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AS3834

4 channel high-precision LED controller for 3D-LCD backlight with integrated step-up controller

1 General Description

The AS3834 is a 4 channel high precision LED controller with PWM inputs for driving external bipolar transistors in LCD-backlight panels, optimized for 2D and 3D operation.

The integrated step-up controller provides the necessary output voltage for the LED string supply.

The SMPS feedback control optimizes the power efficiency by adjusting the LED string supply voltage.

Build in safety features include under-voltage and thermal shutdown as well as open and short LED detection.

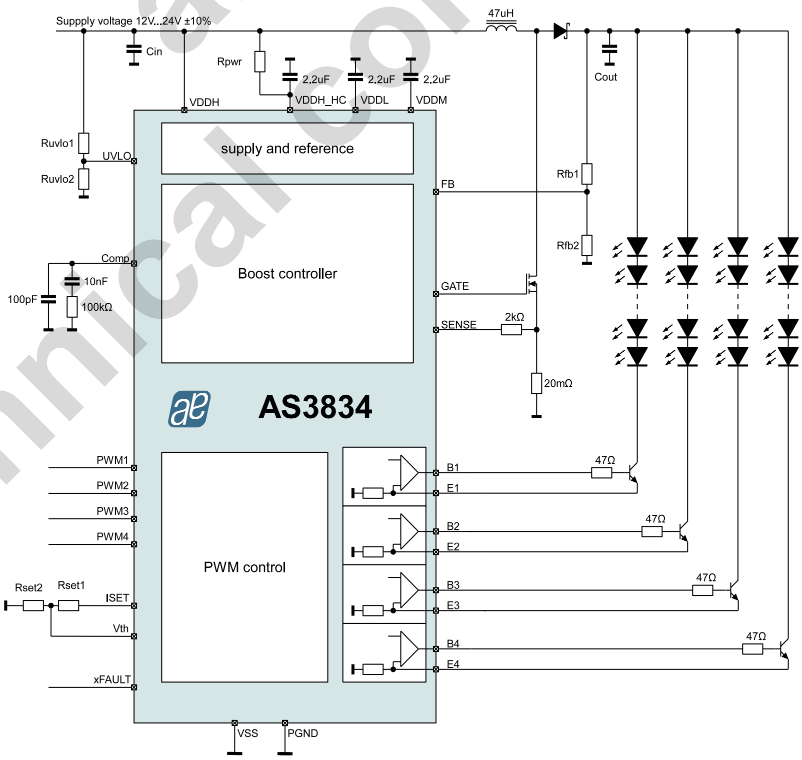
2 Key Features

- 4 channel LED controller
- Step-up controller optimized for 2D/3D mode
- Supply voltage range: 12V to 50V
- Output current up to 270mA per channel
- Absolute current accuracy +/- 0.8%
- Channel to channel accuracy+/- 0.6%
- 4 separated PWM inputs
- Open LED detection and disconnect
- Short LED protection and auto-turnoff
- Undervoltage shutdown
- Temperature shutdown
- Temperature supervision of external BJT
- BJT Beta compensation
- SMPS feedback control
- DCDC Softstart Function
- Over Voltage Protection (OVP)
- Package SOIC-28, TQPF-32
- Package

3 Applications

LED backlighting for 3D-LCD backlight TV sets and monitors

Figure 1. AS3834



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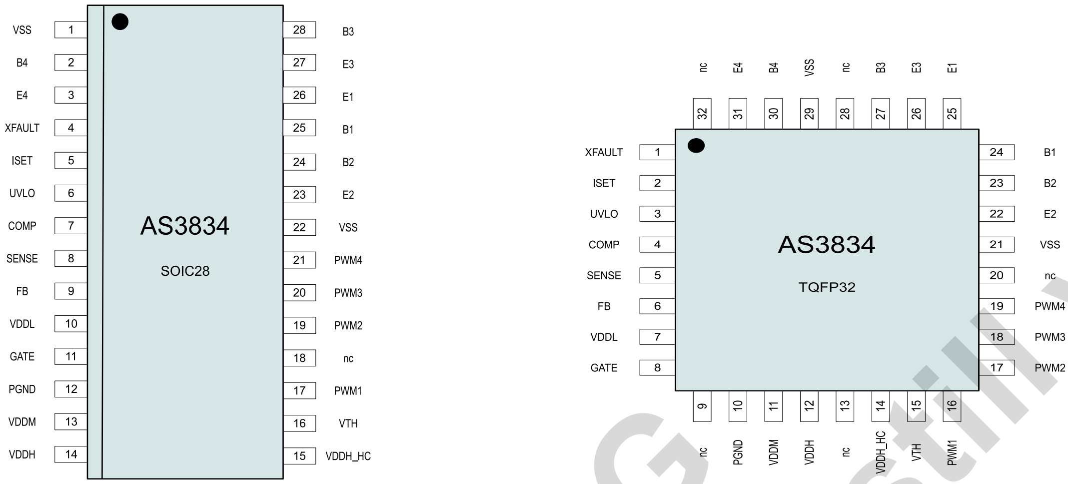
4 Pin Assignments (Top View)

Figure 2. Pin Assignments (Top View)



4.1 Pin Descriptions

Table 1. Pin Descriptions

Pin Number AS3834 TQFP-32	Pin Number AS3834 SOIC-28	Pin Name	Pin Type	Description
29	1	VSS	P	**Analog Ground**
30	2	B4	A_I/O	**Base 4.** Connect to base of external transistor.
31	3	E4	A_I/O	**Emitter 4.** Connect to emitter of external transistor.
1	4	xFAULT	DO_OD	**Fault output.** Active low.
2	5	ISET	A_I/O	**Current setting.** Connect current setting resistor.
3	6	UVLO	A_I/O	**Undervoltage lockout input.**
4	7	COMP	A_I/O	**Compensation network.** Connect compensation network.
5	8	SENSE	A_I/O	**Current sense input**. Provide a short, direct PCB path between this pin and the positive side of the current sense resistor.
6	9	FB	A_I/O	**Output voltage feedback input.** Input for voltage divider. Connect voltage divider output as short as possible to this pin
7	10	VDDL	A_I/O	**Voltage regulator output 3.3V.** Connect 2.2µF decoupling capacitor to GND
8	11	GATE	A_I/O	**Gate driver output.**
10	12	PGND	P	**Power Ground**
11	13	VDDM	P	**Voltage regulator output.** Connect 2.2µF decoupling capacitor to GND
12	14	VDDH	P	**Supply voltage.** Connect 1µF decoupling capacitor to GND
14	15	VDDH_HC	P	**Voltage regulator Input.** Connect 2.2µF decoupling capacitor to GND
15	16	VTH	A_I/O	**Reference input for overtemperature detection.**
16	17	PWM1	DI_PD	**PWM input 1.** PWM input for channel 1
17	19	PWM2	DI_PD	**PWM input 2.** PWM input for channel 2
18	20	PWM3	DI_PD	**PWM input 3.** PWM input for channel 3
19	21	PWM4	DI_PD	**PWM input 4.** PWM input for channel 4
21	22	VSS	P	**Analog Ground**
22	23	E2	A_I/O	**Emitter 2.** Connect to emitter of external transistor.
23	24	B2	A_I/O	**Base 2.** Connect to base of external transistor.
24	25	B1	A_I/O	**Base 1.** Connect to base of external transistor.
25	26	E1	A_I/O	**Emitter 1.** Connect to emitter of external transistor.
26	27	E3	A_I/O	**Emitter 3.** Connect to emitter of external transistor.
27	28	B3	A_I/O	**Base 3.** Connect to base of external transistor.

A_I/O...Analog pin, P...Power pin, DO...digital output, DO_OD...digital output open drain, DI...digital input, DI_PU...digital input with pullup resistor, DI_PD...digital input with pull down resistor

5 Absolute Maximum Ratings

Stresses beyond those listed in Table 2 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 in Electrical Characteristics on page 6 is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 2. Absolute Maximum Ratings

Parameter	Min	Max	Units	Comments
Electrical Parameters				
VDDH to VSS, VDDH_HC to VSS	-0.3	55	V	
VDDM to VSS, GATE to VSS	-0.3	25	V	
xFAULT to VSS	-0.3	7	V	
VDDL to VSS	-0.3	5	V	
Analog Pin Voltage to VSS[1]	-0.3	5	V	
Digital Pin Voltage to VSS[2]	-0.3	5	V	
Input Current (latch-up immunity)	-100	100	mA	Norm: JEDEC 78
Electrostatic Discharge				
Electrostatic Discharge HBM		+/- 1500	V	Norm: MIL 883 E method 3015
Electrostatic Discharge MM		+/- 200	V	Norm: JESD22-A115C
Continuos Power Dissipation (T_A = +70°C)				
Continuos Power Dissipation		1.5	W	P_T[3] for SOIC-28 Package
Continuos Power Dissipation Derating Factor		13	mW / °C	P_{DERATE}[4]
Temperature Ranges and Storage Conditions				
Junction to ambient thermal resistance		76	ºC/W	SOIC-28 Package. For more information about thermal metrics, see application note *AN01 Thermal Characteristics.*
Junction Temperature (T_{Jmax})		+150	ºC	
Storage Temperature Range	-55	+150	ºC	
Package Body Temperature		+260	ºC	The reflow peak soldering temperature (body temperature) specified is in accordance with *IPC/ JEDEC J-STD-020"Moisture/Reflow Sensitivity Classification for Non-Hermetic Solid State Surface Mount Devices".* The lead finish for Pb-free leaded packages is matte tin (100% Sn).
Humidity non-condensing	5	85	%	
Moisture Sensitive Level	1			Represents a max. floor life time of unlimited

1. Pins Vth, UVLO, Comp, Sense, FB, Iset, Ex, Bx
2. Pins PWMx
3. Depending on actual PCB layout and PCB used.
4. P_{DERATE} derating factor changes the total continuous power dissipation (P_T) if the ambient temperature is not 25ºC. Therefore for e.g. T_A=85ºC calculate P_T at 85ºC = P_T - P_{DERATE} x (85ºC - 25ºC)

6 Electrical Characteristics

VDDH = 24V, all voltages referenced to V_{SS}, Typical values are at T_A = +25°C (unless otherwise specified). All limits are guaranteed. The parameters with min. and max values are guaranteed with production tests or SQC (Statistical Quality Control) methods.

Table 3. Electrical Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Units
General						
T_A	Operating Temperature Range	apply proper cooling to stay below maximum allowed TJ.	-20		+85	°C
T_J	Operating Junction Temperature		-20		+115	°C
Power supply						
V_{DDH}	Supply Voltage		+12		+50	V
V_{DDM}	Driver supply voltage regulator output			+9		V
V_{DDL}	3V voltage regulator output			+3.3		V
I_{DD}	Operating Current Consumption	UVLO=2V, PWM1=0, Rset=6kΩ, Vth=0.47V	3.7	4.3	4.8	mA
I_{DDQ}	Quiescent Current Consumption	UVLO=0V, PWM1=0, Rset=6kΩ, Vth=0.47V	2.25	2.50	2.75	mA
Current sink parameters						
I_{LED_100}	Trimmed current accuracy	ILED=100mA, Tj = 25°C excluding error of Rset	-0.8		+0.8	%
I_{LED_ALL}	current accuracy	ILED=50[1] to 270mA, BJT β>50 Tj = -20 to +115°C	-2		+2	%
I_{CH_100}	Channel to channel accuracy	ILED=100mA, Tj = 25°C	-0.6		+0.6	%
V_{IsetX}	Reference Voltage at pins Iset		+1.18	+1.20	+1.22	V
Ratio	Ratio = ILED/Iset			500		
I_{BX}	Base output current limit		5.5		7.5	mA
Short detection comparator						
ACC_{short}	Over-Temperature protection accuracy	Accuracy of V_{be} comparison with V_{TH} level	-10		+10	mV
Power supply regulation						
B_{th}	BJT beta threshold		45	48	52	
Boost controller oscillator						
f_{osc}	Oscillator frequency		220	250	280	kHz
Boost controller PWM						
D_{MAX}	Maximum duty cycle		85	87	89	%
Boost controller error amplifier						
V_{FB}	Reference Voltage at pin FB		+1.23	+1.25	+1.27	V
A_V	Voltage gain			80		dB
BW	Bandwidth	AV = 0dB		2		MHz
I_{FB_in}	Voltage sense input current	pins FB		0.1	0.2	µA
I_{comp_out}	Compensation output current	pins COMP, Vcomp = 1V		10		µA
Boost controller over current protection						
V_{SENSE}	Current sense threshold	pin SENSE	+600	+800	+1000	mV

Table 3. Electrical Characteristics (Continued)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Boost controller driver						
R_{driver}	Driver resistance sink and source	pin GATE	4	6	8	Ω
V_{driver}	GATE maximum output voltage	IGATE = 0mA		VDDM		V
t_{RISE_driver}	GATE voltage rise time	VGATE = 0 to 3V, CLOAD = 3nF	15	25	50	ns
t_{FALL_driver}	GATE voltage fall time	VGATE = 3 to 0V, CLOAD = 3nF	15	25	50	ns
Boost controller under voltage lockout						
V_{UVLO}	Under voltage lockout threshold		+1.28	+1.35	+1.42	V
I_{UVLO_Hyst}	Under voltage lockout hysteresis current			20		µA
Digital pins						
V_{IH}	Logic high input threshold		+1.8			V
V_{IL}	Logic low input threshold				+0.8	V
V_{OL}	Logic low output level	PIN xFAULT open drain. I = -2mA			+0.3	V
R_{PU}	Input resistance Pull-up inputs			300		kΩ
R_{PD}	Input resistance Pull-down inputs			300		kΩ
Thermal protection						
T_{OFF}	Thermal shutdown threshold			140		°C
T_{hyst}	Thermal shutdown hysteresis			30		°C

1. Is is not recommended to set ILED < 50mA in order to minimize influences of offset voltages.

7 Typical Operating Characteristics

$V_{OUT\ Boost}$ = 60V; I_{OUT} = 1A, T_{AMB} = +25ºC (unless otherwise specified).

Figure 3. Boost - Efficiency vs. Output Current; V_{IN} = 13V

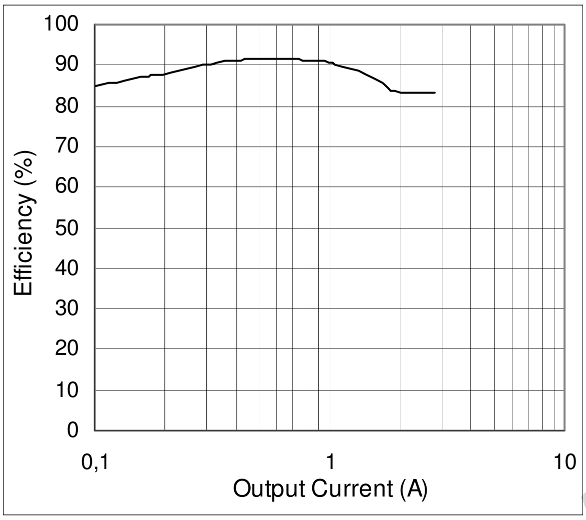


Figure 4. Boost - Efficiency vs. Output Current; V_{IN} = 24V

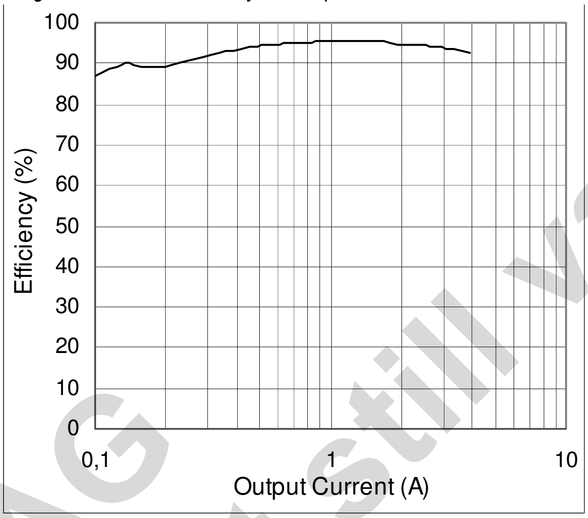


Figure 5. V_{OUT} vs. I_{OUT} ,V_{IN} = 13V

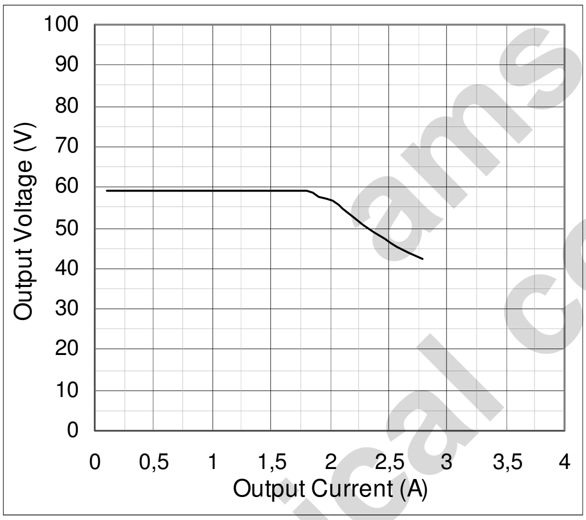


Figure 6. VOUT vs. IOUT , VIN = 24V

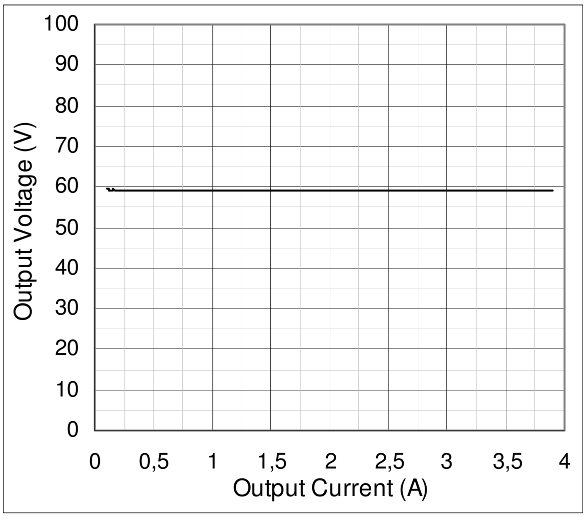


Figure 7. Boost - Efficiency vs. Input Voltage, IOUT = 1A

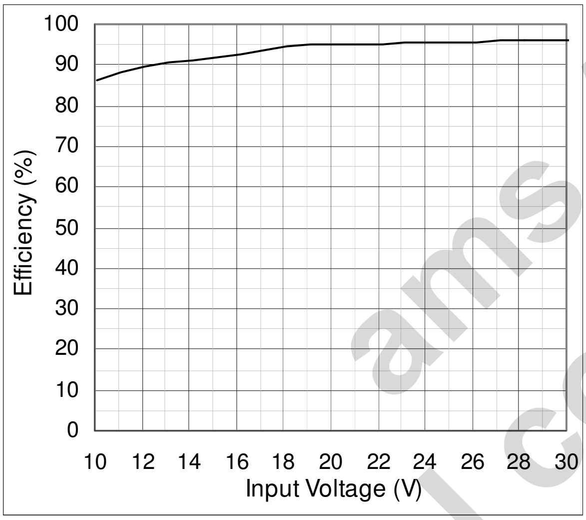
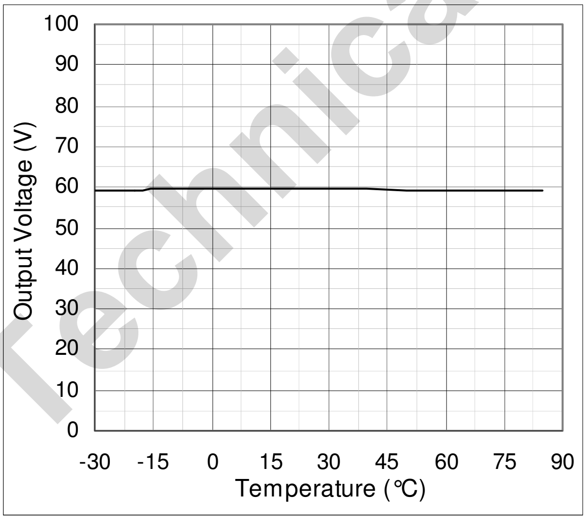


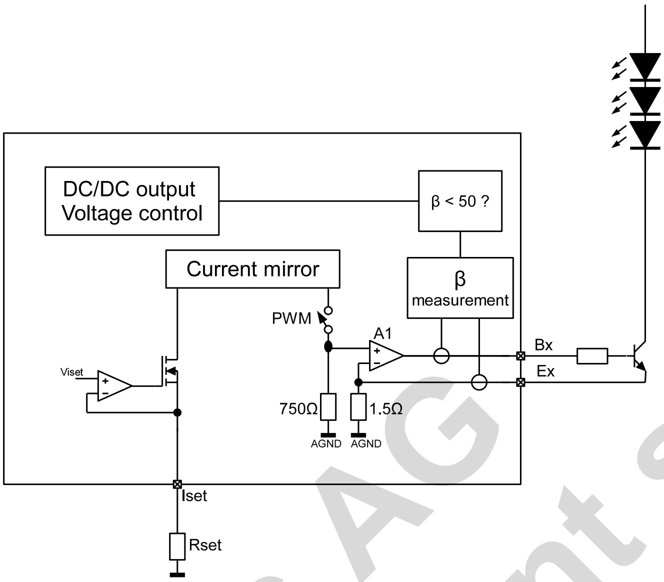
Figure 8. VOUT vs. Temp , VIN = 24V, IOUT = 0.2A



8 Detailed Description

8.1 Precision current output

Figure 9. Current output stage



The LED-current is derived from either Rset using the following equation

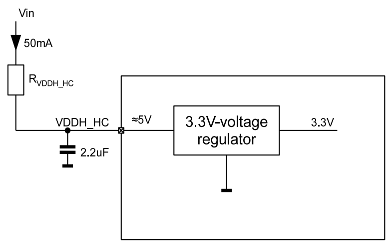
$$I_{LED} = RATIO \times I_{set} = RATIO \times \frac{V_{set}}{R_{set}} = 500 \times \frac{1.2\text{V}}{R_{SET}} \qquad \text{(EQ 1)}$$

I_{set} is protected against a short to ground. In the case of a ground short the current I_{set} is limited to 660uA and the LED-current to 330mA.

I_{set} has a lower limit of 6uA with a 1uA hysteresis.This sets the lower limit of the LED-current to 3mA with R_{set}=200kΩ. If R_{set} is large than 200kΩ, the LED-current is set to 0mA.

8.2 VDDH_HC resistor

Figure 10. VDDH_HC resistor



Pin VDDH_HC is connected to an internal 3.3V voltage regulator. In order to keep the power dissipation of this regulator low, it is recommended to connect pin VDDH_HC to the power supply Vin with a resistor. The resistor should guarantee sufficient voltage drop so that the remaining voltage at pin VDDH_HC is approximately 5V. The power dissipation of the R_{VDDH_HC} hat to be considered.

$$R_{VDDH\_HC} = \frac{V_{in} - 5V}{50mA} \tag{EQ 2}$$

$$P_{R_{VDDH\_HC}} = (50mA)^2 \times R_{VDDH\_HC} \tag{EQ 3}$$

Typical values for R_{VVDH2} are:

VIN = 13V: R_{VDDH_HC}= 150Ω / 0.5W

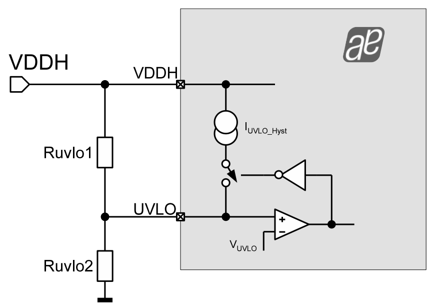
VIN = 24V: R_{VDDH_HC}= 380Ω / 1.5W

8.3 Safety features

8.3.1 Undervoltage lockout

In order to avoid startup of the Boost controller at low supply voltage an undervoltage lockout function is implemented. The boost controller only turns on when the voltage at pin UVLO exceeds V_{UVLO}. Once the boost controller is turned on a current source I_{UVLO_Hyst} is activated which increases the UVLO voltage and so shifts the turn off voltage level.

Figure 11. Undervoltage lockout



Following equations can be derived for adjusting the threshold voltages:

Undervoltage lockout HIGH level:
$$V_{\mathrm{DDH\_UVH}} = V_{UVLO} \times \left(1 + \frac{R_{UVLO1}}{R_{UVLO2}}\right) \quad \text{(EQ 4)}$$

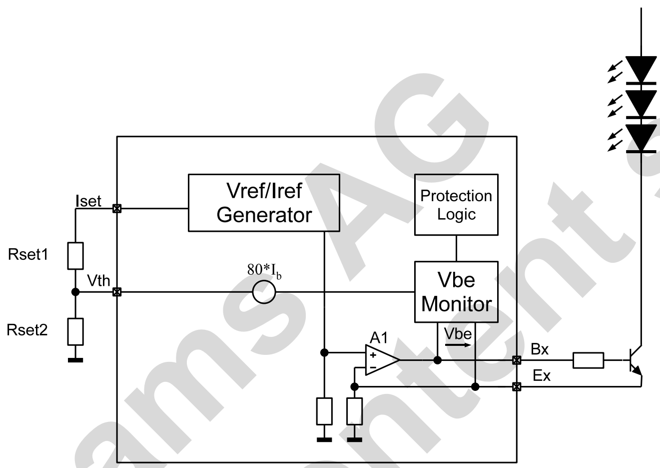
Undervoltage lockout LOW level:
$$V_{\mathrm{DDH\_UVL}} = V_{UVLO} \times \left(1 + \frac{R_{UVLO1}}{R_{UVLO2}}\right) - I_{UVLO} \times R_{UVLO1} \quad \text{(EQ 5)}$$

8.3.2 Overtemperature Shutdown

If the device temperature reaches T_{OFF} the boost controller and all current outputs are turned off. After the temperature has decreased by T_{hyst} all blocks are turned on again.

8.3.3 Short LED protection

Figure 12. Short Led protection



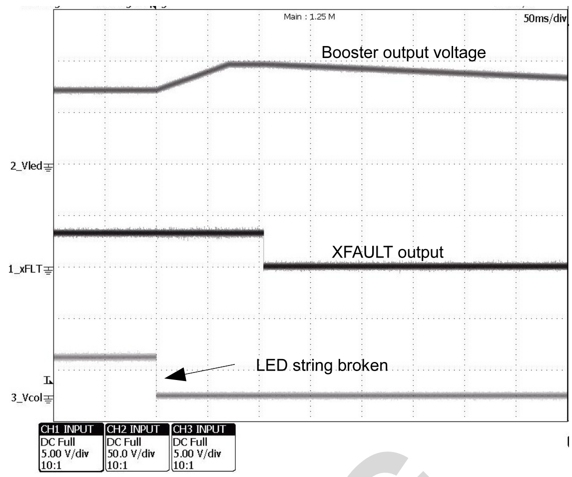
A built in short protection comparator is monitoring the junction temperature T_J of the external bipolar transistors by measuring the base-emitter voltage V_{BE}.

$$V_{BE} = 1{,}2\mathrm{V} - 0.002 \times T_J \qquad \text{Tj....junction temperature in K} \quad \text{(EQ 6)}$$

When the measured V_{BE} gets lower than the voltage applied at pin Vth an overtemperature an hence an short LED condition is detected. Subsequently the fault output is activated (xFAULT = 0) and the corresponding output is deactivated.

8.3.4 Open LED detection

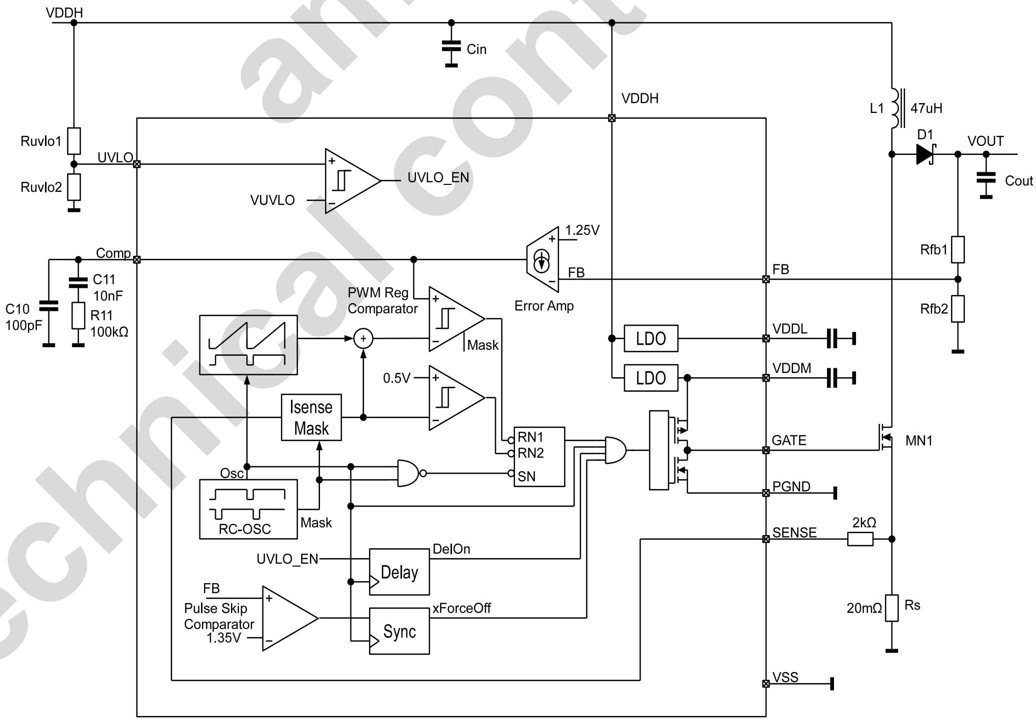
Figure 13. Open Led detection



A broken LED-string is detected during PWM=1. If a LED-string is broken the power supply feedback will increment the IDAC to increase the power supply output voltage. After the IDAC has reached its maximum value, a debounce counter is started. In order to run the debounce counter, the corresponding PWM-signal has to be high for more than 150us. After the debounce counter has counted up for 32ms, the fault output is activated (xFAULT = 0) and the corresponding output is disconnected from the power supply feedback loop.

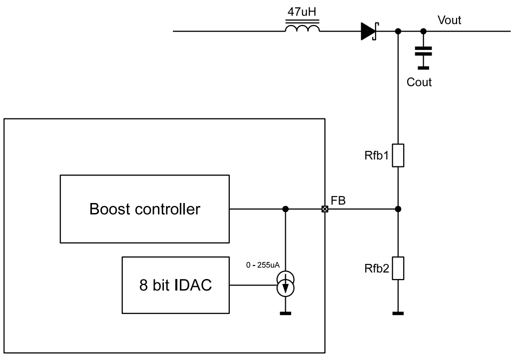
8.4 Boost controller

Figure 14. Boost controller



8.4.1 Setting the output voltage

Figure 15. Vout setting



According to the requirements of the LED strings, the output voltage Vout is adjusted by the internal power supply feedback between: $V_{OUTmin} = V_{fb}\left(1+\frac{R_{fb1}}{R_{fb2}}\right)$ and $V_{OUTmax} = V_{fb}\left(1+\frac{R_{fb1}}{R_{fb2}}\right) + 255\mu A \cdot R_{fb1}$

Once Vout_min and Vout_max is known the external resistors can be caluclated:

$$R_{fb1} = \frac{(V_{OUTmax} - V_{OUTmin})}{255\mu A} \quad \text{(EQ 7)}$$

$$R_{fb2} = \frac{V_{fb}R_{fb1}}{(V_{OUTmin} - V_{fb})} \quad \text{(EQ 8)}$$

Note: The overall resistance should be in the range of 100kΩ to 200kΩ to avoid any noise issues. Keep FB-line as short as possible.

8.4.2 Continuous Conduction Mode (CCM)

For normal operation the converter should stay in continuous conduction mode, to ensure that the inductor value must be bigger than L_{CRIT}.

$$L_{CRIT} = \frac{\left(1 - \frac{V_{IN}}{V_{OUT} + V_D}\right) \times V^2_{IN} \times R}{2 \times f_{SW} \times (V_{OUT} + V_D)^2} \quad \text{(EQ 9)}$$

Where:

V_{IN} ... Input voltage at VDDH

V_{OUT} ... Output voltage

V_D ... Diode forward voltage at D1

f_{SW} ... Switching frequency

R ... Load resistor, should be calculated with minimum current load $R = V_{OUT} / I_{OUT\_min}$

I_{OUT_min} ... Minimum output current (e.g. for LED driver only one LED string is on)

8.4.3 Duty Cycle

Within CCM, the well known relation between input and output voltage is deriped in the following equation:

$$\frac{V_{OUT} + V_D}{V_{IN}} = \frac{1}{1 - D} \quad \text{(EQ 10)}$$

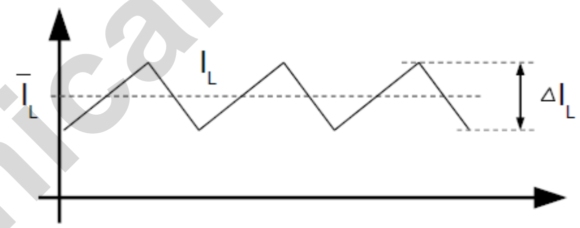
this means for the duty cycle:

$$D = 1 - \frac{V_{IN}}{V_{OUT} + V_D} \quad \text{(EQ 11)}$$

8.4.4 Inductor Current

The inductor current varies during a switching cycle. This variation can be expressed by the mean value of the inductor current and the delta rise/ fall current within each cycle (see Figure 16).

Figure 16. Inductor Current



Mean inductor current:

$$\bar{I}_L = \frac{I_{OUT}}{1 - D} \quad \text{(EQ 12)}$$

Delta inductor current:

$$\Delta I_L = \frac{D \times V_{IN}}{f_S \times L} \quad \text{(EQ 13)}$$

Peak current:

$$I_{pk} = \bar{I}_L + \frac{\Delta I_L}{2} = \frac{I_{OUT}}{1-D} + \frac{D \times V_{IN}}{2 \times f_S \times L} \quad \text{(EQ 14)}$$

RMS inductor current:

$$I_{RMS} = \sqrt{\bar{I}_L^{\,2} + \left(\frac{1}{12} \times \Delta I_L\right)^2} \quad \text{(EQ 15)}$$

This peak current is flowing through MN1 during phase 1 and through D1 during phase 2 of each cycle. Therefore this peak current is important for a proper diode , MOSFET and inductor selection.

Note: The saturation current of the inductor should be about 20 to 30% larger than the peak current

8.4.5 Input Capacitor

The input capacitor has to supply the delta inductor current and it should be selected according to:

$$C_{IN} > \frac{\Delta I_L}{4 \times \Delta V_{IN} \times f_{SW}} \quad \text{(EQ 16)}$$

$$ESR < \frac{\Delta V_{IN}}{2 \times \Delta I_L} \quad \text{(EQ 17)}$$

8.4.6 Output Capacitor

The output capacitor must be chosen according to the max allowable output ripple at high load.

$$C_{OUT} > \frac{I_{OUT-max} \times D}{\Delta V_{OUT} \times f_{SW}} \quad \text{(EQ 18)}$$

$$ESR < \frac{\Delta V_{OUT}}{\left(\frac{I_{OUT}}{1-D} + \frac{V_{IN} \times D}{2 \times L \times f_{SW}}\right)} \quad \text{(EQ 19)}$$

8.4.7 Current Sense Resistor

$$R_{S-max} = \frac{V_{SENSE}}{\bar{I}_L + 0,5 \times \Delta I_L} \quad \text{(EQ 20)}$$

$$P_{RS} = I^2_{L-rms} \times R_S \times D \quad \text{(EQ 21)}$$

Note: Low inductance, specific designed current sensing resistors should be used, e.g. Stackpole Electronics CSR/CSRN series of sensing resistors with less than 0.2nH (typ.).

8.4.8 Compensation Network

A typical choice for values of the compensation network is C10 = 100pF, C11 = 10nF, R11 = 100KΩ. Use these values as initial choice and evaluate the transient response of the system to verify the behavior at output load change.

9 Package Drawings and Markings

Figure 17. TQFP-32 Marking

Table 4. Packaging Code

YY	WW	G	ZZ
last two digits of the current year	manufacturing week	plant identifier	free choice / traceability code

Figure 18. SOIC-28 Marking

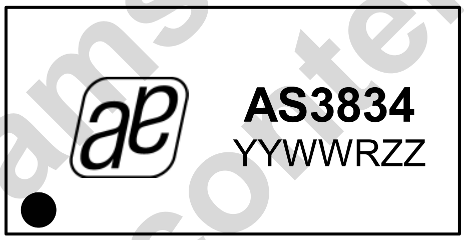
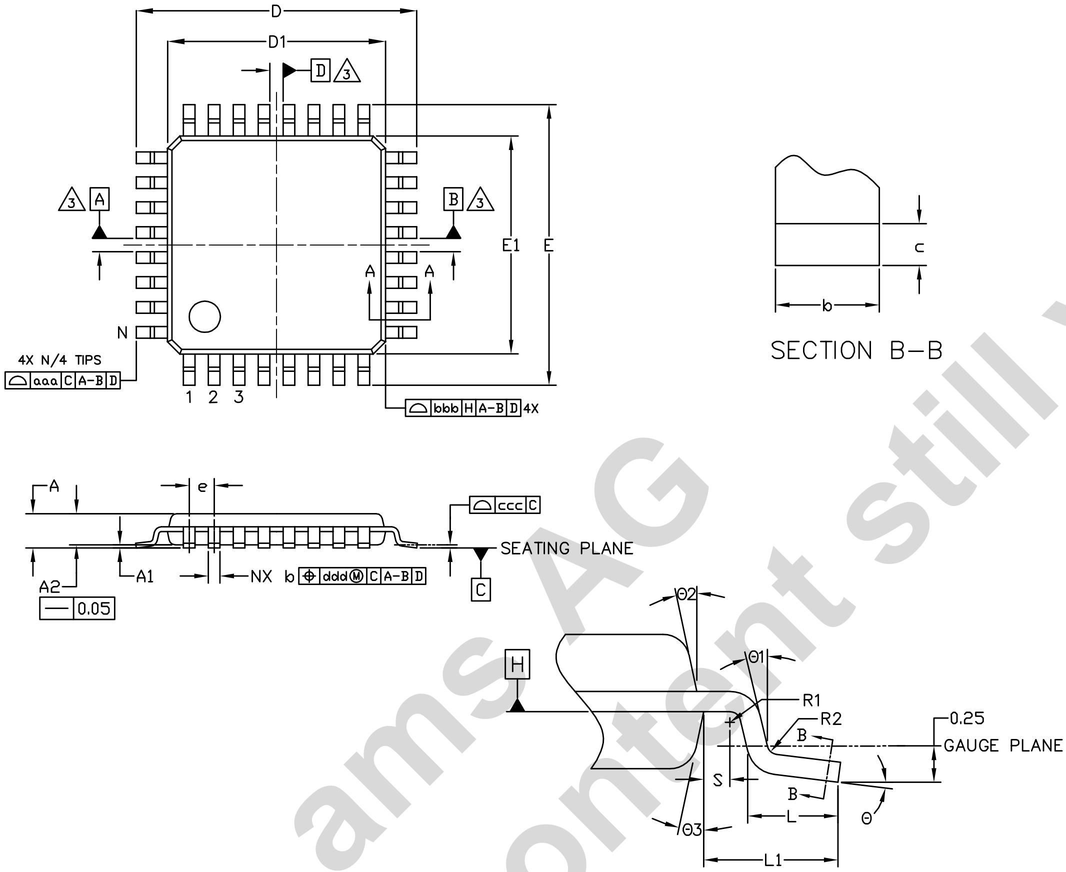


Table 5. Packaging Code

YY	WW	R	ZZ
last two digits of the current year	manufacturing week	plant identifier	free choice / traceability code

Figure 19. TQFP-32 Package



SECTION A-A

REF.	MIN	NOM	MAX
A	–	–	1.20
A1	0.05	–	0.15
A2	0.95	1.00	1.05
b	0.30	0.35	0.45
c	0.09	–	0.20
D		9.00 BSC	
D1		7.00 BSC	
E		9.00 BSC	
E1		7.00 BSC	
e		0.80 BSC	
L	0.45	0.60	0.75
L1		1.00 REF	
R1	0.08	–	–
R2	0.08	–	0.20
S	0.20	–	–
Θ	0°	3.5°	7°
Θ1	0°	–	–
Θ2	11°	12°	13°
Θ3	11°	12°	13°
aaa	–	0.20	–
bbb	–	0.20	–
ccc	–	0.10	–
ddd	–	0.20	–
N		32	

NOTE:

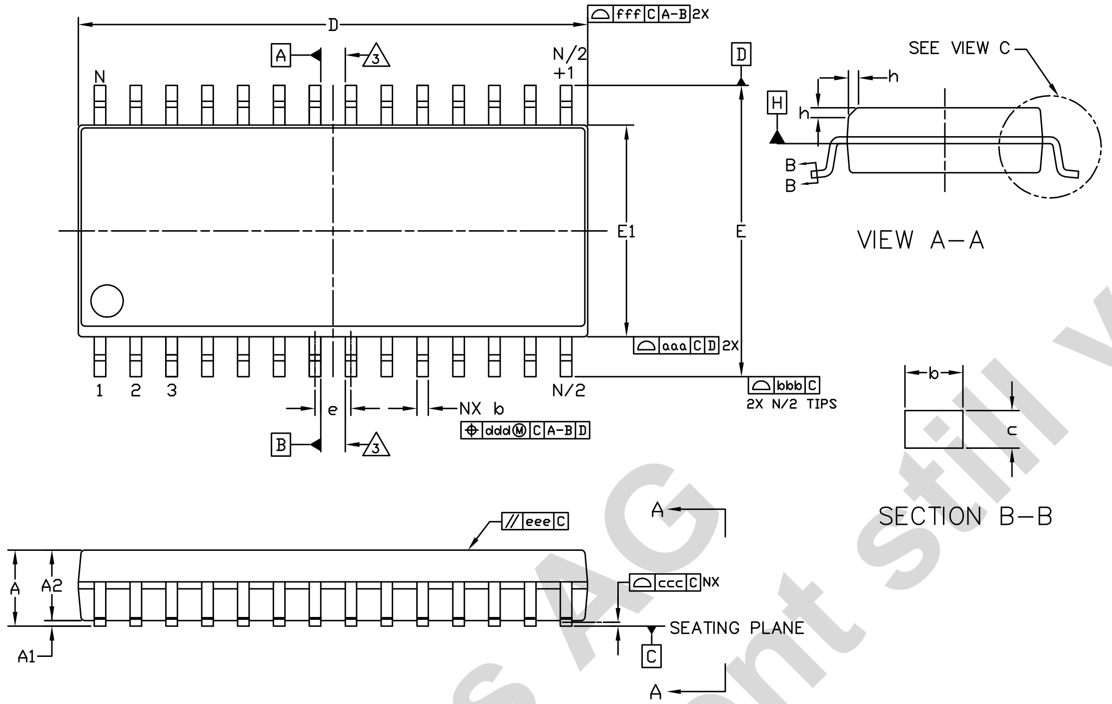
1. DIMENSIONS & TOLERANCEING CONFIRM TO ASME Y14.5M–1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS. ANGELS ARE IN DEGREES.
3. DATUMS A & B TO BE DETERMINED AT DATUM H.

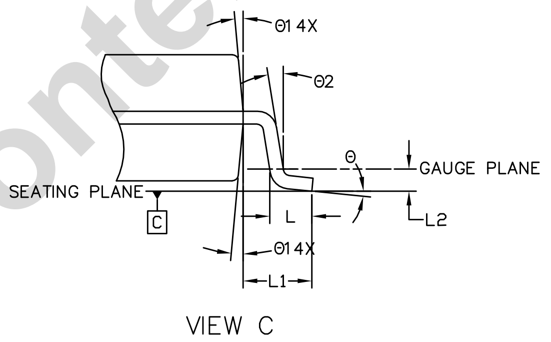
RoHS compliant

green

austriamicrosystems a leap ahead in analog			ASSEMBLY ENGINEERING	
DRAWN RH8	DATE 2010.12.17	REV. N/C	TITLE TQFP 7x7x1.0mm, 32 LEAD,	REFERENCE DOCUMENT JEDEC MS – 026 LATEST REVISION
CHECKED GBO	DATE 2010.12.17		DRAWING NO. BPX	UNIT
APPROVED MKR	DATE 2010.12.17	SHEET 1 OF 1	DIMENSION AND TOLERANCE	SCALE NOT IN SCALE

Figure 20. SOIC-28 Package





REF.	MIN	NOM	MAX
A	–	–	2.65
A1	0.10	–	0.30
A2	2.05	–	–
b	0.31	–	0.51
c	0.20	–	0.33
D		17.90 BSC	
E		10.30 BSC	
E1		7.50 BSC	
e		1.27 BSC	
L	0.40	–	1.27
L1		1.40 REF	
L2		0.25 BSC	
h	0.25	–	0.75
Θ	0°	–	8°
Θ1	5°	–	15°
Θ2	0°	–	–
aaa		0.10	
bbb		0.33	
ccc		0.10	
ddd		0.25	
eee		0.10	
fff		0.20	
ggg		0.15	
N		28	

NOTE:

1. DIMENSIONS & TOLERANCEING CONFIRM TO ASME Y14.5M–1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS. ANGELS ARE IN DEGREES.

3. DATUMS A & B TO BE DETERMINED AT DATUM H.

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DRAWN RH8	DATE 2010.12.16	REV. N/C	ASSEMBLY ENGINEERING TITLE SOIC 300MIL, 28 LEAD	REFERENCE DOCUMENT JEDEC MS – 013 LATEST REVISION
CHECKED GBO	DATE 2010.12.16		DRAWING NO. JTP	UNIT
APPROVED MKR	DATE 2010.12.16	SHEET 1 OF 1	DIMENSION AND TOLERANCE	SCALE NOT IN SCALE

10 Ordering Information

The devices are available as the standard products shown in Table 6.

Table 6. Ordering Information

Ordering Code	Marking	Description	Delivery Form	Package
AS3834-ZTQT	AS3834		Tape & Reel	TQFP-32
AS3834-ZSOT	AS3834		Tape & Reel	SOIC-28

Note: All products are RoHS compliant and austriamicrosystems green.
Buy our products or get free samples online at ICdirect: http://www.austriamicrosystems.com/ICdirect

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or find your local distributor at http://www.austriamicrosystems.com/distributor