAO = 2V to 2.5V, LED = 400Ω to 5.5V, RG = 400	2	4		V/µs
Precision Reference					
REF	T_J = 25°C	4.95	5	5.05	V
	I_{REF} = 0mA to 1mA, V_{LINE} = 10V to 20V	4.925		5.075	V
VA+/REF		0.298	0.3	0.302	V/V
VDD Regulator					
VDD	IDD = 0mA to –15mA, V_{LINE} = 10V to 40V	7	7.5	8	V
I_{VDD}	V_{LINE} = 10V to 40V, CA– = 0V, CA+ = 1V, VA– = 2.9V, CS+ = CS– = 0, I_{REF} = 0		1.3	2	mA

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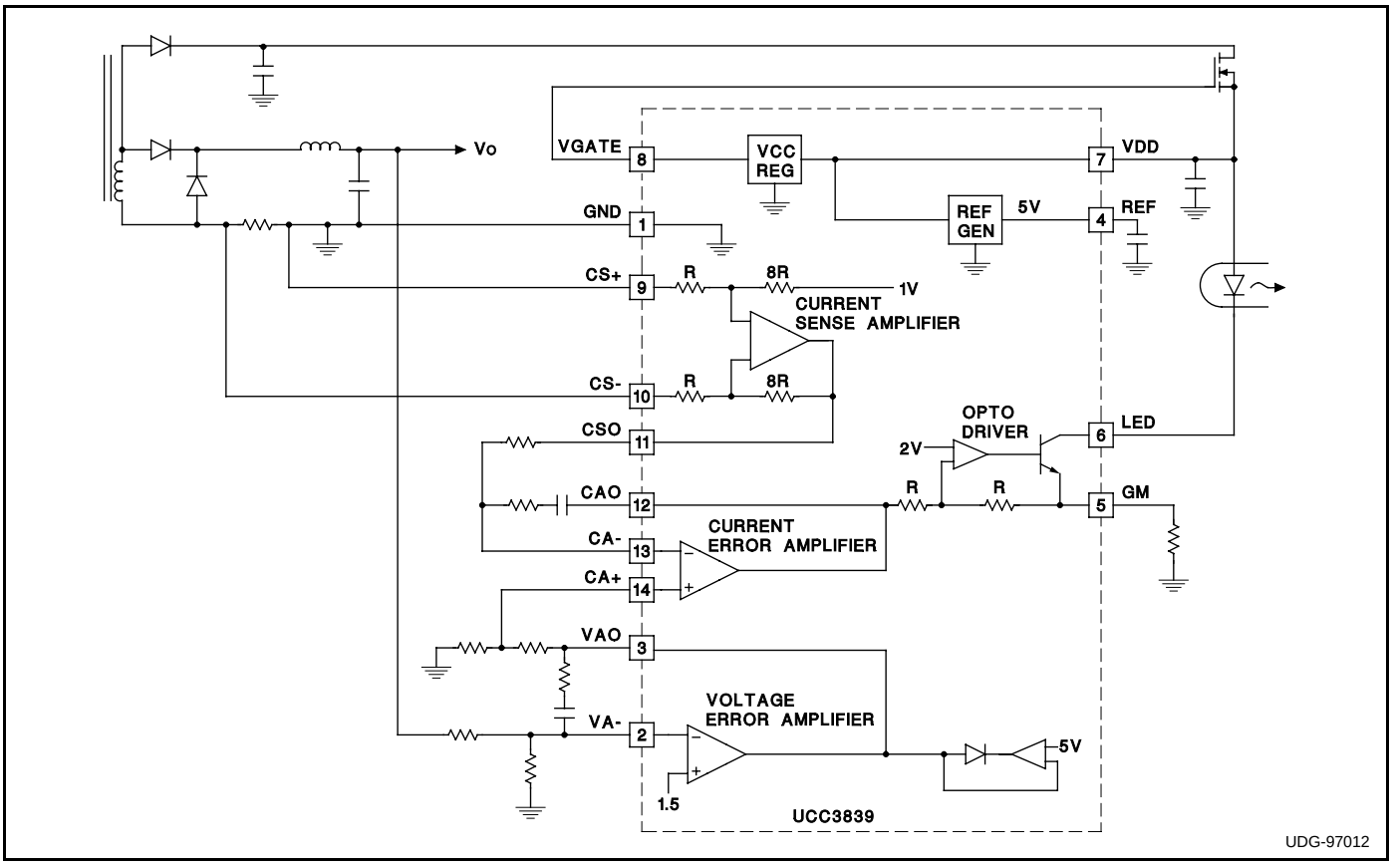

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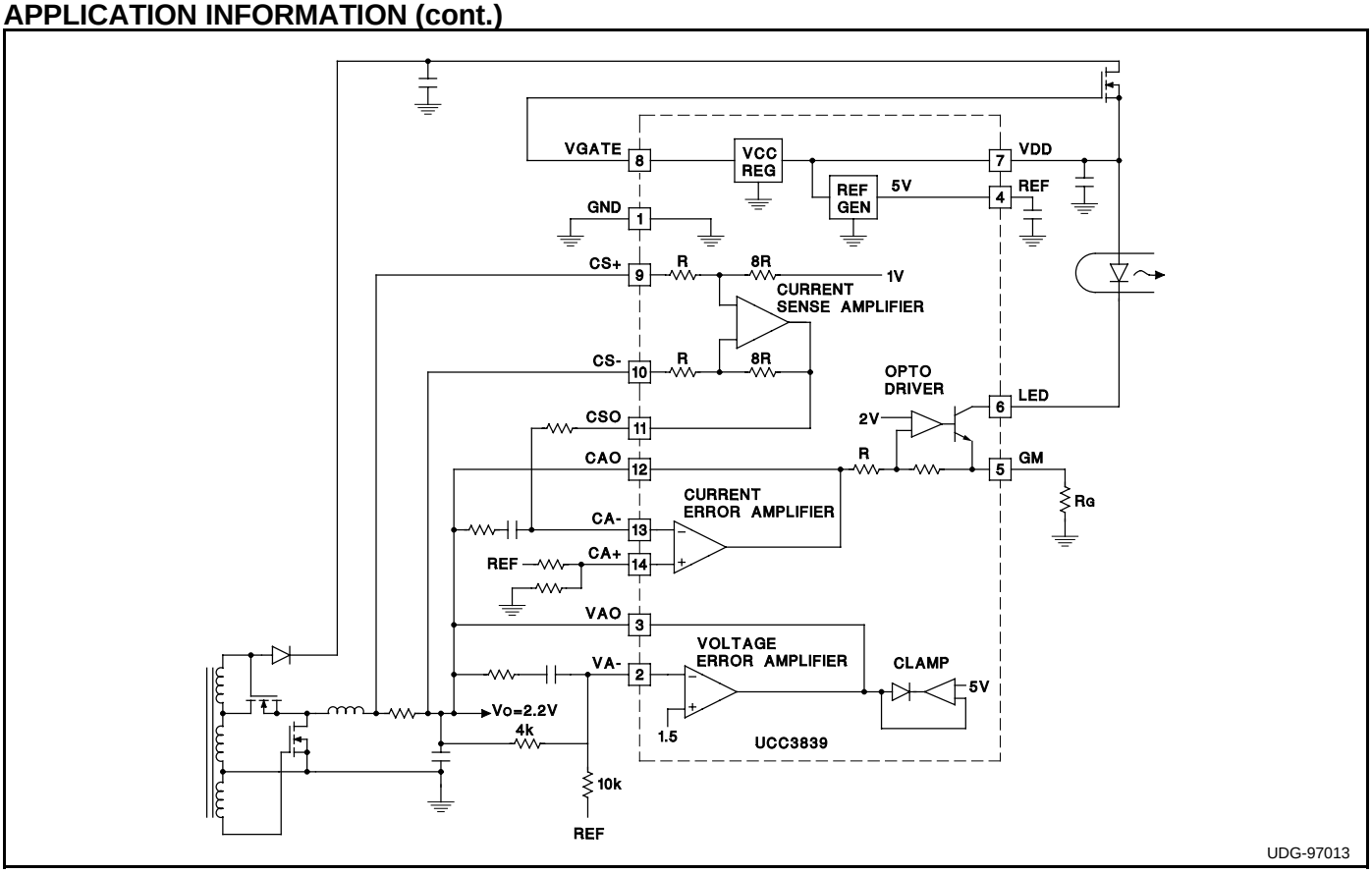
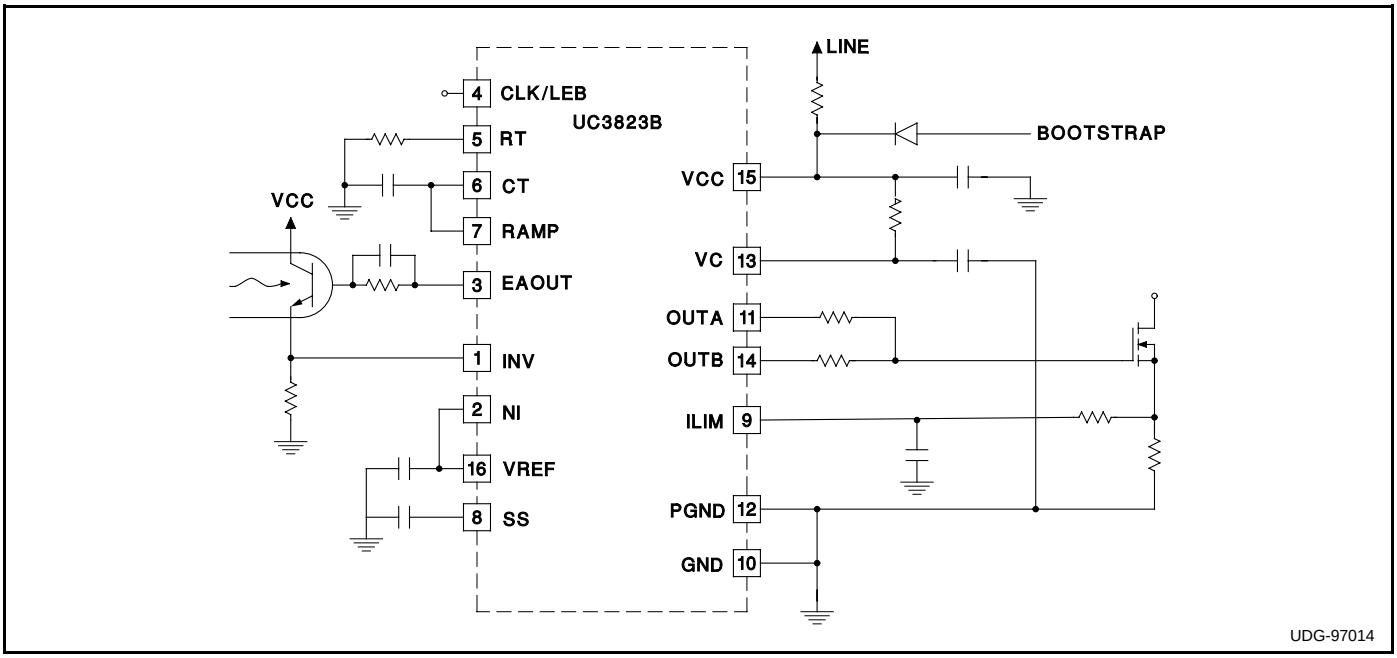


Figure 2. Voltage Mode with Average Current Short Circuit Limit



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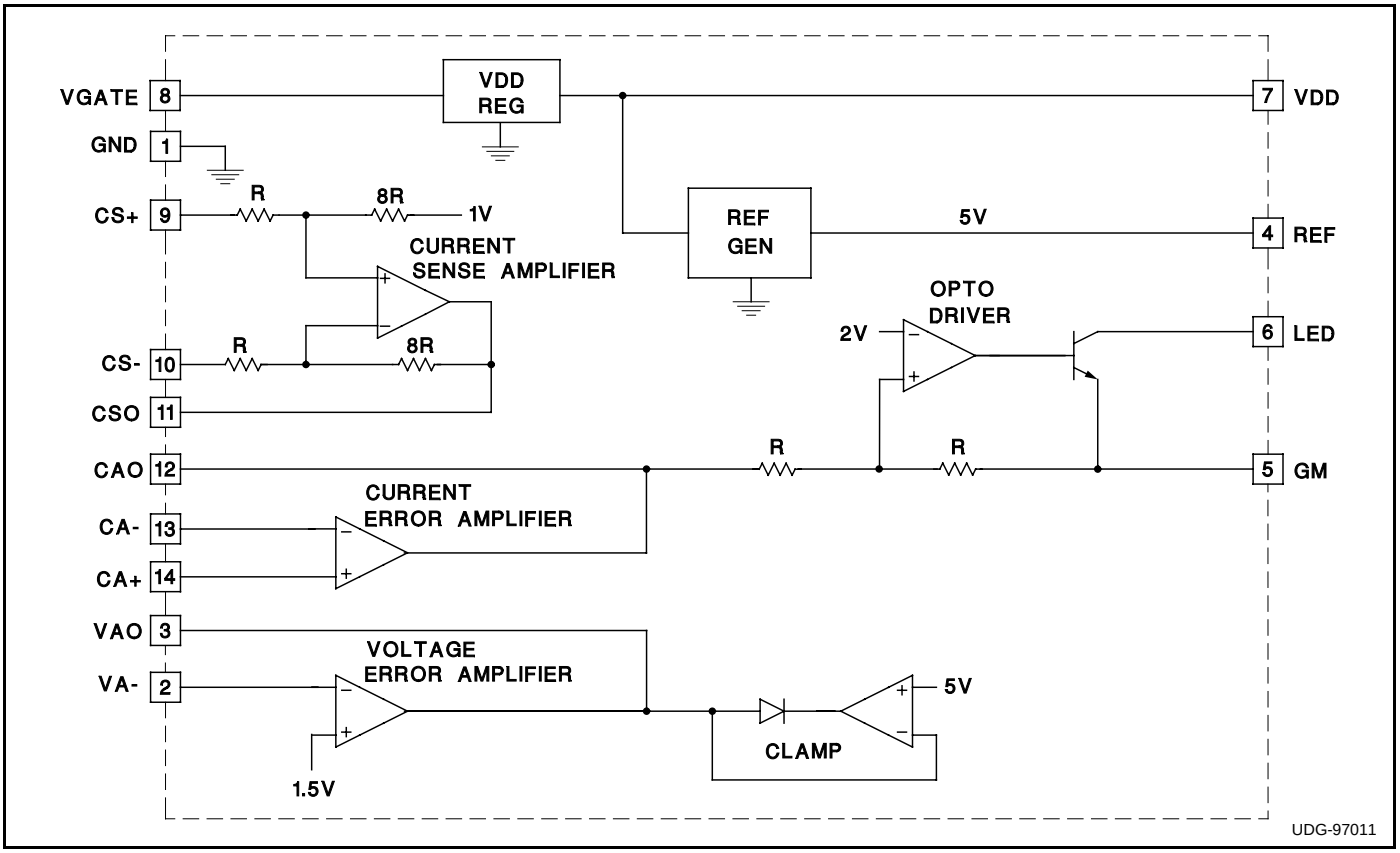

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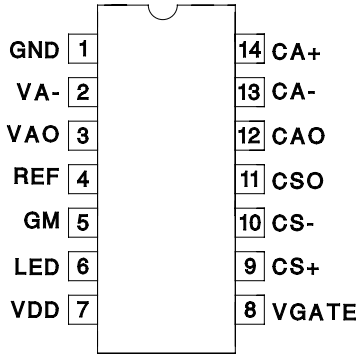
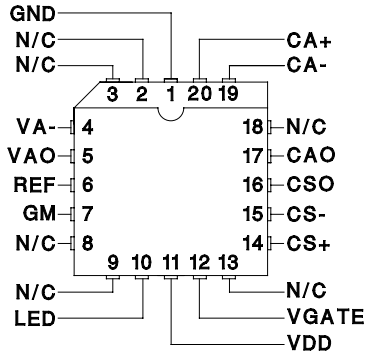


PLCC-20 (Top View)
Q Packages



ELECTRICAL CHARACTERISTICS: Unless otherwise specified, 0°C to 70°C for the UCC3839, –40°C to 85° for the UCC2839 and –55°C to 125°C for the UCC1839. V_{LINE} = 10V, RG = 400Ω. $T_A = T_J$.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Current Error Amplifier					
VIO				10	mV
AVOL		60			dB
CMRR	V_{CM} = 0.5V to 5.5V	60			dB
PSRR	V_{LINE} = 10V to 20V	60			dB
CAO High	CA– = 1V, CA+ = 1.1V, I_{CAO} = –100uA	4.8		7	V
I_{CAO}	CA– = 1V, CA+ = 1.1V, CAO = 0.5V	–500		–250	µA
CAO Low	CA– = 1V, CA+ = 0.9V, I_{CAO} = 500µA		0.2	0.4	V
GBW	F = 100kHz, T_A = 25°C	3	5		MHz
Voltage Error Amplifier					
VA–		1.475	1.5	1.525	V
AVOL		60			dB
PSRR	V_{LINE} = 10V to 20V	60			dB
VAO High	I_{VAO} = –100µA to 100µA	4.8	5	5.2	V
I_{VAO}	VA– = 1.45V, VAO = 0.5V	–500		–250	µA
VAO Low	VA– = 1.55V, VAO = 0.5V, I_{VAO} = 500µA		0.2	0.4	V
GBW	(Note 1)	3	5		MHz
Current Sense Amplifier					
CSO Zero	CS+ = CS– = –0.3V to 5.5V, I_{CSO} = –100µA to 100µA	0.95	1	1.05	V
AV	CS+ = 0, CS– = 0mV to –200mV	7.8	8	8.2	V/V

ELECTRICAL CHARACTERISTICS (cont.): Unless otherwise specified, 0°C to 70°C for the UCC3839, –40°C to 85° for the UCC2839 and –55°C to 125°C for the UCC1839. V_{LINE} = 10V, RG = 400Ω. $T_A = T_J$.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Current Sense Amplifier (cont.)					
Slew Rate	CS+ = 0, CS– = 0mV to –0.5V	2	4		V/µs
CSO	CS+ = –200mV, CS– = –700mV	4.8	5	5.2	V
LED Driver					
I_{LED}	LED = 5.5V, CA– = 1V, CA+ = 1.1V, RG = 400		0	10	µA
	LED = 5.5V, CA– = 1V, CA+ = 0.9V, RG = 400	9	10	11	mA
Gm	LED = 5.5V, CAO = 1V to 3V, RG = 400	2.25	2.5	2.75	mS
Slew Rate	CAO = 2V to 2.5V, LED = 400Ω to 5.5V, RG = 400	2	4		V/µs
Precision Reference					
REF	T_J = 25°C	4.95	5	5.05	V
	I_{REF} = 0mA to 1mA, V_{LINE} = 10V to 20V	4.925		5.075	V
VA+/REF		0.298	0.3	0.302	V/V
VDD Regulator					
VDD	IDD = 0mA to –15mA, V_{LINE} = 10V to 40V	7	7.5	8	V
I_{VDD}	V_{LINE} = 10V to 40V, CA– = 0V, CA+ = 1V, VA– = 2.9V, CS+ = CS– = 0, I_{REF} = 0		1.3	2	mA

Note 1: Guaranteed by design. Not 100% tested in production.

PIN DESCRIPTIONS

CA–: Current Error Amplifier Negative Input.

CAO: Current Error Amplifier Output. Output source current is limited, and output sink current is guaranteed to be greater than the VAO output source current. Current loop compensation components are generally connected to CAO and CA–.

CA+: Current Error Amplifier Positive Input.

CS–: Current Sense Amplifier Negative Input

CSO: Current Sense Amplifier Output. Internally set gain V_{OUT}/V_{IN} = 8 V_{IN} = 0V results in CSO = 1V.

CS+: Current Sense Amplifier Positive Input.

GM: Gm (transconductance) Programming Pin. Resistor R_{GM} = 400Ω to GND.

GND: Chip Ground.

LED: Output of LED Driver. Connect LED from VDD pin to LED.

REF: 5V Precision Reference Buffer Output. Minimum Decoupling Capacitance = 0.01µF

VA–: Voltage Error Amplifier Negative Input. Voltage Error Amplifier is internally referenced to 1.5V

VAO: Voltage Error Amplifier Output. In a two loop average current mode control configuration, VAO is connected to CA+ and is the current command signal. VAO is internally clamped not to exceed 5V for short circuit control. In a single loop voltage mode control configuration with a parallel average short circuit current control loop, VAO is connected directly to CAO. Output source current is limited, and output sink current is guaranteed to be greater than the CAO output source current.

VDD: 7.5V Regulator output. Supply for most of the chip. Minimum Decoupling Capacitance = 0.01µF

VGATE: External FET Gate Control Voltage.

APPLICATION INFORMATION

Figure 1 shows a typical secondary side average current mode controller configuration using the UCC3839. In this configuration, output voltage is sensed and regulated by the voltage error amplifier. Its output, VAO provides the reference for the current error amplifier at the CA+ pin. VAO can be connected to CA+ directly or through a resistive divider depending on the particular application requirements.

Average current mode control needs accurate output current information which is provided by a low value current sense resistor. The voltage proportional to the converter's output current is sensed and amplified by the precision current sense amplifier of the chip. The onboard current sense amplifier has a gain of 8 and is intended for differential sensing of the shunt voltage with a common mode voltage range from 0V up to 5V. The output of the current sense amplifier, CSO is 1V for zero input which guarantees that the circuit can control currents down to 0A.

APPLICATION INFORMATION (cont.)

The CSO signal is fed to the CA– input of the current error amplifier through a resistor. The current error amplifier takes the VAO and CSO signals and generates the error signal for the pulse width modulator.

Since the PWM function is located on the primary side of the power converter the CAO signal must be sent across the safety isolation boundary. The UCC3839 anticipates an opto-coupler to provide isolation between primary and secondary. Therefore, CAO drives a transconductance amplifier that controls LED current in an opto-isolator. During start up and when CAO exceeds 4V, the current in the LED drops to zero. Maximum LED current is obtained during normal operation as CAO reaches its lowest potential. Its value is determined by the programming resistor value from the GM pin to circuit GND.

An alternative secondary side controller configuration is introduced in Figure 2. In this circuit, the voltage and current control loops of the UCC3839 are connected parallel. It can be achieved by connecting the VAO and CAO pins together. The error amplifier with the lower output voltage controls the current in the opto-coupler providing the feedback signal for the PWM section on the primary side. Voltage regulation is still maintained by the voltage error amplifier until a user programmable output current is reached. At this time CAO will take control over the Gm amplifier and the output current of the converter will be regulated while the output voltage falls below its nominal value. This current level is set at the CA+ input by a resistive divider from the 5V reference of the chip.

Since the chip is powered from a peak rectifier which maintains the bias supply for the UCC3839 even under short circuit conditions, both of these techniques can be used to eliminate the short circuit runaway problem in isolated power supplies using peak current mode control on the primary side.

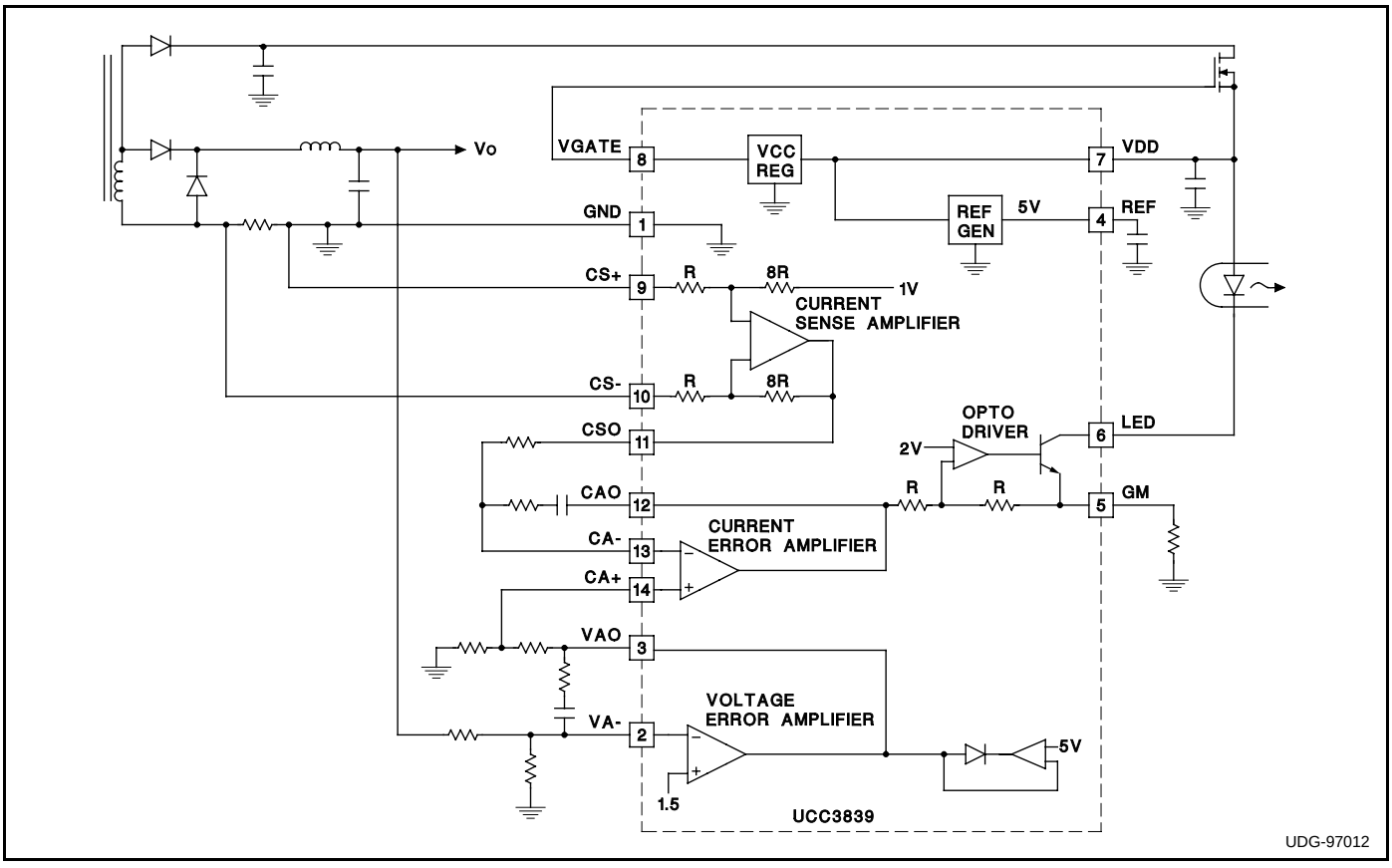


Figure 1. Secondary Side Average Current Mode Controller

APPLICATION INFORMATION (cont.)

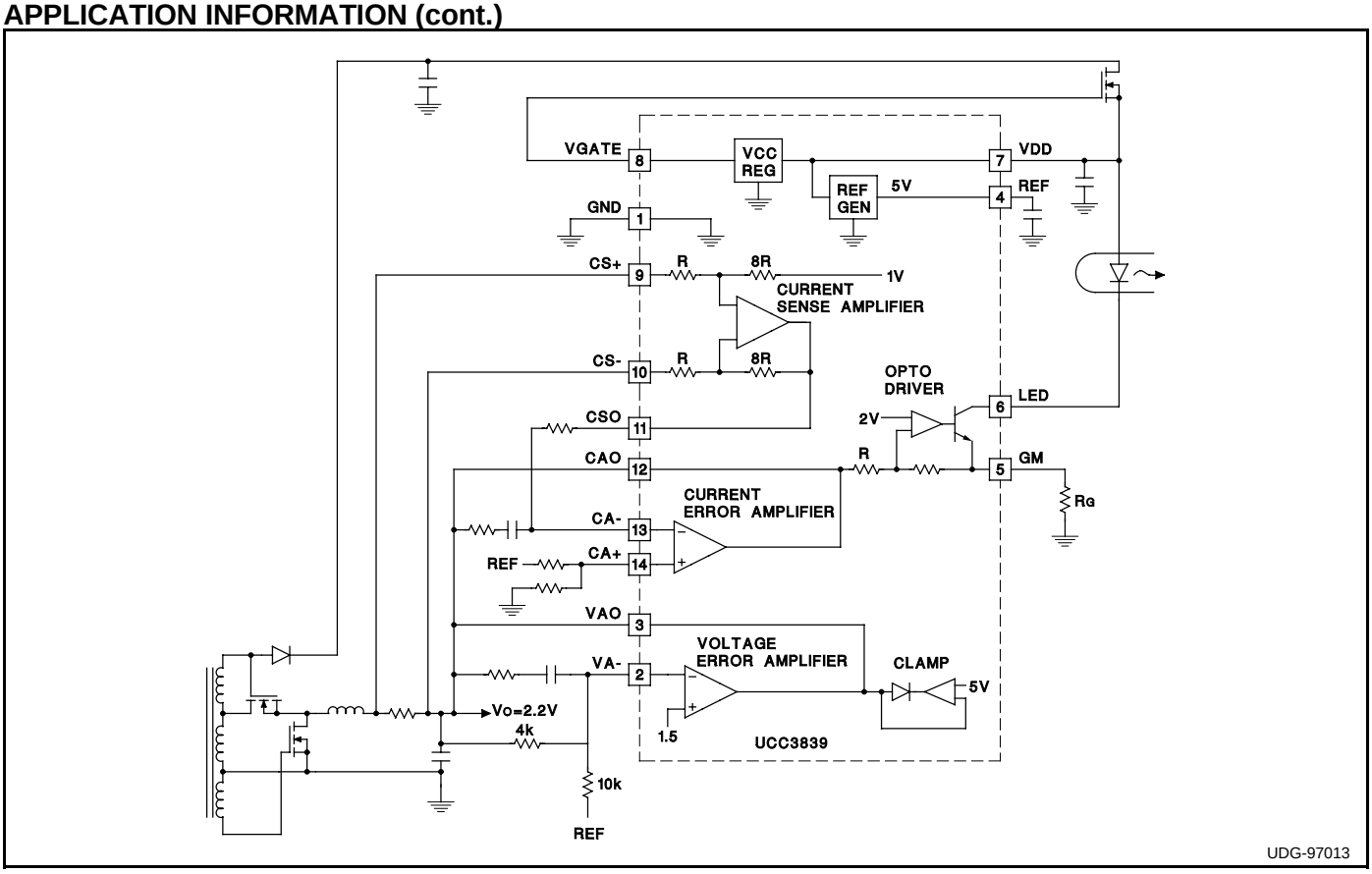


Figure 2. Voltage Mode with Average Current Short Circuit Limit

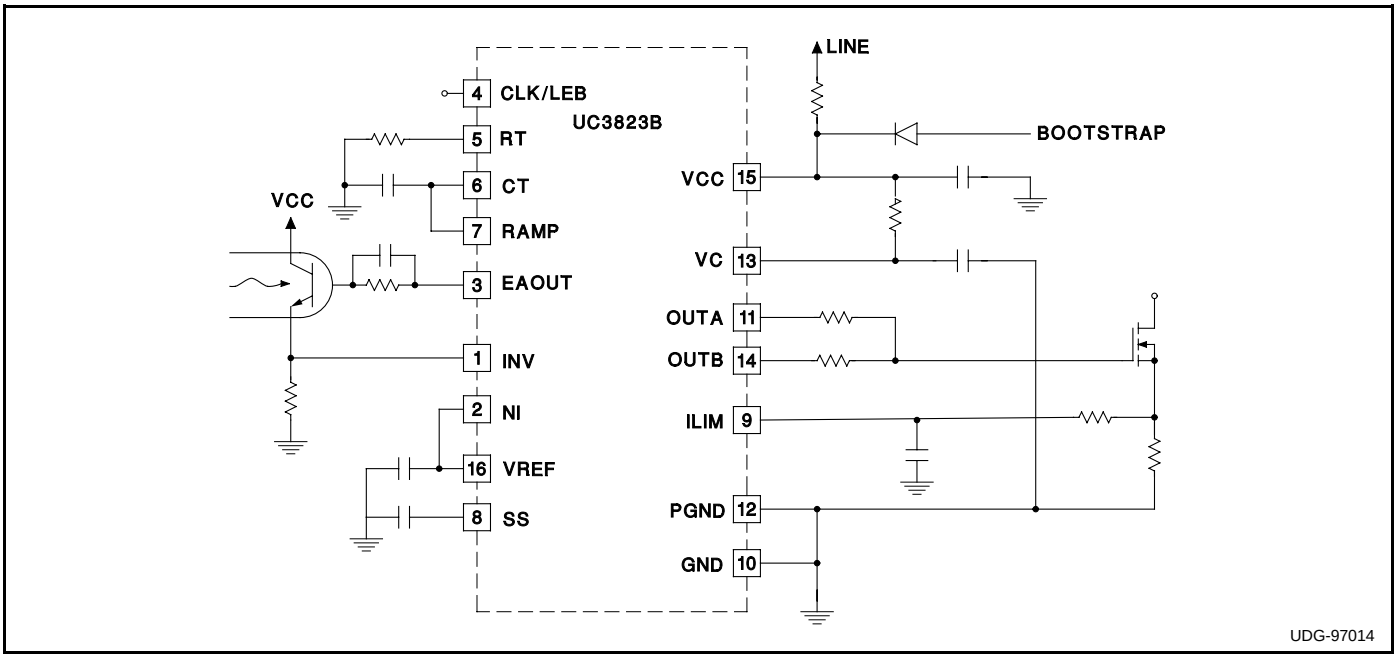


Figure 3. Typical Primary Side Circuit For Use With Secondary Side Average Current Mode Controller

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