High Efficiency, Wide Voltage Range 42-LED Driver

Features

- Wide input range: 5V~20V
- Drive up to 42 LEDs
- High efficiency LED driver (up to 90%)
- High frequency step-up converter (1MHz)
- Highly integrated solution
  - o Integrated 30V Power MOSFET
  - o Internal compensation and soft start
- Integrated 6-channel current sink
  - o High accuracy regulation up to 30mA
  - o 1.5% Typ. current matching
- Dual dimming scheme up to 9600:1 range
  - o Single wire enable and 32-step dimming
  - o PWM dimming with <1µs rise/fall time
- Low quiescent current (900µA)
- LED open/short protection
- Adjustable Over-voltage protection
- Cycle-by-cycle inductor current limit (2.6A)
- 0.1 µA shutdown current
- Pb-free Package: TQFN44-16
- -40 to +85 C° Temperature Range

Applications

Notebook PC, LCD monitor
Digital Photo Frames
Automotive Navigation
Portable media, DVD players
Other LED applications

Brief Description

The KTD304 is the ideal power solution for white LED backlighting used with medium size LCD panels. It is a highly integrated step up DC-DC converter with wide input voltage range from 5V to 20V, accommodating two to four series lithium ion batteries or other regulated supplies such as 5V, 9V or 12V. The KTD304 integrates a 30V Power MOSFET as well as compensation and soft start circuitry, which results in a simpler and smaller solution with much fewer external components. High switching frequency (1MHz) allows the use of a smaller inductor and capacitor to further reduce the solution size.

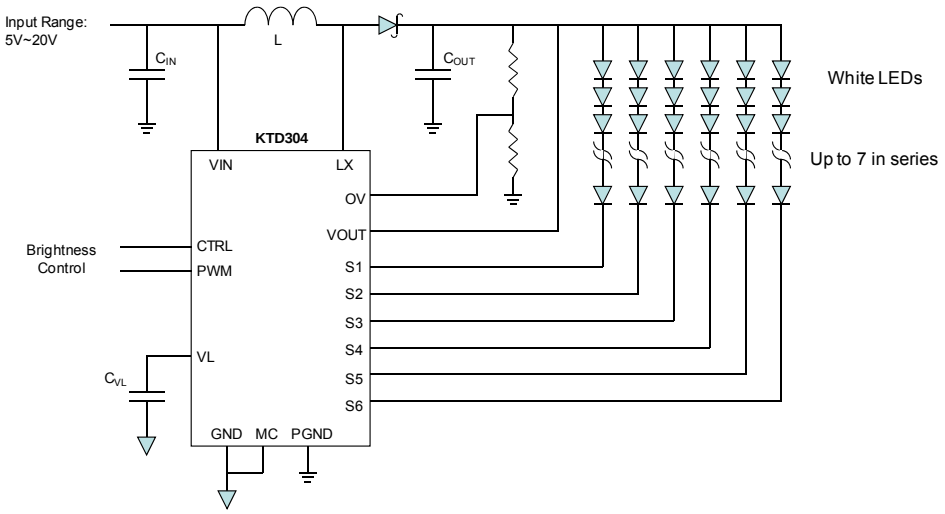
Each of the six regulated current sinks in the KTD304, can control up to 30mA. With a maximum of 30V at the output of the step-up converter, each string can connect up to seven LEDs in series, for a total of 42-LEDs.

The KTD304 is equipped with an internal decoder that allows 32 step sink current programming with a one-line control signal. For additional flexibility, PWM dimming control is included for extended dimming range.

Various protection features are built into the KTD304, including cycle-by-cycle input current limit protection, output over-voltage protection, LED fault (open or short) protection and thermal shutdown protection. The leakage current in shutdown mode is 0.1µA.

The KTD304 is available in a RoHS compliant 16-lead 4x4x0.75mm ThinQFN.

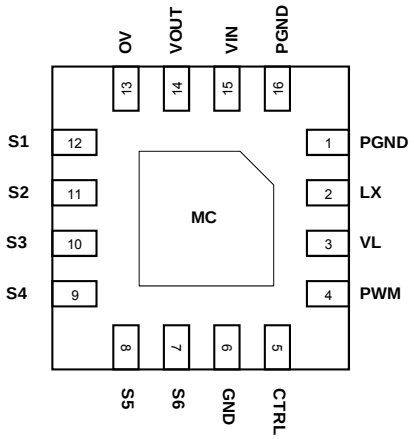
Typical Application



Pin Descriptions

Pin # (TQFN44-16)	Name	Function
1,16	PGND	Power Ground pin
2	LX	Switching node of the step-up converter
3	VL	Internal voltage supply. Connect 1uF decoupling capacitor here
4	PWM	Pulse width controlled dimming input. Connect this pin to VL when not used
5	CTRL	IC enable and serial interface LED dimming control
6	GND	Analog Ground pin
7	S6	Regulated output current sink #6
8	S5	Regulated output current sink #5
9	S4	Regulated output current sink #4
10	S3	Regulated output current sink #3
11	S2	Regulated output current sink #2
12	S1	Regulated output current sink #1
13	OV	Over voltage feedback sense pin. Programmable with a resistor divider, this pin has an internal 1.33V threshold
14	VOUT	Output voltage sense pin
15	VIN	Input supply pin for the IC
MC		Metal chassis. Connect to ground for electrical and thermal usage. MC is internally connected to Analog Ground pin.

TQFN44-16 Bottom View



Absolute Maximum Ratings (1)

(T_A=25ºC unless otherwise noted)

Symbol	Description	Value	Units
VIN	Input voltage	-0.3 to 25	V
LX, VOUT, Sx	High voltage nodes	-0.3 to 32	V
VL, OV	Low voltage nodes	-0.3 to 6	V
CTRL, PWM	Control pins	-0.3 to 25	V
T_J	Operating Temperature Range	-40 to 150	°C
T_s	Storage Temperature Range	-65 to 150	°C
T_{LEAD}	Maximum Soldering Temperature (at leads, 10 sec)	300	°C
ESD	HBM electrical static discharge	2.0	kV

NOTE:

1. Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device. Functional operation at conditions other than the operating conditions specified is not implied. Only one Absolute Maximum rating should be applied at any one time.

Thermal Capabilities

Symbol	Description	Value	Units
θ_{JA}	Thermal Resistance – Junction to Ambient[1]	50	°C/W
P_D	Maximum Power Dissipation at $T_A \leq 25°C$	2.0	W
$\Delta P_D/\Delta T$	Derating Factor Above T_A = 25°C	-20	mW/°C

NOTE: 1. Junction to Ambient thermal resistance is highly dependent on PCB layout. Values are based on thermal properties of the device when soldered to an EV board.

Ordering Information

Part Number	Marking*	Operating Temperature	Package
KTD304EEJ	AHYYZ	40˚C to +85°C	TQFN44-16

* "YYZ" is the date code and assembly code.

Electrical Characteristics [1]:

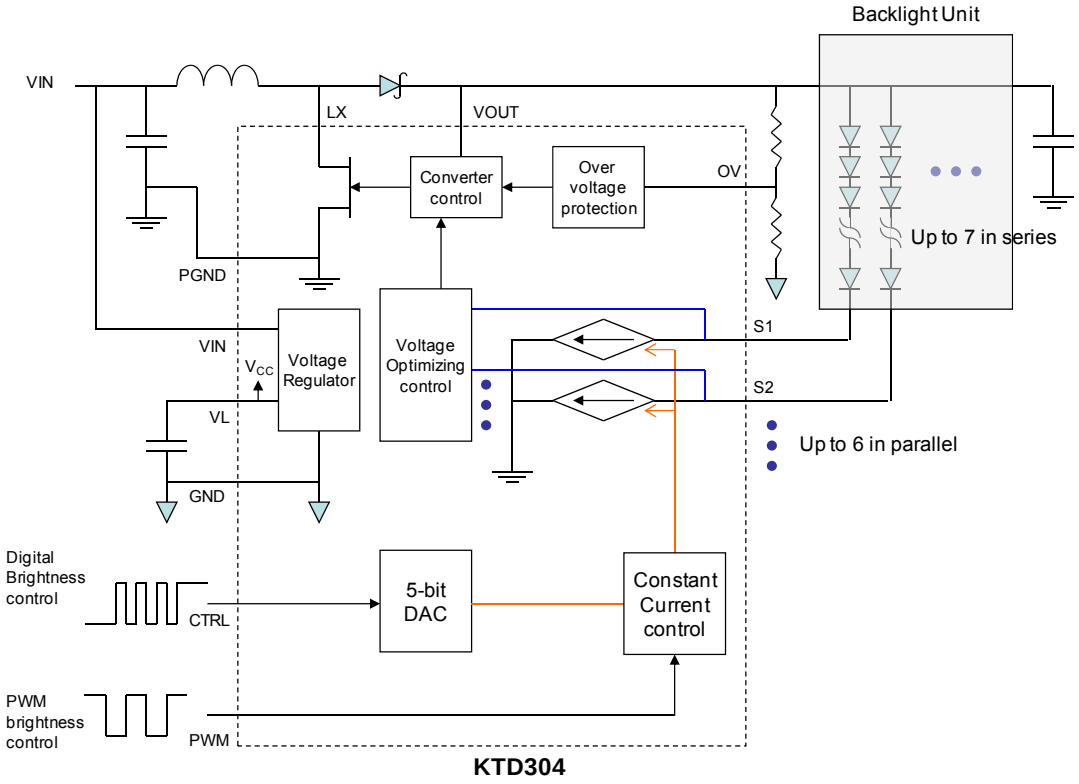
Unless otherwise noted, the *Min* and *Max* specs are applied over the full operation temperature range of －40˚C to +85°C, while *Typ* values are specified at room temperature (25°C)**.** VIN = 10V, C_{VL} = 1μF.

Symbol	Description	Conditions	Min	Typ	Max	Units
IC Supply						
V_{IN}	Input operating range		5		20	V
UVLO	Input under voltage lockout	Rising edge	4.0	4.25	4.5	V
$UVLO_{HYST}$	UVLO hysteresis			0.12		V
I_Q	IC standby current	Not switching		0.9	2.0	mA
	IC operating current	Switching		4.5	8	mA
I_{SHDN}	V_{IN} pin shutdown current	CTRL = GND		0.1	1.0	μA
Step-Up Converter						
$R_{DS(ON)}$	NMOS on-resistance			0.35	0.8	Ω
I_{LIM}	Peak NMOS current limit			2.6		A
F_{SW}	Oscillator frequency			1.0		MHz
D_{max}	Maximum duty cycle		91	94		%
V_{OV}	OV pin threshold		1.22	1.33	1.44	V
T_S	Start-up time			400		μs
Current Sink						
I_D	Output current accuracy	current setting=30mA (DATA=1)		±1	±5	%
		current setting=2.5mA (DATA=29)		±1.5	±7	%
	Output current matching[2]	current setting=30mA (DATA=1)		1.5	3.5	%
V_sov	Current sink over voltage threshold			6.7		V
T_{FAULT}	Current sink Fault Delay			64		ms
Control						
V_{TH-L}	CTRL, PWM pin logic low threshold				0.6	V
V_{TH-H}	CTRL, PWM pin logic high threshold		2.8			V
T_{EN}	Initial turn-on time at CTRL pin before recognizing the next pulse		300			μs
$T_{HIGH(MIN)}$	CTRL pin minimum logic High pulse width timing		0.4			μs
T_{LOW}	CTRL pin logic Low pulse width timing		0.4		150	μs
T_{OFF}	CTRL pin minimum shut down pulse width timing				600	μs
T_{J-TH}	IC junction thermal shutdown threshold			140		°C
	IC junction thermal shutdown hysteresis			15		°C

Note:

1. The KTD304 is guaranteed to meet performance specifications over the –40˚C to +85°C operating temperature range by design, characterization and correlation with statistical process controls.
2. The current matching between channels is defined as |Id-Iavg|max/Iavg .

Functional Block Diagram



Functional Description

The KTD304 is a unique current regulated step-up (boost) converter. Six current regulating devices are integrated to drive six strings of LEDs. Unused channels need to be connected to ground (GND).

The voltage step-up is accomplished by a boost topology, using an inductor-based DC-DC switching converter, in which the inductor serves as an energy storage device in the system. By integrating a high voltage optimized MOSFET, the KTD304 internal switching frequency is 1MHz while still maintaining high power efficiency. Unlike a traditional DC-DC boost converter with a fixed output voltage, the KTD304 dynamically changes its output voltage regulation parameters depending on the load. The use of unique control schemes maintains accurate current regulation in each of the six current sinks while leaving the output voltage at a minimum, increasing the overall conversion efficiency. The internal step-up converter dynamically controls the voltage at the output high enough to drive the LED string with the highest total forward voltage.

The control interface is designed for maximum design flexibility and compatibility with various types of system controls. The simplest control is achieved by asserting a logic high on CTRL pin; this turns each output sink on to 30mA. Pulling CTRL pin low for greater than 600µs will turn off the IC. The next level of control is accomplished by injecting a series of pulses into CTRL pin to program the sink current in 32 steps. The number of rising edges is detected internally and decoded to the current level illustrated in Table 1. The output current levels are evenly spaced at 1.25mA for the first 17 data points. After that the current step is reduced to 0.625mA, allowing better resolution for dimming. The final level of control is based on the popular PWM dimming scheme which is supported via the PWM pin. Both PWM and CTRL pins can be used together to provide the maximum range of current steps.

Application Information

Current Dimming using CTRL Pin

The current level decoding happens immediately after detecting a minimum of 400ns pulse. The first logic High or pulse at the CTRL pin takes the current level to maximum of 30mA. Each subsequent qualified rising edge will reduce the output current. See Table 1 for detailed current level versus number of pulses. The current level maintains unchanged as long as the CTRL pin stays High. The longest low pulse guaranteed not to be mistaken as a shutdown command should not exceed 150µs. However, the IC is guaranteed to be shut down after the CTRL is kept Low for at least 600µs.

Table 1, Current Settings

DATA	I_{Sx} (mA)	DATA	I_{Sx} (mA)
1	30.000	17	10.000
2	28.750	18	9.375
3	27.500	19	8.750
4	26.250	20	8.125
5	25.000	21	7.500
6	23.750	22	6.875
7	22.500	23	6.250
8	21.250	24	5.625
9	20.000	25	5.000
10	18.750	26	4.375
11	17.500	27	3.750
12	16.250	28	3.125
13	15.000	29	2.500
14	13.750	30	1.875
15	12.500	31	1.250
16	11.250	32	0.625

Active logic high/low or external pull up/down are required since there is no internal pull-up or pull-down at the CTRL pin. An example for programming the output current is shown in Figure 1.

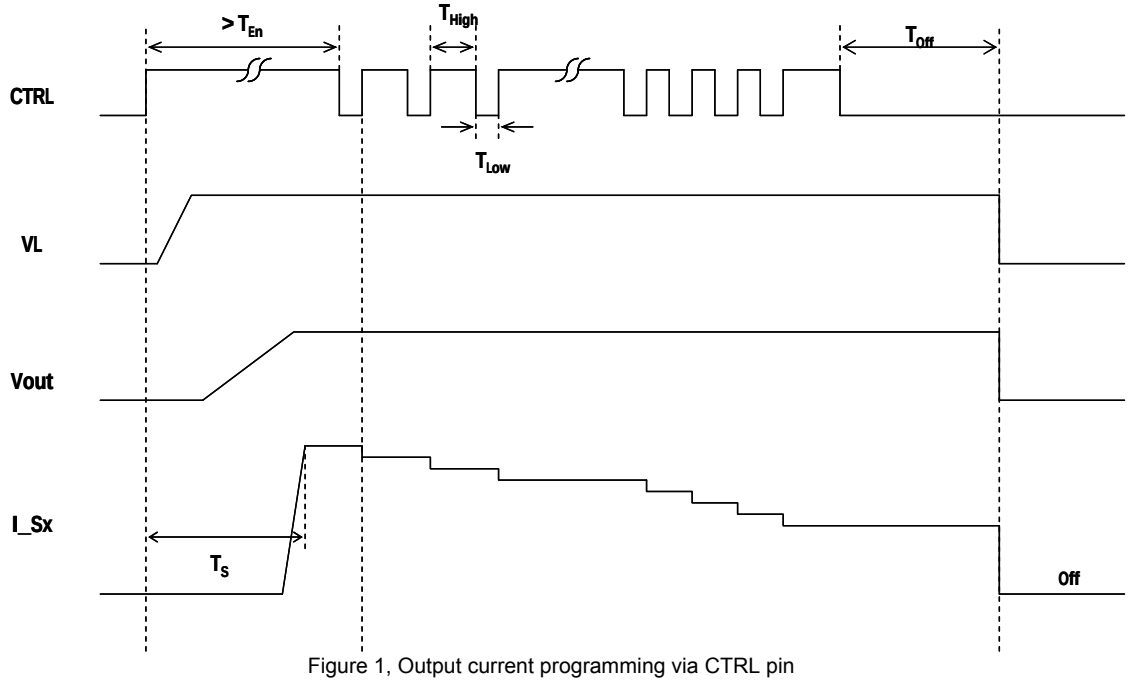


Figure 1, Output current programming via CTRL pin

Since the CTRL pin also acts as the IC enable pin, there is a one-time Enable Time (T_{EN}) of 300µs (min) every time the IC is enabled at CTRL pin. The internal IC logic is being powered up during this time period and may not be able to read input signals properly during the T_{EN} power up sequence. It is strongly recommended that the second pulse should not be sent to CTRL pin until after the T_{EN} time. Once the IC is activated, this T_{EN} does not apply any longer. With the minimum spec of 400ns for T_{LOW} and T_{HIGH}, the KTD304 can interface with a signal as fast as 1.25MHz assuming 50% duty cycle. The maximum spec for T_{LOW} is 150µs. Assuming 50% duty cycle signal, the slowest control the KTD304 can react to is 3.3kHz.

The output current can be decreased by simply adding the number of pulses according to Table 1. For example, add 8 pulses to change current from 15mA to 7.5mA (changing from data 13 to data 21).

Increasing the current level requires a simple translation. Since the data in Table 1 automatically circles around, adding 32 to the data in the target current level to figure out the number of pulses needed.

Example: To change from 1.25mA (data 31) to 15mA (data 13), send in 14 pulses (13+32-31=14).

Current Dimming using PWM Pin

KTD304 allows maximum flexibility with a PWM signal control input which can be used for dimming. The IC must remain Enabled at CTRL pin during PWM dimming, which means the step-up converter is active to reduce the response time. For the widest range of control, serial interface programming at CTRL pin can be used in conjunction with PWM dimming. Combining this with the fast response of the step-up converter, each LED channel can typically recover from no current within 1µs. This allows very short PWM on-time or a duty-cycle with fine resolution. Assume a 50µs minimum on-time for a 100Hz PWM signal, a 200:1 ratio can be achieved by PWM. Since the serial interface offers additional 48:1 ratio (30mA to 0.625mA), the combined dimming range for KTD304 is 9600:1 in this case.

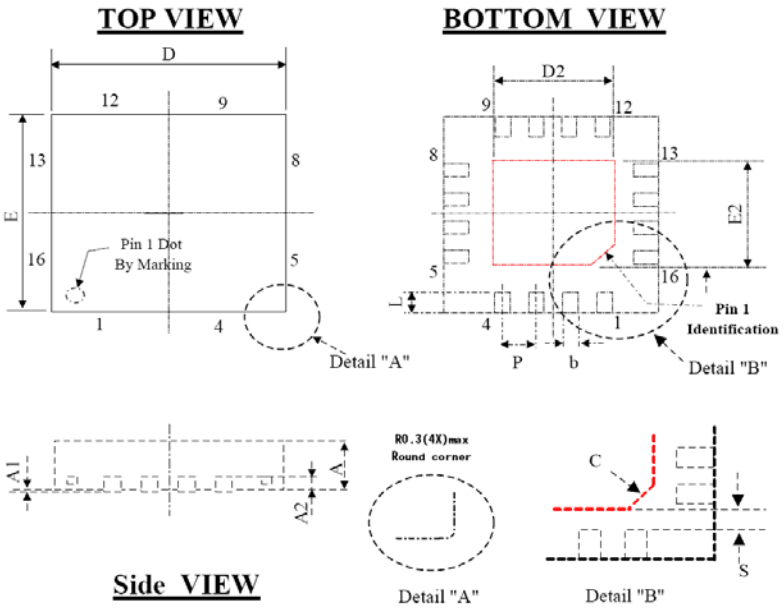
Fault Protection

Each current sink is protected against LED short or open conditions. If an LED short circuit condition arises, the current sink continues to regulate until $V_{SINK} > V_{SOV}$. When any sink node voltage goes above V_{SOV} (6.7V) for more than 64ms (while PWM dimming signal remains high), that channel's current sink will be turned off, and other channels will still work if they don't trigger this fault condition. For example, if one or more LEDs on a channel are shorted, that channel's sink voltage will increase. If the voltage goes above 6.7V for more than 64ms, the Current Sink Fault Protection will be triggered and only this faulty string will be disabled by shutting off this current sink. All other channels will continue normal operation if they don't have a fault condition. When PWM dimming control is used, the 64ms fault delay is accumulated only when PWM signal is high; the PWM low time is not counted into the fault delay, so the delay time will be 64ms/D_{PWM} (D_{PWM} is the duty cycle of the PWM signal).

In case of an LED failing open, the current sink voltage of the failed string will go close to ground and dominate the boost converter control loop. As a result the output voltage will move up to the over-voltage threshold, set by the external resistor divider. Once the over-voltage incident is flagged internally, the faulty channel(s) will be disabled. Then the output voltage of the boost converter will go back to normal level. During the entire process, the rest of the LED strings (healthy LED strings) would continue normal operation.

The fault conditions are reset when the IC is powered down and up again.

Packaging Information



Unit: mm	TQFN44-16 Outline Spec	
Symbol	Min.	Max.
A	0.65	0.85
A1	0.005	0.050
A2	0.177	0.280
b	0.25	0.35
C	0.45 REF	
D	3.95	4.05
D2	2.35	2.45
E	3.95	4.05
E2	2.35	2.45
L	0.50	0.60
P	0.65 BSC	
S	0.2 REF	