IS32BL3554

BOOST TYPE LED DRIVER WITH 4-CHANNEL CURRENT SOURCE

September 2015

GENERAL DESCRIPTION

The IS32BL3554 is a white LED driver for backlight applications based on a highly efficient boost controller operating over a wide input voltage range of 4.5V to 33V.

The IS32BL3554 contains four regulated current sources with 1.5% (Typ.) current matching between strings for a uniform LED brightness. Each current source can be programmed via an external resistor to drive from 20mA to 180mA. A fast slew rate current source allows high frequency and narrow pulse width dimming signals to achieve a very high contrast ratio. The device operating frequency can be adjusted from 0.1MHz to 1MHz.

The IS32BL3554 has safety protection features to prevent damage during fault conditions. Protection features include an internal soft-start circuit to prevent a high inrush current during startup, open/short LED protection to automatically disable a faulty current source, over temperature protection (OTP), cycle-by-cycle current limit, under voltage lockout (UVLO), programmable OVP, VOUT short / Schottky diode open protection and Schottky Diode short-circuit protection.

The IS32BL3554 is available in a thermally enhanced eTSSOP-16 package.

FEATURES

- Input voltage range: 4.5V to 33V
- 4-Channel LED current sinks, 180mA per string
- LED current adjustable from 20mA to 180mA
- String-to-string current matching accuracy: 1.5%
- Adjustable operating frequency: 100kHz to 1MHz
- External PWM dimming
- High contrast ratio
- Less than 3μA shutdown current
- Programmable soft-start
- Built-in protection features
  - OCP, OTP, UVLO
  - Open/short LED protection
  - Programmable OVP
  - Schottky Diode/inductor short-circuit protection
- Automotive AEC-Q100 qualified

APPLICATIONS

- Automotive Lighting
- LCD Monitor/TV
- LCD Display Module

TYPICAL APPLICATION CIRCUIT

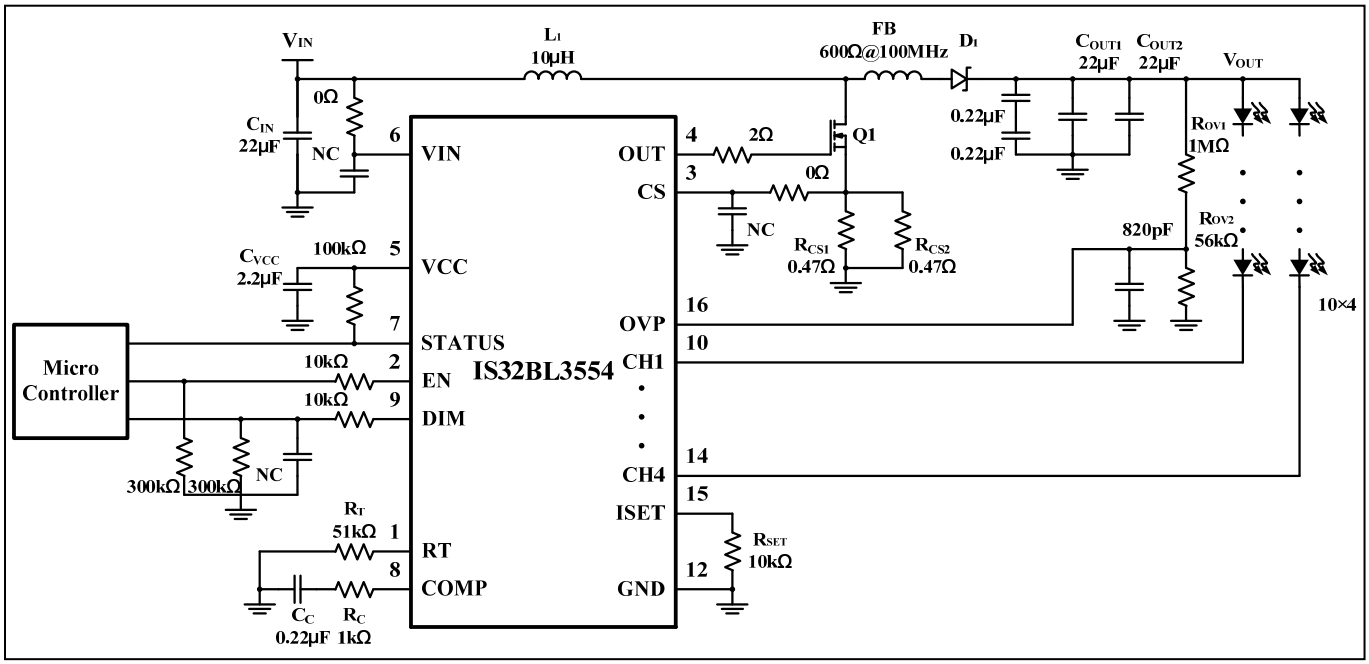
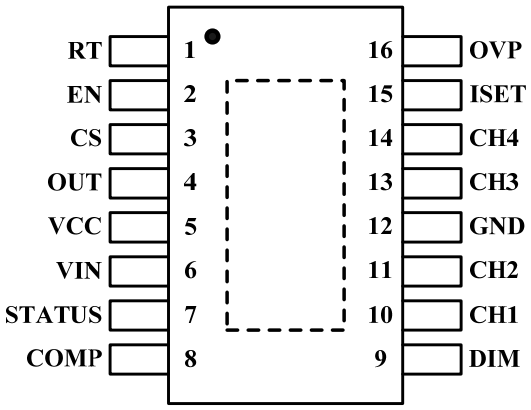


Figure 1 Typical Application Circuit

PIN CONFIGURATION

Package	Pin Configuration (Top View)
eTSSOP-16	

PIN DESCRIPTION

No.	Pin	Description
1	RT	A resistor value to ground sets the switching frequency from 100kHz to 1MHz.
2	EN	Enable Input. The IC is Enabled when this pin is above 2.4V. The IC is Disabled and in Shutdown mode when this pin is below 0.5V. In shutdown mode only a minimal 3μA current is consumed.
3	CS	Current Sense Input from the switching converter. A sense resistor from the source of the external N-MOSFET to GND sets the switching current limit.
4	OUT	Switching N-MOSFET Gate Drive Output. This pin outputs a high voltage (5V/V_{CC}-0.5V) to drive an external switching N-MOSFET.
5	VCC	5V linear regulator output. Bypass this pin to GND with a ceramic capacitor as close as possible to the pin.
6	VIN	Supply input (4.5V to 33V). Bypass VIN to GND with a capacitor (typical 10μF) to keep the DC input voltage constant.
7	STATUS	LED operation status will output logic low if a fault is detected.
8	COMP	Soft-start and control loop compensation.
9	DIM	PWM signal input for LED dimming. If dimming is not implemented, connect it to VCC pin 5.
10,11	CH1,CH2	LED current sink 1 and 2 (up to 180mA). If unused leave the pin open unconnected.
12	GND	Ground. Connect all grounds at a single point.
13,14	CH3,CH4	LED current sink 3 and 4 (up to 180mA). If unused leave the pin open unconnected.
15	ISET	LED Current Adjust Input. Connect a resistor R_{ISET} between ISET pin and GND to set the reference current through each LED string.
16	OVP	Over Voltage Protection pin. Connect a resistor-divider from the switching converter output to this pin. The OVP comparator reference is internally set to 2.0V. Above 2.0V triggers OVP and shuts down switch power; switch resumes normal operation when the pin voltage drops below hysteresis voltage.
	Thermal Pad	Connect to GND.

ORDERING INFORMATION

Automotive Range: -40°C to +125°C

Order Part No.	Package	QTY
IS32BL3554-ZLA3-TR	eTSSOP-16, Lead-free	2500/Reel
IS32BL3554-ZLA3		96/Tube

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ABSOLUTE MAXIMUM RATINGS

Input voltage, V_{IN}	-0.3V ~ +42V
CH1 to CH4 voltage, V_{CH}	-0.3V ~ +55V
GND pin voltage, V_{GND}	-0.3V ~ +0.3V
Voltage in other pins, V_{PIN}	-0.3V ~ +7.0V
Thermal resistance, θ_{JA} Thermal simulation @25°C ambient temperature, still air convection, 2s2p boards according to JESD51.	39.9°C/W
Operating junction temperature, T_J	150°C
Lead Temperature(Soldering, 10s), T_{LEAD}	260°C
Storage temperature range, T_{STG}	−65°C ~ +150°C
Operating ambient temperature range, T_A	−40°C ~ +125°C
ESD(HBM) ESD(CDM)	2kV 750V

Note:
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 condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V_{IN}	Input voltage		4.5		33	V
f_{OSC}	Switch frequency		0.1		1	MHz
V_{LEDX}	LED channel voltage				50	V
I_{LEDX}	LED channel current		20		180	mA
f_{PWM}	PWM dimming frequency	(Note 1)	0.1		20	kHz
T_A	Operating ambient temperature		-40		125	°C

ELECTRICAL CHARACTERISTICS

V_{IN} =12V, V_{EN}=5V, T_A = T_J = -40°C ~ +125°C, Typical values are at T_A = 25°C.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
Input Supply						
V_{IN}	Input voltage		4.5		33	V
I_{CC}	Quiescent current	No switching		3	5	mA
I_{SD}	Shutdown current	V_{EN} = V_{DIM} = 0V		0.1	3	μA
V_{UVLO}	UVLO	V_{IN} Rising	3.4	3.8	4.2	V
V_{UVLO_HYS}	UVLO hysteresis			0.2		V
VCC Section						
V_{CC}	VCC voltage	V_{IN} ≥ 5.5V		5		V
		V_{IN} < 5.5V, I_{LOAD} = 10mA		V_{IN}-0.1		V
t_{RISING}	Out pin rising time	1nF load (Note 1)		30	50	ns
$t_{FALLING}$	Out pin falling time	1nF load (Note 1)		30	50	ns
	Load Regulation	V_{IN} = 12V, I_{LOAD} = 0mA ~ 30mA		5	10	mV/mA
	Line Regulation	V_{IN} = 6.5V ~ 12V, I_{LOAD} = 1mA		3	10	mV/V

ELECTRICAL CHARACTERISTICS (CONTINUED)

V_{IN} =12V, V_{EN}=5V, T_A = T_J = -40°C ~ +125°C, Typical values are at T_A = 25°C.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
High Frequency Oscillator						
$t_{ON-TIME}$	Minimum on-time	f = 500kHz (Note 1)		200		ns
f_{OSC}	Switch frequency (10% variation)	R_T = 100kΩ	440	520	570	kHz
D_{MAX}	Maximum duty cycle	f = 500kHz	88	90		%
Enable Logic And Dimming Logic						
V_{EN_H}	EN high voltage		2.4			V
V_{EN_L}	EN low voltage				0.5	V
V_{DIM_H}	PWM logic for external dimming		2.5			V
V_{DIM_L}					0.3	V
t_{PWM_MIN}	PWM dimming minimum pulse width	(Note 1)		$3/f_{OSC}$		μs
Power Switch Drive						
V_{LIMIT}	Current limit threshold voltage		480	560	640	mV
V_{LIMIT2}	D/I short threshold voltage		720	800	930	mV
t_{LEB}	Current sense LEB time	(Note 1)	80	100	150	ns
Compensation And Soft Start (COMP Pin)						
G_{EA}	Error amplifier trans-conductance			2300		μA/V
I_{O_H}	Sourcing current	V_{COMP}=0.5V	55	120	200	μA
I_{O_L}	Sinking current	V_{COMP}=2V	60	120	200	μA
Over-Voltage Protection						
V_{OVP}	OVP threshold voltage	V_{OUT} rising, T_A= -40°C, 25°C	1.8	2.0	2.2	V
		V_{OUT} rising, T_A= 125°C	1.8	2.0	2.25	V
V_{OVP_HYS}	OVP hysteresis		200	250	330	mV
V_{OVP_SD}	Shutdown under abnormal condition		3.0	3.2	3.6	V

ELECTRICAL CHARACTERISTICS (CONTINUED)

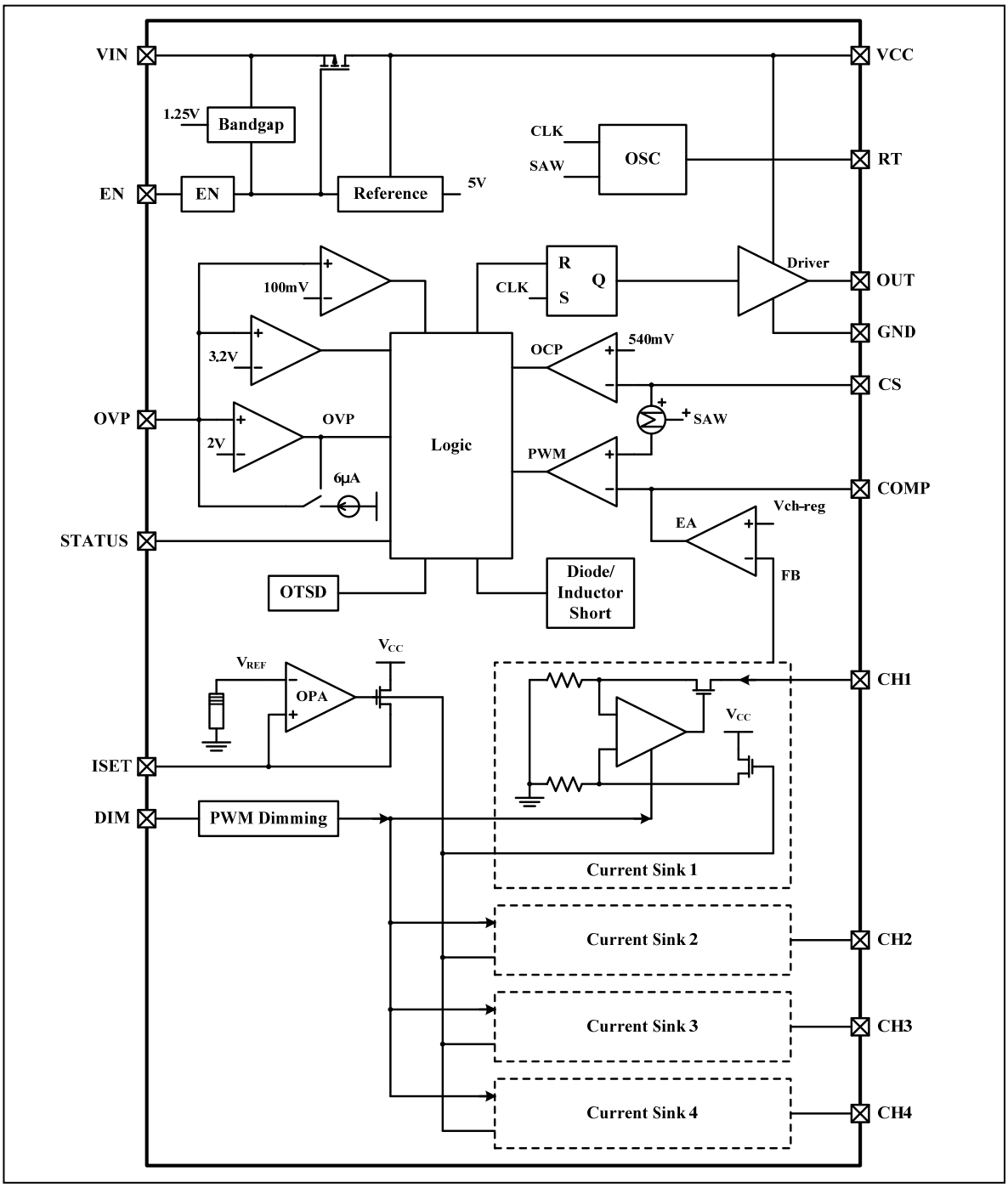
V_{IN} =12V, V_{EN}=5V, T_A = T_J = -40°C ~ +125°C, Typical values are at T_A = 25°C.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
Current Source						
I_{CH_MATCH}	LED current matching between each string	T_A = 25°C,125°C, I_{LED} = 100mA (Note 2)		1.5	5	%
		T_A = -40°C, I_{LED} = 100mA (Note 2)		2	8	
I_{LED}	Regulation current per channel	T_A = 25°C,125°C, R_{SET} = 12kΩ	90	100	110	mA
		T_A = -40°C, R_{SET} = 12kΩ		100		
V_{LED_REG}	Minimum LED regulation voltage	I_{LED} = 100mA		230	400	mV
I_{LED_LEAK}	CH1 to CH4 leakage current	V_{EN} = 0V, V_{LED} = 50V		0.1	1	μA
V_{LED_S}	LED Short protection threshold		6.6	7.3	8.0	V
Over-Temperature Protection						
T_{OTSD}	Thermal shutdown temperature	(Note 1)		160		ºC
T_{HYS}	Thermal shutdown recovery	(Note 1)		140		ºC

Note 1: Guaranteed by design and characterization, not production tested.

Note 2: $I_{ST_MATCH} = \frac{I_{MAX} - I_{MIN}}{2 \times I_{AVG}} \times 100\%$.

FUNCTIONAL BLOCK DIAGRAM



APPLICATION INFORMATION

DESCRIPTION

The IS32BL3554 is a highly integrated HBLED driver with all the features required of a backlight driver for HB LEDs used in automotive displays as well as other small to medium size LCD display applications. The device operates from an input voltage up to 33V. Advanced features include detection and string disconnect for open LED strings, partial or fully shorted strings and unused strings. Overvoltage protection clamps the converter output voltage to the programmed OVP threshold in the event of an open LED string condition. The STATUS pin outputs string open or short circuit conditions and over voltage or over temperature conditions.

ENABLE

When the EN pin connected to a logic-low the IS32BL3554 will completely shut down, reducing its current consumption to less than 3μA. The device is enabled when the logic threshold at EN exceeds 2.4V and it is disabled when it is lower than 0.5V.

LED CURRENT SETTING

The maximum LED current per channel can be adjusted up to 180mA via ISET pin. When ≥ 180mA current is needed for an application, two or more channels can be paralleled to provide larger drive current. Connect resistor R_{SET} between ISET pin and GND to set the reference current I_{SET}. The LED current can be expressed as below Equation (1):

$$I_{LED}[mA] = \frac{1200}{R_{SET}[k\Omega]} \qquad (1)$$

The current regulator of the IS32BL3554 has a fast response so that it can allow a very high contrast ratio.

DIMMING CONTROL

A PWM signal applied to the DIM pin will adjust the LED current to all enabled channels. During the “high level” period of the PWM signal, the LED is turned ON and 100% of the current flows, while during the “low level” period the LED is turned OFF and almost no current flows. This ON/OFF operation generates an average current flow that will set the LED brightness between 1%×I_{CHX_MAX} to 100% × I_{CHX_MAX}. A 100Hz (or higher) PWM signal frequency can be applied to PWM pin.

CONTRAST RATIO

The PWM dimming contrast ratio (CR) of the system depends on the PWM frequency, the value of external components, input/output voltage and so on.

The CR definition can be showed by following Equation (2):

$$CR = \frac{1}{D_{MIN}} \qquad (2)$$

Where, $D_{MIN} = \frac{t_D + t_{SU}}{t_{PWM}}$ and $t_{PWM} = \frac{1}{f_{PWM}}$

t_D is the propagation delay from the time PWM logic signal goes high to the time that the LED driver begins to increase the output current. t_{SU} is the slew up time needed for the output current from zero to the set level.

Base on the equations, the lower PWM dimming frequency, f_{PWM}, the higher contrast ratio, as these fixed delays consume a smaller portion of the dimming period, t_{PWM}. The lower limit for f_{PWM} is approximately 100Hz, below which the eye no longer blends the pulses into a perceived continuous light. The upper limit is determined by the minimum contrast ratio that is required.

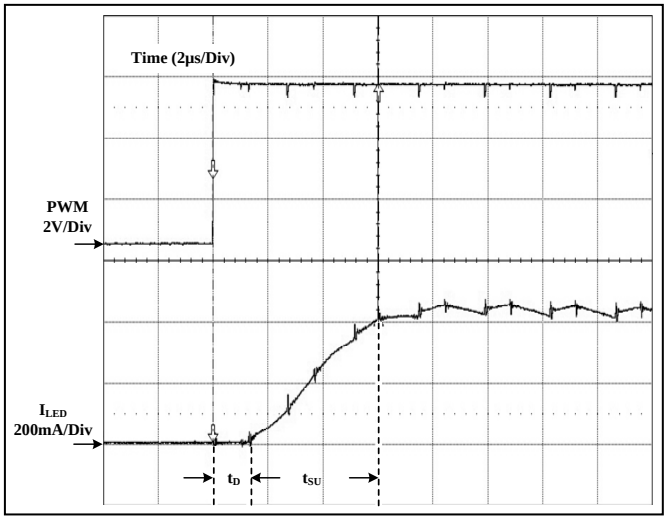


Figure 2 PWM vs. LED Current

FREQUENCY SELECTION

The IS32BL3554’s switching frequency can be adjusted between 100kHz to 1MHz by using an external resistor R_T, placed between RT pin and GND. A low frequency operation can help to reduce switch loss for a higher efficiency while a high frequency operation will minimize the external component size. The approximate operating frequency can be expressed as below Equation (3):

$$f_{OSC}[MHz] = \frac{52}{R_T[k\Omega]} \qquad (3)$$

STATUS OUTPUT

The STATUS output provides a warning of extreme operating or fault conditions. After initial power up, the STATUS pin will output a logic low (normally high) if any of the following conditions exists:

(1) Any string is open
(2) LED short circuit protection
(3) Shut down under abnormal condition
(4) Over voltage protection
(5) Over temperature protection
(6) Schottky Diode short protection
(7) VOUT Short/Open Schottky Diode protection

PROTECTION FEATURES

The IS32BL3554 is designed with integrated safety features for a reliable and stable operation in the normal operating range. In the event of more than one fault condition occurring, the higher priority condition will take precedence.

SOFT START

The internal soft start circuit prevents a high inrush current during startup.

OVER VOLTAGE PROTECTION

The IS32BL3554 integrates an OVP circuit to prevent system damage should the output voltage become excessive. To maintain a safe output level, the integrated OVP circuit continuously monitors the voltage output level. The OVP pin is connected to the center tap of voltage-divider (R_{OV1} and R_{OV2}) connected between high voltage output and GND. If the voltage on OVP pin exceeds 2.0V the IS32BL3554 stops switching, which causes the output voltage to drop. When the OVP pin voltage drops below the threshold the device begins oscillating once again, which causes the output voltage to rise. This OVP hysteresis is 250mV (V_{OVP_HYS}). The formula to calculate V_{OVP} can be expressed as below Equation (4):

$$V_{OVP} = \frac{(R_{OV1} + R_{OV2}) \times 2.0V}{R_{OV2}} \qquad (4)$$

V_{OVP} = OVP voltage

V_{OVP_HYS} = OVP hysteresis voltage

OVER CURRENT PROTECTION

The IS32BL3554 integrates an OCP circuit. The CS pin is connected to the external voltage-sense resistor (R_{CS}) that is placed between the drain of MOS and GND. If the voltage on CS pin exceeds 0.56V (V_{LIMIT}), it is turned OFF immediately and will not turn ON until the next cycle begins.

SCHOTTKY DIODE/INDUCTOR SHORT CIRCUIT PROTECTION

The IS32BL3554 features a Schottky diode/inductor short-circuit protection circuit. When CS pin voltage exceeds 0.8V (V_{LIMIT2}) for more than 16 switching clocks, the IC will latch. The voltage of CS is monitored after a short delay of Leading Edge Blanking signal.

LED OPEN CIRCUIT PROTECTION

The IS32BL3554 integrates an LED open-circuit protection circuit. When any LED string is open, V_{OUT} will boost up until the voltage at OVP pin reaches an approximate 2.0V threshold. The IC will automatically ignore the open string whose corresponding pin voltage is less than 100mV and the remaining string will continue operation. If all the strings are open and the voltage at OVP reaches a threshold of 2.0V, the MOSFET drive GATE will turn off and IC will shut down and latch.

LED SHORT CIRCUIT PROTECTION

The IS32BL3554 integrates an LED short-circuit protection circuit. If the voltage at any of the two channel pins exceeds a threshold of approximately 7.3V (V_{LED_S}) during normal operation, the corresponding string is turned off and is latched off. To reset the latch and start operation, the V_{IN} and/or EN must be toggled OFF/ON. The priority of the LED short detecting logic is lower than the open LED and OVP logic. The LED short circuit detection logic is triggered when V_{LED_MIN} is <0.1V under dimming on mode. It is disabled when an LED open occurs or when the output voltage resumes to the regulated output level.

V_{OUT} SHORT / OPEN SCHOTTKY DIODE PROTECTION

The IS32BL3554 monitors the OVP pin, if the OVP pin voltage is less than 0.1V, MOSFET drive output will turn off. This protects the converter if the output schottky diode is open or V_{OUT} is shorted to ground.

UNDER VOLTAGE LOCKOUT

The IS32BL3554 provides an under voltage lockout circuit with built in hysteresis to prevent an undefined status during startup. The UVLO circuit shuts down the device when V_{CC} drops below 3.6V (typical) and will turn when V_{CC} rises above 3.8V. The UVLO circuit has a 200mV hysteresis (V_{UVLO_HYS}), which means the device will start up when V_{CC} rises above 3.8V.

OVER TEMPERATURE PROTECTION

The thermal overload protection prevents excessive power dissipation from overheating and damaging the IS32BL3554. If the junction temperature exceeds approximately 160ºC (T_{OTSD}), the IC will shut down to allow it to cool down. The device will begin a soft-start process when the junction temperature (T_J) of the die falls below approximately 140ºC (T_{HYS}).

SHUT DOWN UNDER ABNORMAL CONDITION

The IS32BL3554 integrates a shutdown under abnormal condition protection circuit. When the OVP pin voltage exceeds 3.2V (V_{OVP_SD}), the IC will latch. The EN pin must then be toggled to restart the IC. This feature can be used for any other protection to shut down the IC.

APPLICATION INFORMATION

DESIGN EXAMPLE FOR IS32BL3554

This section describes a component calculation method for selecting component values when designing with the IS32BL3554 (Figure 1).

For the purposes of this example, the following assumptions are given as application requirements:

V_{IN} = 12V
LED Loading = 10×4
LED current per channel, I_{LED} = 120mA
LED V_{F1} = 3.2V at 120mA
f_{OSC} = 1MHz
Efficiency, η = 90%

Once the initial operating parameters have been identified, the next step is to sequentially calculate the individual parameters in an ordered manner starting with Step 1 and continuing step by step until the final Step 5.

Step 1: Calculate the LED current setting resistor R_{SET} using Equation (5):

$$I_{LED}[mA] = \frac{1200}{R_{SET}[k\Omega]} \quad (5)$$

The I_{LED} = 120mA, so the R_{SET} should be:

$$R_{SET}[k\Omega] = \frac{1200}{I_{LED}[mA]} = \frac{1200}{120} = 10k\Omega$$

Choose a 10kΩ resistor for R_{SET}.

Step 2: Calculate the frequency setting resistor R_T using Equation (6):

$$f_{OSC}[MHz] = \frac{52}{R_T[k\Omega]} \quad (6)$$

Therefore, for an f_{OSC} = 1MHz, R_T is calculated as:

$$R_T[k\Omega] = \frac{52}{f_{OSC}[MHz]} = \frac{52}{1} = 52k\Omega$$

Choose a standard resistor value of 51kΩ for R_T.

Note: A high f_{OSC} operating frequency will result in a smaller PWM duty cycle enabling high contrast dimming results.

Step 3: Calculate OVP resistors R_{OV1} and R_{OV2}, using Equation (7):

$$V_{OVP}[V] = \frac{(R_{OV1} + R_{OV2}) \times 2.0}{R_{OV2}} \quad (7)$$

Step 3a: Calculate the maximum required LED output voltage, V_{OUT}.

$$V_{OUT} = (Number\ SERIES\ LED) \times V_{F1} = 10 \times 3.2 = 32V \quad (8)$$

Step 3b: Use V_{OVP} Equation (4) to calculate R_{OV1} and R_{OV2}.

$$V_{OVP}[V] = \frac{(R_{OV1} + R_{OV2}) \times 2.0}{R_{OV2}} = 1.2 \times V_{OUT} = 1.2 \times 32V = 38.4V$$

Therefore, $R_{OV1} = 18.2 \times R_{OV2}$

Pick a standard resistor value of 56kΩ for R_{OV2} then calculate for R_{OV1} = 1.0MΩ.

Note: Multiplier 1.2x is added for design margin to cover noise and output ripple voltage.

Step 4: Choose the input filter capacitor. The input capacitor (C_{IN}) filters the current peaks drawn from the input supply and reduces noise injection into the IS32BL3554. A 22μF/63V electrolytic capacitor is recommended for most applications.

Step 5: Choose the output capacitors. The output capacitors provide filtering for both the boost converter and for the PWM dimming function. The biggest factors that contribute to the size of the output capacitor are: PWM dimming frequency and PWM duty cycle. Another major contributor is leakage current, $I_{LK;}$ the reverse current of the switching diode. In this design the PWM dimming frequency is to be 100Hz and the minimum duty cycle is 0.1%. Typically, the voltage variation on the output, V_{COUT}, during PWM dimming must be less than 250mV, to minimize any audible hum. The output capacitance is calculated using Equation (9):

$$C_{OUT} = I_{LK} \times \frac{1 - D_{MIN}}{f_{PWM} \times V_{COUT}} = 1000 \times \frac{1 - 0.001}{100 \times 0.25} = 39.96\mu F \quad (9)$$

Where I_{LK}= 1mA.

Because capacitors tend to degrade when subjected to high voltages; a capacitance value greater than 39.96μF should be selected.

Two 22μF 63V capacitors connected in parallel are a good choice to fulfill this requirement.

Step 6: Calculate duty cycle D_{ON} using Equation (10):

$$D_{ON} = \frac{V_{OUT} - V_{IN}}{V_{OUT}} = \frac{32-12}{32} = 62.5\% \quad (10)$$

The turn on time t_{ON} is calculated using Equation (11) below:

$$t_{ON} = \frac{D_{ON}}{f_{OSC}} = \frac{0.625}{1} = 0.625\mu s \quad (11)$$

Step 6a: Calculate the average input current $I_{IN(Avg)}$, using Equation (12):

$$I_{IN(Avg)} = \frac{V_{OUT} \times I_{LED} \times 4}{V_{IN} \times \eta} = \frac{32 \times 0.12 \times 4}{12 \times 0.9} \approx 1.42A \quad (12)$$

Equation (13) is used to calculate the maximum ripple current $I_{RIPPLE(MAX)}$:

$$I_{RIPPLE(MAX)} = 2 \times I_{IN(Avg)} = 2 \times 1.42 = 2.84A \quad (13)$$

Step 6b: Calculate the minimum inductor value, L_1. using Equation (14):

$$L_{CCM(MIN)} = \frac{V_{IN} \times t_{ON}}{I_{RIPPLE(MAX)}} = \frac{12 \times 0.625}{2.84} \approx 2.64\mu H \quad (14)$$

The selected value for L_1 should be higher than the $L_{CCM(MIN)}$. A lower inductance for L_1 will result in a narrower PWM duty cycle for high contrast dimming. The trade off for a low inductance is higher output current ripple. Therefore choose a 10μH inductor for L_1.

Step 6c: Determining the peak input current I_{PEAK}, calculated as follows:

First calculate the ripple current I_{RIPPLE} using Equation (15):

$$I_{RIPPLE} = \frac{t_{ON} \times V_{IN}}{L_1} = \frac{0.625 \times 12}{10} \approx 0.75A \quad (15)$$

Then calculate the inductor peak current using Equation (16):

$$I_{PEAK} = I_{IN(Avg)} + 0.5 \times I_{RIPPLE} = 1.42 + 0.5 \times 0.75 = 1.795A \quad (16)$$

Step 6d: The peak current protect resistor R_{CS} is shown in Equation (17):

$$R_{CS}[\Omega] = 0.8 \times \frac{0.54}{I_{PEAK}[A]} = 0.8 \times \frac{0.54}{1.795} \approx 0.24\Omega \quad (17)$$

Choose a 0.235Ω resistor for R_{CS}.

Generally a constant term, 0.8x, is added when calculating the R_{CS} value. A lower R_{CS} value will result in a higher I_{PEAK} to prevent over current protection errors.

Step 7: The boost converter requires a diode to carry the inductor current during the MOSFET off time. Schottky diodes are recommended due to their fast recovery time and low forward voltage. D_1 should be rated to handle the maximum output voltage (plus switching node ringing) and the peak switch current. The conduction loss of the diode is calculated by:

$$P_{DIODE} = I_{RMS_OFF} \times V_F$$

$$I_{RMS_OFF}^{\ 2} = \frac{V_{IN}}{V_{OUT}} \times \left(I_{IN}^{\ 2} + \frac{\Delta I_L^{\ 2}}{12} \right) \quad (18)$$

Where V_F is the forward voltage of the Schottky diode.

Step 8: The IS32BL3554 integrates a soft start and control loop compensation in COMP Pin. The soft start feature allows the boost converter to gradually reach its initial steady state output voltage, thereby reducing startup stresses and current surges. The startup time is controlled by an internal 130μA (I_{CS}) current source and the external compensation circuit composed of C_C and R_C. When powering on, after the V_{IN} UVLO threshold is satisfied, the internal 130μA current source charges the external capacitor C_C. The COMP pin voltage will ramp up slowly and limit the inrush current during startup. The soft start time is determined by the Equation (19):

$$t_{SS} = \frac{V_{COMP} \times C_C}{I_{CS}} \quad (19)$$

Where V_{COMP} is the voltage of COMP pin and I_{CS} is the internal source current. Typically, a value of R_C=1kΩ and C_C=0.22μF is sufficient for operating at 500kHz.

Low-ESR Surface-Mount Ceramic Capacitors (MLCCs) are recommended. For most applications, ceramic capacitors with X7R temperature characteristics are preferred. These capacitors have tight capacitance tolerance (as good as ±10%) and hold their value over temperature (X7R: ±15% over -55°C to 125°C).

Step 9: The IS32BL3554 includes an internal low dropout linear regulator with the output pin VCC. This pin is used to power the internal PWM controller, control logic and MOSFET driver. The regulator generates a 5V supply when V_{IN}≥5.5V. When V_{IN} is less than 5.5V, connect VCC directly to VIN.

The VCC pin should be decoupled with a 2.2μF ceramic capacitor placed as close to the pin as possible. This capacitor keeps VCC voltage steady when the system operates at a high frequency. X7R type ceramic capacitors should be used for decoupling due to their good thermal stability.

CLASSIFICATION REFLOW PROFILES

Profile Feature	Pb-Free Assembly
Preheat & Soak Temperature min (Tsmin) Temperature max (Tsmax) Time (Tsmin to Tsmax) (ts)	150°C 200°C 60-120 seconds
Average ramp-up rate (Tsmax to Tp)	3°C/second max.
Liquidous temperature (TL) Time at liquidous (tL)	217°C 60-150 seconds
Peak package body temperature (Tp)*	Max 260°C
Time (tp)** within 5°C of the specified classification temperature (Tc)	Max 30 seconds
Average ramp-down rate (Tp to Tsmax)	6°C/second max.
Time 25°C to peak temperature	8 minutes max.

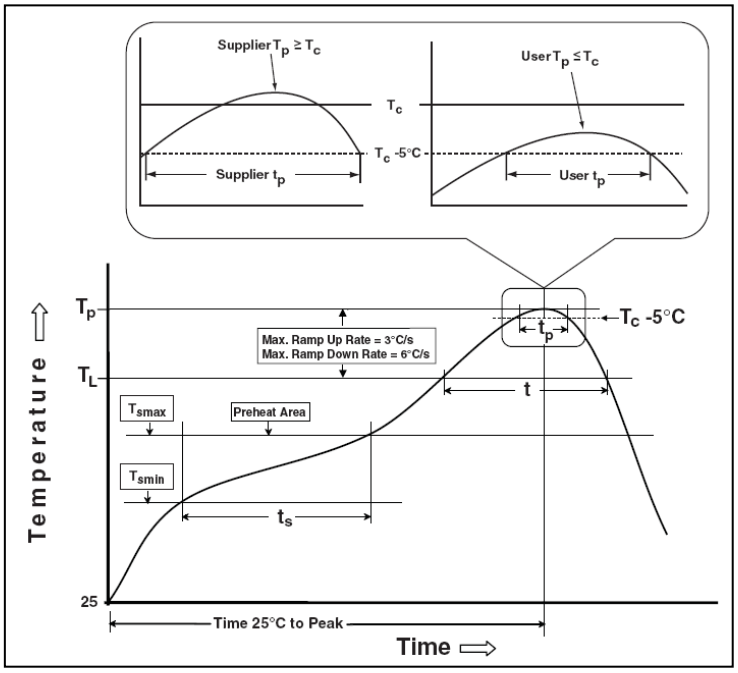
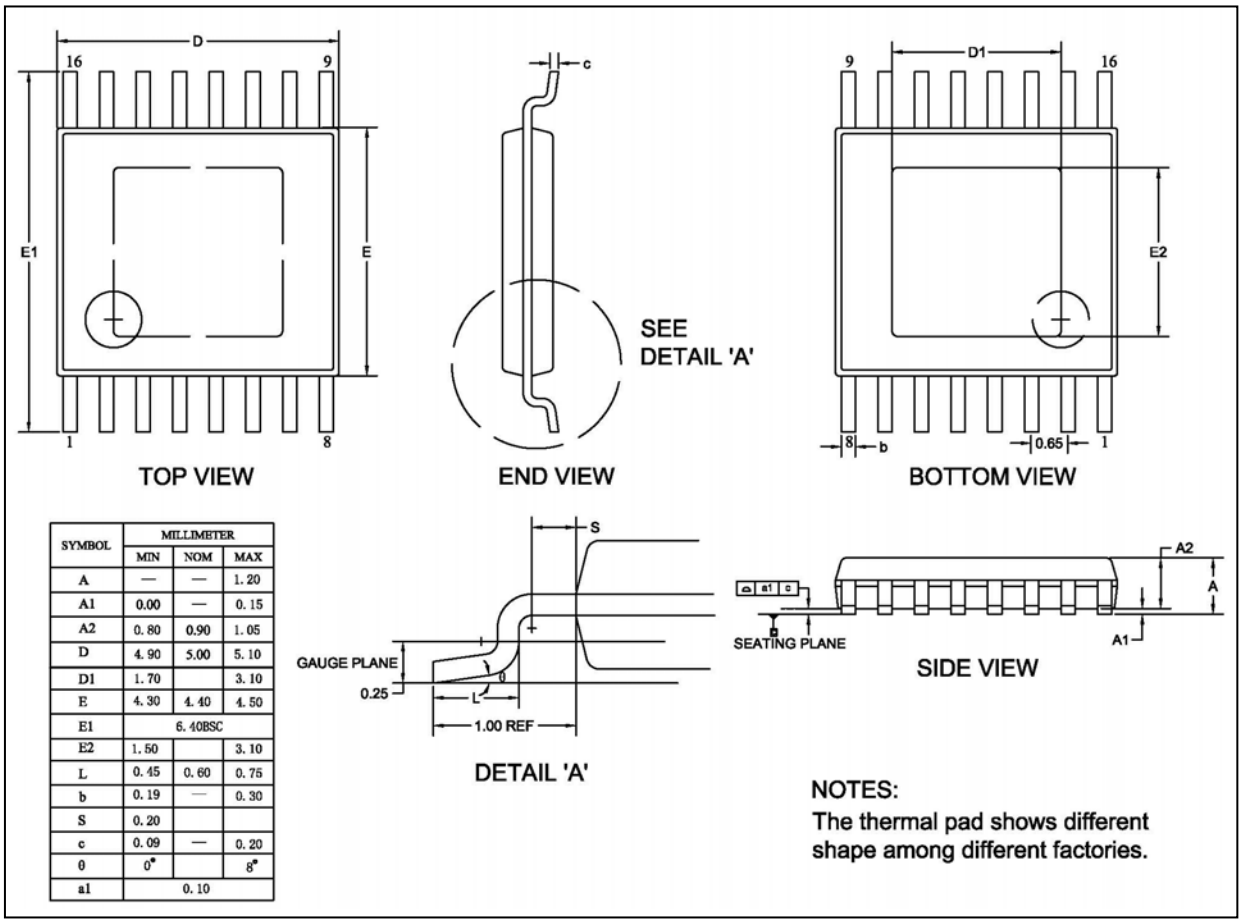


Figure 3 Classification Profile

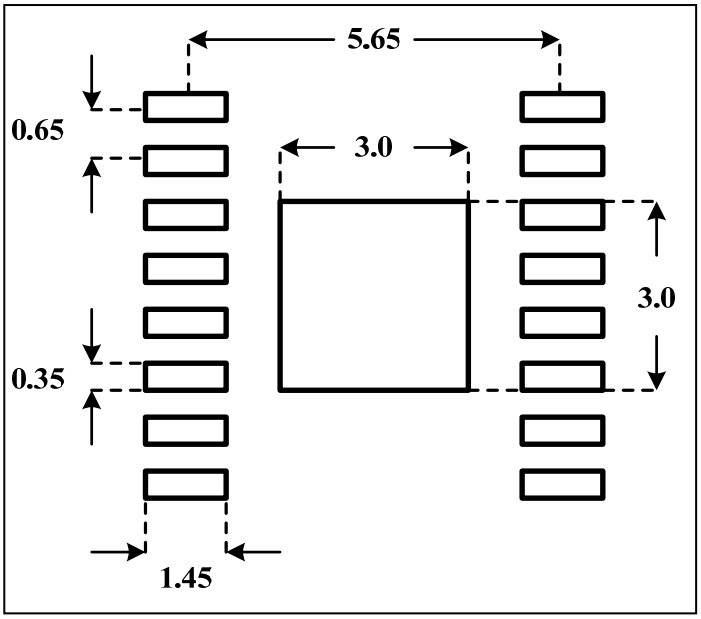
PACKAGE INFORMATION

eTSSOP-16



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	—	—	1.20
A1	0.00	—	0.15
A2	0.80	0.90	1.05
D	4.90	5.00	5.10
D1	1.70		3.10
E	4.30	4.40	4.50
E1	6.40BSC		
E2	1.50		3.10
L	0.45	0.60	0.75
b	0.19	—	0.30
S	0.20		
c	0.09	—	0.20
θ	0°		8°
a1	0.10		

RECOMMENDED LAND PATTERN



Note:

1. Land pattern complies to IPC-7351.
2. All dimensions in MM.
3. This document (including dimensions, notes & specs) is a recommendation based on typical circuit board manufacturing parameters. Since land pattern design depends on many factors unknown (eg. User's board manufacturing specs), user must determine suitability for use.

REVISION HISTORY

Revision	Detail Information	Date
A	Initial release	2013.12.22
B	1. Revise VLED voltage to 50V/55V(ABSOLUTE MAXIMUM RATINGS) 2. Add land pattern 3. Add revision history	2015.06.10
C	Add contrast ratio description	2015.09.01