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## 36V/30V/24V Step-Up LED Driver with Internal Diode and Serial Control

## Features

- Wide Vin input range: 2.7V to 5.5 V
- Wide output range: up to 10 series LEDs
- Integrated 40 V high current switch (0.52A limit)
- High efficiency boost converter (up to 85\%)
- Highly integrated solution
- Integrated diode
- Internal compensation and soft start
- ExpressWire ${ }^{\text {TM }}$ interface dual method dimming with single pin (CTRL)
- 256-step Serial dimming control
- High resolution PWM dimming
- High accuracy across full load range
- LED open-circuit (OVP) protection
- KTD2801 : 36V
- KTD2801A : 30V
- KTD2801B : 24V
- Low 200 mV feedback voltage
- 1MHz High switching frequency
- Simple, small solution size
- $<1 \mu \mathrm{~A}$ shutdown current
- Small TDFN22-6 and Thin SOT23 package
- RoHS and Green compliant
- $-40^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$ Temperature Range


## Applications

- LED backlighting
- Mobile Phones, Handheld Devices
- Digital Photo Frames, Automotive Navigation


## Brief Description

The KTD2801/A/B is a versatile constant current LED driver with a high efficiency DC-DC step up "boost" converter architecture. The low-side power MOSFET and high-side diode are integrated in the device, minimizing the total number of external components. Unique technology and high 0.52A current limit allow KTD2801 to drive up to 36 V output (10 LEDs in series), or KTD2801A 30V output (8 LEDs in series) or KTD2801B 24 V output (6 LEDs). Alternatively, the KTD2810 can deliver 40 mA total current for two parallel strings of up to 6 series LEDs. It can also maximize the current capability while achieving high conversion efficiency. The optimized 1 MHz switching frequency results in small external component size. The driver is equipped with an internal decoder that allows digital FB control dimming for 256-step (8-bit) current programming and can also be used for PWM dimming with a one-line control signal.

Various protection features are built into the KTD2801/A/B, including cycle-by-cycle input current limit protection, LED open-circuit (output over voltage) protection and thermal shutdown protection. The leakage current in shutdown mode is less than $1 \mu \mathrm{~A}$.

The device is available in a RoHS compliant 6-lead TDFN22 package and 6-lead Thin SOT-23 package

## Typical Application


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## KTD2801/A/B

## Pin Descriptions

| Pin \# |  | Name | Function |
| :---: | :---: | :---: | :--- |
| TDFN22-6 | TSOT-23-6 |  | IC control pin. Can be used to enable/disable the IC, as well as to program the <br> output current using ExpressWire Control or PWM dimming. |
| 1 | 4 | CTRL | 6 |
| VIN | Input supply pin for the IC |  |  |
| 2 | 5 | VOUT | Output voltage pin |
| 3 | 3 | FB | Feedback voltage pin |
| 4 | 2 | GND | Converter/IC ground <br> 5 |
| 6 | 1 | LX | Switching node of the step-up converter <br> MC |

TDFN22-6 PKG
(Top View)


TSOT-23-6 PKG
(Top View)

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## Absolute Maximum Ratings ${ }^{1}$

## ( $\mathrm{T}_{\mathrm{A}}=25^{\circ} \mathrm{C}$ unless otherwise noted)

| Symbol | Description |  | Value | Units |
| :---: | :---: | :---: | :---: | :---: |
| VIN | Input voltage |  | -0.3 to 6.0 | V |
| LX, VOUT | High voltage nodes | KTD2801 | -0.3 to 40 | V |
|  |  | KTD2801A | -0.3 to 34 |  |
|  |  | KTD2801B | -0.3 to 28 |  |
| FB, CTRL | Other pins |  | -0.3 to VIN+0.3 | V |
| $\mathrm{T}_{J}$ | Operating Temperature Range |  | -40 to 150 | ${ }^{\circ} \mathrm{C}$ |
| $\mathrm{T}_{\mathrm{s}}$ | Storage Temperature Range |  | -65 to 150 | ${ }^{\circ} \mathrm{C}$ |
| TLEAD | Maximum Soldering Temperature (at leads, 10 sec ) |  | 300 | ${ }^{\circ} \mathrm{C}$ |

## Thermal Capabilities

| Symbol | Description | Value | Units |
| :---: | :--- | :---: | :---: |
| TDFN22-6 |  |  |  |
| $\theta_{\mathrm{JA}}$ | Thermal Resistance - Junction to Ambient ${ }^{2}$ | 65 | ${ }^{\circ} \mathrm{C} / \mathrm{W}$ |
| $\mathrm{P}_{\mathrm{D}}$ | Maximum Power Dissipation at $\mathrm{T}_{\mathrm{A}} \leq 25^{\circ} \mathrm{C}$ | 1.54 | W |
| $\Delta \mathrm{P}_{\mathrm{D}} /{ }^{\circ} \mathrm{C}$ | Derating Factor Above $\mathrm{T}_{\mathrm{A}}=25^{\circ} \mathrm{C}$ | -15.4 | $\mathrm{~mW} /{ }^{\circ} \mathrm{C}$ |
| TSOT23-6 |  |  |  |
| $\theta_{\mathrm{JA}}$ | Thermal Resistance - Junction to Ambient ${ }^{2}$ | 190 | ${ }^{\circ} \mathrm{C} / \mathrm{W}$ |
| $\mathrm{P}_{\mathrm{D}}$ | Maximum Power Dissipation at $\mathrm{T}_{\mathrm{A}} \leq 25^{\circ} \mathrm{C}$ | 0.526 | W |
| $\Delta \mathrm{P}_{\mathrm{D}} /{ }^{\circ} \mathrm{C}$ | Derating Factor Above $\mathrm{T}_{\mathrm{A}}=25^{\circ} \mathrm{C}$ | -1.9 | $\mathrm{~mW} /{ }^{\circ} \mathrm{C}$ |

## Ordering Information

| Part Number | OVP Threshold <br> (nominal) | Marking $^{3}$ | Operating Temperature | Package |
| :--- | :---: | :---: | :---: | :---: |
| KTD2801ECD-TR | 36 V | FFYYZ | $-40^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$ | TDFN22-6 |
| KTD2801AECD-TR | 30 V | FUYYZ | $-40^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$ | TDFN22-6 |
| KTD2801BECD-TR | 24 V | FGYYZ | $-40^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$ | TDFN22-6 |
| KTD2801EHD-TR | 36 V | FFYYZ | $-40^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$ | TSOT23-6 |
| KTD2801AEHD-TR | 30 V | FUYYZ | $-40^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$ | TSOT23-6 |
| KTD2801BEHD-TR | 24 V | FGYYZ | $-40^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$ | TSOT23-6 |

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## Electrical Characteristics ${ }^{4}$

Unless otherwise noted, the Min and Max specs are applied over the full operation temperature range of $-40^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$, while Typ values are specified at room temperature $\left(25^{\circ} \mathrm{C}\right)$. $\mathrm{VIN}=3.6 \mathrm{~V}$.


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Electrical Characteristics Continued ${ }^{5}$

| Symbol | Description | Conditions | Min | Typ | Max | Units |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Control |  |  |  |  |  |  |
| $\mathrm{V}_{\text {TH-L }}$ | CTRL logic low threshold |  |  |  | 0.4 | V |
| VTH-H | CTRL logic high threshold |  | 1.4 |  |  | V |
| Rctri | CTRL pull down resistor |  |  | 300 |  | $\mathrm{k} \Omega$ |
| toff | CTRL low pulse width to shutdown | CTRL high to low | 2.5 |  |  | ms |
| tew_det | ExpressWire detection time ${ }^{6}$ |  | 260 |  |  | $\mu \mathrm{S}$ |
| tew_delay | ExpressWire detection delay time |  | 140 |  |  | $\mu \mathrm{S}$ |
| tew_win | ExpressWire detection window time |  | 1 |  |  | ms |
| tos | Start time of programming data |  | 2 |  |  | $\mu \mathrm{S}$ |
| teod_h | End of data high time |  | 350 |  |  | $\mu \mathrm{S}$ |
| teod_L | End of data low time |  | 2 |  | 64 | $\mu \mathrm{S}$ |
| th_LB | High time low bit | Logic 0 | 2 |  | 64 | $\mu \mathrm{S}$ |
| tL_LB | Low time low bit | Logic 0 | $2 \times \mathrm{th}_{\text {L }} \mathrm{LB}$ |  | 128 | $\mu \mathrm{S}$ |
| tH_HB | High time high bit | Logic 1 | $2 \times \mathrm{t}$ __-HB |  | 128 | $\mu \mathrm{S}$ |
| tL_HB | Low time high bit | Logic 1 | 2 |  | 64 | $\mu \mathrm{S}$ |
| fıIm | Recommended PWM dimming frequency |  | 5 |  | 100 | kHz |
| D DIM | PWM dimming duty cycle resolution | $\mathrm{f}_{\text {DIM }}=20 \mathrm{kHz}$ | 2 |  |  | \% |
|  |  | $\mathrm{f}_{\text {DIM }}=30 \mathrm{kHz}$ | 3 |  |  | \% |
| $\mathrm{T}_{\text {J-TH }}$ | IC junction thermal shutdown threshold |  |  | 150 |  | ${ }^{\circ} \mathrm{C}$ |
|  | IC junction thermal shutdown hysteresis |  |  | 15 |  | ${ }^{\circ} \mathrm{C}$ |

5. The KTD2801 is guaranteed to meet performance specifications over the $-40^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$ operating temperature range by design, characterization and correlation with statistical process controls.
6. To select ExpressWire programming, the CTRL pin must be low for more than $t_{\text {EW_det }}$ during $\mathrm{t}_{\text {Ew_win. }}$.
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## Typical Characteristics

$\mathrm{V}_{\mathrm{IN}}=3.6 \mathrm{~V}, \mathrm{~L}=22 \mu \mathrm{H}$ (Coilcraft LPS4018-223), $\mathrm{C}_{\mathrm{IN}}=10 \mu \mathrm{~F}$, Cout $=0.47 \mu \mathrm{~F}$ with 8 LEDs in series at 20 mA , $T_{\text {AMB }}=25^{\circ} \mathrm{C}$, unless otherwise specified.

## Efficiency vs. Input Voltage



Efficiency vs. Input Voltage (lout $=40 \mathrm{~mA}, 2 \mathrm{P} 6 \mathrm{~S}$ LEDs)


Quiescent Current (non-switching)


Efficiency vs. LED Current


CTRL Logic Threshold Voltage


Operating Current (switching)

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## Typical Characteristics (continued)

$\mathrm{V}_{\mathrm{IN}}=3.6 \mathrm{~V}, \mathrm{~L}=22 \mu \mathrm{H}, \mathrm{C}_{\mathrm{IN}}=10 \mu \mathrm{~F}$, Cout $=0.47 \mu \mathrm{~F}$ with 8 LED in series at $20 \mathrm{~mA}, \mathrm{~T}_{\text {Amb }}=25^{\circ} \mathrm{C}$, unless otherwise specified.

Soft Start Turn On


Steady State Switching


PWM Dimming ( $10 \mathrm{kHz}, 50 \%$ duty cycle)


Turn Off


Turn On with LED Open (OVP)


PWM Dimming Linearity (20kHz)

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## KTD2801/A/B

## Typical Characteristics (continued)

$\mathrm{V}_{\mathrm{IN}}=3.6 \mathrm{~V}, \mathrm{~L}=22 \mu \mathrm{H}, \mathrm{C}_{\mathrm{IN}}=10 \mu \mathrm{~F}$, Cout $=0.47 \mu \mathrm{~F}$ with 8 LEDs in series at $20 \mathrm{~mA}, \mathrm{~T}_{\mathrm{AMB}}=25^{\circ} \mathrm{C}$, unless otherwise specified.

Switching Frequency

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## Functional Block Diagram



## Functional Description

The KTD2801/A/B uses a constant-frequency current-mode boost converter architecture to control the LED current by regulating the feedback voltage. Please refer to the functional block diagram above for an explanation of the device operation. At the beginning of each switching cycle, the internal power MOSFET turns on between the LX node and GND. A slope compensation ramp is added to the output of the current sense amplifier and the result is fed into the positive input of the comparator (COMP). When this voltage goes above the output voltage of the error amplifier ( $\mathrm{g}_{\text {м }}$, the power MOSFET is turned off. The voltage at the output of the $\mathrm{g}_{м}$ block amplifies the difference between the reference voltage and the feedback voltage (FB), so that FB voltage can be regulated to the reference voltage.

The driver has built-in soft-start to limit the inrush current during startup and to limit the amount of overshoot on the output. Protection features in the KTD2801 include over-voltage protection (OVP), cycle-by-cycle current limit protection and thermal shutdown. OVP protects in the event where an LED fails open, which forces the feedback voltage to zero. This causes the boost converter to operate in maximum duty cycle mode, ramping up the output voltage. Switching will stop when the output reaches the OVP threshold. The OVP feature protects the IC from damaging itself by exceeding the voltage rating on LX/VOUT pins.

The control interface can be used for either PWM dimming or ExpressWire ${ }^{T M}$ single-wire control. In ExpressWire mode, it accepts a data set into the CTRL pin to program the reference voltage. The data contains 8 bits, yielding 256 different current levels. In PWM dimming mode, PWM pulse is provided at CTRL pin to program the reference voltage according to the duty cycle of the PWM signal, so that the LED current is proportional to the PWM duty cycle. The simplest control method is accomplished by toggling CTRL between high and low to program the output current between $I_{\text {max }}$ and 0 mA . $I_{\text {max }}$ is set by the resistor connected between FB and GND. Please see LED Maximum Current Setting section in this document to determine the proper resistor value.

The KTD2801 enters shutdown mode whenever the CTRL input pin is pulled low for more than 2.5 ms .
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## Dimming Mode Selection

KTD2801 CTRL pin can be used for both PWM dimming and ExpressWire ${ }^{\text {TM }}$ dimming. The dimming mode is selected when the IC is enabled. By default, the dimming mode is PWM dimming.
To use ExpressWire ${ }^{\text {TM }}$ dimming, the first few pulses at CTRL pin should meet the following timing requirement shown in Figure 1.


Figure 1. Dimming Mode Detection Pulses

1. After the IC is powered up, CTRL's 1st pulse high width (ExpressWire detection delay time) tew_delay should be greater than $140 \mu \mathrm{~s}$.
2. CTRL's 1st pulse low width (ExpressWire detection time) tew_det should be greater than $260 \mu \mathrm{~s}$.
3. The programming pulses should be started within the ExpressWire detection window tew_win, which is 1 ms . Otherwise the default setting or previous stored setting will be used to set the reference voltage.

Once CTRL's initial pulses meet the above timing requirement, the IC enters ExpressWire dimming mode. Then the user can continue to send programming pulses to adjust the reference voltage. Once ExpressWire dimming mode is selected, the IC can only change to PWM dimming mode by resetting the IC through CTRL pin or power on reset.

## PWM Brightness Dimming Using CTRL Pin

After the IC is power reset, driving the CTRL pin continuously high will result in the FB voltage regulated at 200 mV nominal. However, the CTRL pin allows a PWM signal ( 5 kHz to 100 kHz ) to reduce this regulation voltage to control LED brightness dimming. The relationship between the duty cycle and FB voltage is given by the equation:

$$
V_{F B}=D C \times 200 \mathrm{mV}
$$

Where DC is the duty cycle of the PWM signal applied to CTRL pin, and 200 mV is the default internal reference voltage.

KTD2801 internally applies the PWM input signal to the 200 mV reference voltage which creates a 200 mV (peak) signal with the same duty cycle as the PWM input signal. This is fed into an RC low pass filter which gives a DC voltage proportional to the duty cycle of the PWM signal. This voltage is connected to the error amplifier as the reference voltage for the FB pin regulation. This means the PWM signal controls the current via translation to a DC signal to accomplish analog dimming. The advantage of this method is the elimination of audible noise which can occur when the LED current is pulsed at the frequency of the PWM dimming signal. For best performance, the PWM dimming frequency should be in the range of 5 kHz to 100 kHz . The minimum frequency requirement is determined by the ExpressWire detection delay and detection time specification in described in Dimming Mode Selection.
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## ExpressWire ${ }^{\text {TM }}$ Dimming Using CTRL Pin

The CTRL pin features a ExpressWire ${ }^{\text {TM }}$ digital interface to program LED brightness. KTD2801 uses the ExpressWire protocol for digital dimming, which can program the FB voltage to 256 linear steps, shown in Table 1. The default step is full scale when the device is first enabled ( $\mathrm{V}_{\mathrm{FB}}=200 \mathrm{mV}$ ). The programmed reference voltage is stored in an internal register. A power reset will bring the value back to the default setting; however, using CTRL to shut down the IC will not reset the internal register. Restarting the IC to ExpressWire dimming mode without setting the new FB voltage value will set the FB voltage back to the previous setting before the IC is shut down by CTRL pin.
Table 1. ExpressWire ${ }^{\text {TM }}$ Interface - FB Voltage Programming Table

| Code | $\mathrm{V}_{\mathrm{FB}}(\mathrm{mV})$ | Code | $\mathrm{V}_{\mathrm{FB}}(\mathrm{mV})$ | Code | $\mathrm{V}_{\mathrm{FB}}(\mathrm{mV})$ | Code | $\mathrm{V}_{\mathrm{FB}}(\mathrm{mV})$ | Code | $\mathrm{V}_{\mathrm{FB}}(\mathrm{mV})$ | Code | $\mathrm{V}_{\mathrm{FB}}(\mathrm{mV})$ | Code | $\mathrm{V}_{\mathrm{FB}}(\mathrm{mV})$ | Code | $\mathrm{V}_{\mathrm{FB}}(\mathrm{mV})$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0 | 0.78 | 32 | 25.78 | 64 | 50.78 | 96 | 75.78 | 128 | 100.78 | 160 | 125.78 | 192 | 150.78 | 224 | 175.78 |
| 1 | 1.56 | 33 | 26.56 | 65 | 51.56 | 97 | 76.56 | 129 | 101.56 | 161 | 126.56 | 193 | 151.56 | 225 | 176.56 |
| 2 | 2.34 | 34 | 27.34 | 66 | 52.34 | 98 | 77.34 | 130 | 102.34 | 162 | 127.34 | 194 | 152.34 | 226 | 177.34 |
| 3 | 3.13 | 35 | 28.13 | 67 | 53.13 | 99 | 78.13 | 131 | 103.13 | 163 | 128.13 | 195 | 153.13 | 227 | 178.13 |
| 4 | 3.91 | 36 | 28.91 | 68 | 53.91 | 100 | 78.91 | 132 | 103.91 | 164 | 128.91 | 196 | 153.91 | 228 | 178.91 |
| 5 | 4.69 | 37 | 29.69 | 69 | 54.69 | 101 | 79.69 | 133 | 104.69 | 165 | 129.69 | 197 | 154.69 | 229 | 179.69 |
| 6 | 5.47 | 38 | 30.47 | 70 | 55.47 | 102 | 80.47 | 134 | 105.47 | 166 | 130.47 | 198 | 155.47 | 230 | 180.47 |
| 7 | 6.25 | 39 | 31.25 | 71 | 56.25 | 103 | 81.25 | 135 | 106.25 | 167 | 131.25 | 199 | 156.25 | 231 | 181.25 |
| 8 | 7.03 | 40 | 32.03 | 72 | 57.03 | 104 | 82.03 | 136 | 107.03 | 168 | 132.03 | 200 | 157.03 | 232 | 182.03 |
| 9 | 7.81 | 41 | 32.81 | 73 | 57.81 | 105 | 82.81 | 137 | 107.81 | 169 | 132.81 | 201 | 157.81 | 233 | 182.81 |
| 10 | 8.59 | 42 | 33.59 | 74 | 58.59 | 106 | 83.59 | 138 | 108.59 | 170 | 133.59 | 202 | 158.59 | 234 | 183.59 |
| 11 | 9.38 | 43 | 34.38 | 75 | 59.38 | 107 | 84.38 | 139 | 109.38 | 171 | 134.38 | 203 | 159.38 | 235 | 184.38 |
| 12 | 10.16 | 44 | 35.16 | 76 | 60.16 | 108 | 85.16 | 140 | 110.16 | 172 | 135.16 | 204 | 160.16 | 236 | 185.16 |
| 13 | 10.94 | 45 | 35.94 | 77 | 60.94 | 109 | 85.94 | 141 | 110.94 | 173 | 135.94 | 205 | 160.94 | 237 | 185.94 |
| 14 | 11.72 | 46 | 36.72 | 78 | 61.72 | 110 | 86.72 | 142 | 111.72 | 174 | 136.72 | 206 | 161.72 | 238 | 186.72 |
| 15 | 12.50 | 47 | 37.50 | 79 | 62.50 | 111 | 87.50 | 143 | 112.50 | 175 | 137.50 | 207 | 162.50 | 239 | 187.50 |
| 16 | 13.28 | 48 | 38.28 | 80 | 63.28 | 112 | 88.28 | 144 | 113.28 | 176 | 138.28 | 208 | 163.28 | 240 | 188.28 |
| 17 | 14.06 | 49 | 39.06 | 81 | 64.06 | 113 | 89.06 | 145 | 114.06 | 177 | 139.06 | 209 | 164.06 | 241 | 189.06 |
| 18 | 14.84 | 50 | 39.84 | 82 | 64.84 | 114 | 89.84 | 146 | 114.84 | 178 | 139.84 | 210 | 164.84 | 242 | 189.84 |
| 19 | 15.63 | 51 | 40.63 | 83 | 65.63 | 115 | 90.63 | 147 | 115.63 | 179 | 140.63 | 211 | 165.63 | 243 | 190.63 |
| 20 | 16.41 | 52 | 41.41 | 84 | 66.41 | 116 | 91.41 | 148 | 116.41 | 180 | 141.41 | 212 | 166.41 | 244 | 191.41 |
| 21 | 17.19 | 53 | 42.19 | 85 | 67.19 | 117 | 92.19 | 149 | 117.19 | 181 | 142.19 | 213 | 167.19 | 245 | 192.19 |
| 22 | 17.97 | 54 | 42.97 | 86 | 67.97 | 118 | 92.97 | 150 | 117.97 | 182 | 142.97 | 214 | 167.97 | 246 | 192.97 |
| 23 | 18.75 | 55 | 43.75 | 87 | 68.75 | 119 | 93.75 | 151 | 118.75 | 183 | 143.75 | 215 | 168.75 | 247 | 193.75 |
| 24 | 19.53 | 56 | 44.53 | 88 | 69.53 | 120 | 94.53 | 152 | 119.53 | 184 | 144.53 | 216 | 169.53 | 248 | 194.53 |
| 25 | 20.31 | 57 | 45.31 | 89 | 70.31 | 121 | 95.31 | 153 | 120.31 | 185 | 145.31 | 217 | 170.31 | 249 | 195.31 |
| 26 | 21.09 | 58 | 46.09 | 90 | 71.09 | 122 | 96.09 | 154 | 121.09 | 186 | 146.09 | 218 | 171.09 | 250 | 196.09 |
| 27 | 21.88 | 59 | 46.88 | 91 | 71.88 | 123 | 96.88 | 155 | 121.88 | 187 | 146.88 | 219 | 171.88 | 251 | 196.88 |
| 28 | 22.66 | 60 | 47.66 | 92 | 72.66 | 124 | 97.66 | 156 | 122.66 | 188 | 147.66 | 220 | 172.66 | 252 | 197.66 |
| 29 | 23.44 | 61 | 48.44 | 93 | 73.44 | 125 | 98.44 | 157 | 123.44 | 189 | 148.44 | 221 | 173.44 | 253 | 198.44 |
| 30 | 24.22 | 62 | 49.22 | 94 | 74.22 | 126 | 99.22 | 158 | 124.22 | 190 | 149.22 | 222 | 174.22 | 254 | 199.22 |
| 31 | 25.00 | 63 | 50.00 | 95 | 75.00 | 127 | 100.00 | 159 | 125.00 | 191 | 150.00 | 223 | 175.00 | 255 | 200.00 |

The ExpressWire ${ }^{T M}$ protocol consists of 8 data bits in conjunction with DS (Data Start) and EOD (End Of Data) for acknowledge condition of data bit.

The protocol starts from DS time for data input and ends with EOD time to recognize the end of data. Figure 2 shows the ExpressWire ${ }^{T M}$ interface protocol.

The Low $\operatorname{Bit}(0)$ and $\operatorname{High} \operatorname{Bit}(1)$ is based on a time detection algorithms between tlow and thigh.
The $t_{L}$ lB is low time of the Low $\operatorname{Bit}(0)$ and the $t_{\text {H_LB }}$ is high time of the Low $\operatorname{Bit}(0)$.
The $t_{\text {__ }}$ нв is low time of the $\operatorname{High} \operatorname{Bit}(1)$ and the $t_{\text {н_ }}$ нв is high time of the $\operatorname{High} \operatorname{Bit}(1)$.
It can be simplified to :
Low $\operatorname{Bit}(0)$ : th_LB < tL_LB, but with tL_LB at least $2 x$ th_LB (see Figure 2)
High Bit(1) : tн_нв > t__нв, but with tн_нв at least $2 x$ tı_нв (see Figure 2)


Figure 2. ExpressWire ${ }^{\text {TM }}$ Interface - bit Coding Time

## ExpressWire ${ }^{\text {TM }}$ Interface Protocol

Output control and programmability is achieved by using the CTRL pin. Refer to the figures below for further explanation of the interface protocol.


Figure 3. ExpressWire ${ }^{\text {TM }}$ Interface Protocol Overview
Table 2. CTRL Data Bit Table

| IC PIN | Byte | Bit <br> Number | Name | Direction | Description |
| :---: | :---: | :---: | :---: | :---: | :---: |
| CTRL | Data Byte | 7 (MSB) | D7 | Input | DATA BIT 7 |
|  |  | 6 | D6 |  | DATA BIT 6 |
|  |  | 5 | D5 |  | DATA BIT 5 |
|  |  | 4 | D4 |  | DATA BIT 4 |
|  |  | 3 | D3 |  | DATA BIT 3 |
|  |  | 2 | D2 |  | DATA BIT 2 |
|  |  | 1 | D1 |  | DATA BIT 1 |
|  |  | 0 (LSB) | D0 |  | DATA BIT 0 |

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Table 3. CTRL - Disable Control

| IC PIN | Control | Description |
| :---: | :---: | :--- |
| CTRL | Low <br> $(>2.5 \mathrm{~ms})$ | - Device Shutdown |


| DATA IN | Setto Register <br> and Values |  |  |
| :--- | :--- | :--- | :---: |
| Data | DATA BYTE (D7:D0) | EOD | SET TO |
| Start | NEW EVENT |  |  |



Figure 4. ExpressWire ${ }^{\text {TM }}$ Interface - Set to Data Register Overview

## LED Maximum Current Setting

LED maximum current setting, Imax, is determined by the feedback resistor R1 (connected between FB and GND pins). The feedback voltage is internally set at 200 mV at $100 \%$ dimming setting. The LED current is programmed according to the formula $I_{\text {max }}=200 \mathrm{mV} /$ R1. For accurate LED current settings, precision $1 \%$ resistors are recommended. The formula and table for R1 selection are shown below.
R1 = 200mV / Imax

Table 4. Current Setting Resister (1\%Values)

| R1 ( $\mathbf{\Omega})$ <br> $\mathbf{1 \%}$ Values | IMAX Current <br> $(\mathbf{m A})$ |
| :---: | :---: |
| 200.0 | 1 |
| 40.2 | 5 |
| 20.0 | 10 |
| 13.3 | 15 |
| 10.0 | 20 |
| 6.7 | 30 |
| 2.0 | 100 |

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## Application Information

## Inductor Selection

A $10 \mu \mathrm{H}$ or $22 \mu \mathrm{H}$ inductor is recommended for the typical application. If high efficiency is a critical requirement, a low DCR inductor should be selected. The inductor's saturation current rating should also exceed the peak input current.
Table 5. Recommended Inductor Part Numbers

| Inductor Part Number | Value <br> $(\boldsymbol{\mu H})$ | DCR ( $\mathbf{\Omega})$ | Saturation <br> Current $(\mathbf{A})$ | Dimensions <br> $(\mathbf{m m})$ | Manufacturer |
| :---: | :---: | :---: | :---: | :---: | :---: |
| LPS4018-103ML | 10 | 0.20 max | 1.3 | $4 \times 4 \times 1.8$ | Coilcraft |
| LPS4018-223ML | 22 | 0.36 max | 0.74 | $4 \times 4 \times 1.8$ | Coilcraft |
| VLF4012AT-100MR79 | 10 | 0.35 | 0.79 | $3.5 \times 3.7 \times 1.2$ | TDK |
| VLF4014AT-100MR90 | 10 | 0.26 | 0.9 | $3.5 \times 3.7 \times 1.4$ | TDK |
| VLCF5020T-100MR87 | 10 | $0.182 \max$ | 0.87 | $5 \times 5 \times 2.0$ | TDK |
| VLCF5020T-220MR58 | 22 | $0.373 \max$ | 0.58 | $5 \times 5 \times 2.0$ | TDK |

## Capacitor Selection

Small size X5R or X7R ceramic capacitors are recommended for the KTD2801 application. A 10رF input capacitor and a $0.1 \mu \mathrm{~F}$ to $0.47 \mu \mathrm{~F}$ output capacitor are suggested for up to 10 -series LED applications. To prevent too much inrush current during LED open load condition, output capacitor values larger than $0.47 \mu \mathrm{~F}$ are not allowed for 10 -series LED applications.

Table 6. Recommended Ceramic Capacitor Vendors

| Manufacturer | Website |
| :---: | :---: |
| Murata | www.murata.com |
| AVX | www.avx.com |
| Taiyo Yuden | www.t-yuden.com |

## Optional Diode Selection

The KTD2801 has an integrated diode connected between LX and Vout. This internal diode provides excellent performance for up to 10-LED application; however, if more LEDs or higher efficiency is desired, an external low $\mathrm{V}_{\mathrm{F}}$ diode can be placed in parallel with the internal diode. In this configuration, a Schottky diode is recommended in KTD2801 applications because of its low forward voltage drop and fast reverse recovery time. The current rating of the Schottky diode should exceed the peak current of the boost converter. The voltage rating should also exceed the target output voltage.
Table 7. Recommended Schottky Diode Part Numbers

| Application | Schottky Diode <br> Part Number | Forward <br> Voltage <br> (V) | Forward <br> Current <br> $(\mathbf{m A )}$ | Reverse <br> Voltage <br> (V) | Manufacturer |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Up to 10 series LEDs | PMEG4005EJ | 0.42 | 500 | 40 | NXP |
| Up to 10 series LEDs | PMEG4010EJ | 0.54 | 1000 | 40 | NXP |
| $4 / 5 / 6$-series LEDs, 24V OVP | B130 | 0.52 | 1000 | 30 | Vishay |
| 8/10-series LEDs, 36V OVP | B150 | 0.75 | 1000 | 50 | Vishay |

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## Typical Application Circuits



Figure 5. Application Circuit for 10 LEDs in Series at 20 mA


Figure 6. Application Circuit for 2P6S LEDs at 40mA Output Current

## Layout Recommendation

PCB layout is very important for high frequency switching regulators in order to keep the loop stable and minimize noise. The input capacitor CIN should be very close to the IC to get the best decoupling. The traces to the inductor $L$ and output capacitor COUT should be kept as short as possible to minimize noise and ringing. FB is a sensitive node and it should be kept separate from the LX switching node in the PCB layout.


Figure 7. Recommended PCB Layout for TDFN22-6 Package
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## Packaging Information

TDFN22-6

Top View
Bottom View


| Dimension | mm |  |  |
| :---: | :---: | :---: | :---: |
|  | Min. | Typ. | Max. |
| A | 0.70 | 0.75 | 0.80 |
| A3 | 0.2 BSC |  |  |
| b | 0.25 | 0.30 | 0.35 |
| D | 1.90 | 2.00 | 2.10 |
| D2 | 1.40 | 1.50 | 1.60 |
| E | 1.90 | 2.00 | 2.10 |
| E2 | 0.80 | 0.90 | 1.00 |
| e | $0.65 B S C$ |  |  |
| L | 0.20 | 0.25 | 0.30 |

Side View

Recommended Footprint

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## TSOT23-6



Recommended Footprint


* Dimensions are in millimeters

[^2]
[^0]:    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.
    2. 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.
    3. "YYZ" is the date code and assembly code.
[^1]:    4. The KTD2801 is guaranteed to meet performance specifications over the $-40^{\circ} \mathrm{C}$ to $+85^{\circ} \mathrm{C}$ operating temperature range by design, characterization and correlation with statistical process controls.
[^2]:    Kinetic Technologies cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Kinetic Technologies product. No intellectual property or circuit patent licenses are implied. Kinetic Technologies reserves the right to change the circuitry and specifications without notice at any time.

