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# FAN73402

## LED Backlight Driving Boost Switch

### Features

- Single-Channel Boost LED Switch
- Internal Power MOSFET for PWM Dimming:  
 $R_{DS(ON)}=1.0\ \Omega$  at  $V_{GS}=10\ V$ ,  $BV_{DSS}=200\ V$
- Current-Mode PWM Control
- Internal Programmable Slope Compensation
- Wide Supply Voltage Range: 10 V to 35 V
- LED Current Regulation:  $\pm 1\%$
- Programmable Switching Frequency
- Analog and PWM Dimming
- Wide Dimming Ratio: On Time=10  $\mu s$  to DC
- Cycle-by-Cycle Current Limiting
- Thermal Shutdown: 150°C
- Open-LED Protection (OLP)
- Over-Voltage Protection (OVP)
- Over-Current Protection (OCP)
- Error Flag Generation (for External Load Switch)
- Internal Soft-Start
- 16-Lead SOIC Package

### Applications

- LED Backlight for LCD TV
- LED Backlight for LCD Monitor
- LED Lighting

### Description

The FAN73402 is a single-channel boost controller that integrates an N-channel power MOSFET for PWM dimming using Fairchild's proprietary planar Double-diffused MOSFET (DMOS) technology.

The IC operates as a constant-current source for driving high-current LEDs.

It uses Current Mode control with programmable slope compensation to prevent subharmonic oscillation. The IC provides protections including: open-LED protection, over-voltage protection, and direct-short protection for high system reliability.

The IC internally generates a FAULT signal with delay if an abnormal LED string condition occurs. PWM dimming and analog dimming functions can be implemented independently. Internal soft-start prevents inrush current flowing into output capacitor at startup.



### Ordering Information

| Part Number | Operating Temperature Range | Package  | Packing Method |
|-------------|-----------------------------|--|----------------|
| FAN73402MX  | -40°C to +125°C             | 16-Lead, Small-Outline Integrated Circuit (SOIC) | Tape & Reel    |

Block Diagram

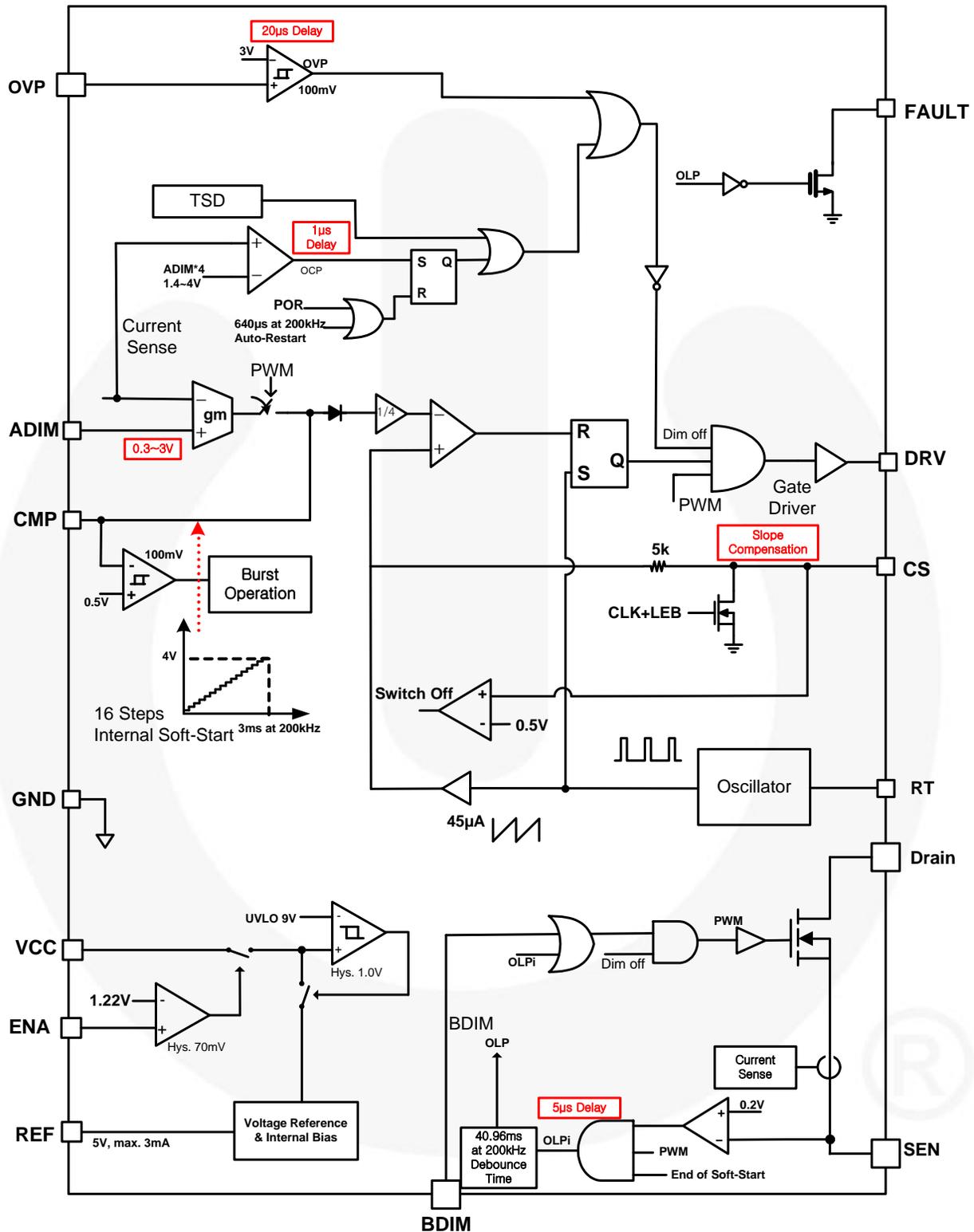


Figure 1. Internal Block Diagram

## Pin Assignments

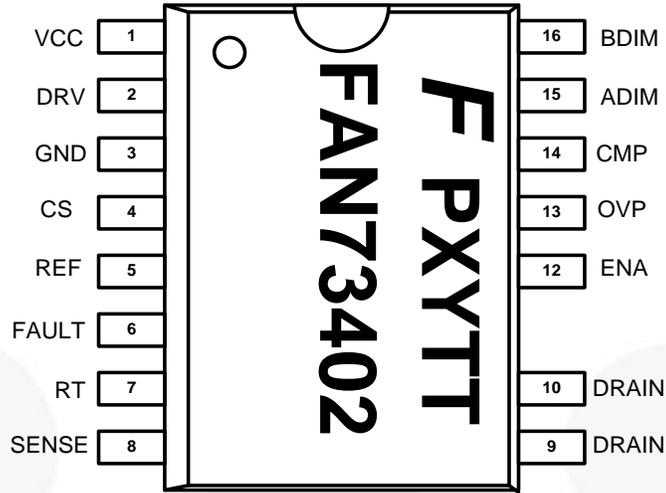


Figure 2. Package Diagram

## Pin Definitions

| Pin # | Name  | Description   |
|-------|-------|---|
| 1     | VCC   | This pin is the supply voltage of the IC.   |
| 2     | DRV   | This pin is the gate drive signal of the boost switch.  |
| 3     | GND   | This pin is the ground of the IC.   |
| 4     | CS    | This pin is for sensing the current flowing through an external MOSFET. It includes a built-in 300 ns blanking time. The peak of the current flowing through the MOSFET is limited to this pin voltage. Slope compensation of the boost controller can be programmed through the series resistor of this pin. |
| 5     | REF   | This pin is the 5 V reference voltage pin. Maximum current capability is 3 mA.  |
| 6     | FAULT | This pin is for indicating the fault signal. This pin is connected to the open drain. When OLP protection is occurred, the FAULT pin is pulled HIGH.  |
| 7     | RT    | Oscillator frequency set of the boost switch (50 kHz ~ 300 kHz).  |
| 8     | SENSE | This pin is for sensing the current flowing through the LEDs. A sensing resistor is connected from this pin to ground. This pin is connected to the negative input of the internal error amplifier.   |
| 9, 10 | DRAIN | Drain pin of PWM dimming power MOSFET.  |
| 12    | ENA   | Enable input pin. If voltage of this pin is higher than 1.22 V, the IC starts to operate. If the voltage of this pin is lower than 1.15 V, the IC stops operating.  |
| 13    | OVP   | Over-voltage protection input pin. Output voltage of the boost circuit is connected to this pin through a resistor divider circuit. If this pin voltage is higher than 3 V, OVP is triggered.   |
| 14    | CMP   | This pin is the error amplifier output. Typically, a compensation capacitor and resistor are connected to this pin from the ground.   |
| 15    | ADIM  | This pin is for setting the current flowing through the LEDs. This pin is connected to the positive inputs of the internal error amplifier. Linear voltage range of ADIM is 0.3 V~3.0 V.  |
| 16    | BDIM  | This pin is for the burst dimming signal. If this pin voltage is HIGH, the internal dimming MOSFET is turned on. If this pin voltage is LOW, the dimming MOSFET is turned off.  |

**Note:**

- Pin 11 is a "No Connect" pin (not shown in Figure 2).

## Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.  $T_A=25^{\circ}\text{C}$  unless otherwise specified.

| Symbol        | Parameter   | Min. | Max. | Unit                        |
|---------------|---|------|------|-----------------------------|
| $V_{CC}$      | Supply Voltage  | 10   | 35   | V                           |
| $T_A$         | Operating Temperature Range                             | -40  | +125 | $^{\circ}\text{C}$          |
| $T_J$         | Junction Temperature                                    |      | +150 | $^{\circ}\text{C}$          |
| $T_{STG}$     | Storage Temperature Range                               | -65  | +150 | $^{\circ}\text{C}$          |
| $\Theta_{JA}$ | Thermal Resistance Junction-to-Ambient <sup>(2,3)</sup> |      | 120  | $^{\circ}\text{C}/\text{W}$ |
| $P_D$         | Power Dissipation                                       |      | 0.9  | W                           |

### Notes:

- Thermal resistance test board; size 76.2 mm x 114.3 mm x 1.6 mm (1S0P); JEDEC standard: JESD51-2, JESD51-3.
- Assume no ambient airflow.

## Pin Breakdown Voltage

| Pin # | Name  | Value | Unit |
|-------|-------|-------|------|
| 1     | VCC   | 35    | V    |
| 2     | DRV   | 20    | V    |
| 3     | GND   |       | V    |
| 4     | CS    | 6     | V    |
| 5     | REF   | 6     | V    |
| 6     | FAULT | 35    | V    |
| 7     | RT    | 6     | V    |
| 8     | SENSE | 6     | V    |

| Pin # | Name  | Value | Unit |
|-------|-------|-------|------|
| 9     | DRAIN | 200   | V    |
| 10    | DRAIN | 200   | V    |
|       |       |       |      |
| 12    | ENA   | 6     | V    |
| 13    | OVP   | 6     | V    |
| 14    | CMP   | 6     | V    |
| 15    | ADIM  | 6     | V    |
| 16    | BDIM  | 6     | V    |

## Electrical Characteristics

For typical values,  $T_A = 25^\circ\text{C}$  and  $V_{CC} = 15\text{ V}$  unless otherwise specified. Specifications to  $-40^\circ\text{C} \sim 125^\circ\text{C}$  are guaranteed by design based on final characterization results.

| Symbol                               | Parameter                                       | Condition   | Min. | Typ. | Max. | Unit            |
|--------------------------------------|---|---|------|------|------|-----------------|
| <b>Supply Voltage Section</b>        |   |   |      |      |      |                 |
| $V_{CC}$                             | Input DC Supply Voltage Range <sup>(4)</sup>    |   | 10   |      | 35   | V               |
| $I_{SD}$                             | Shutdown Mode Supply Current                    | BDIM Connected to GND                                   |      | 2    | 4    | mA              |
| <b>Under-Voltage Lockout Section</b> |   |   |      |      |      |                 |
| $V_{th}$                             | Start Threshold Voltage                         |   | 8.3  | 9.0  | 9.7  | V               |
| $V_{th,hys}$                         | Start Threshold Voltage Hysteresis              |   | 0.5  | 1.0  | 1.5  | V               |
| $I_{st}$                             | Standby Current                                 | $V_{CC}=V_{th}-0.2$                                     |      | 200  | 300  | $\mu\text{A}$   |
| <b>ON/OFF Section</b>                |   |   |      |      |      |                 |
| $V_{ON}$                             | On-State Input Voltage                          |   | 2    |      | 5    | V               |
| $V_{OFF}$                            | Off-State Input Voltage                         |   |      |      | 0.8  | V               |
| <b>Error Amplifier Section</b>       |   |   |      |      |      |                 |
| $G_m$                                | Error Amplifier Transconductance <sup>(4)</sup> | $V_{ADIM}=1\text{ V}$                                   | 100  | 300  | 500  | $\mu\text{mho}$ |
| $A_{V\_ro}$                          | Error Amplifier Output impedance <sup>(4)</sup> |   |      | 20   |      | M $\Omega$      |
| $A_V$                                | Error Amplifier Open-Loop Gain <sup>(4)</sup>   |   |      | 60   |      | dB              |
| $V_{offset}$                         | Input Offset Voltage                            | $V_{ADIM}=1\text{ V}$                                   | -10  |      | 10   | mV              |
| $I_{sin}$                            | CMP Sink Current                                | $V_{ADIM}=1\text{ V}, V_{SENSE}=2\text{ V}$             | 100  | 200  | 300  | $\mu\text{A}$   |
| $I_{sur}$                            | CMP Source Current                              | $V_{ADIM}=1\text{ V}, V_{SENSE}=0\text{ V}$             | 100  | 200  | 300  | $\mu\text{A}$   |
| $V_{IDR}$                            | Input Differential Voltage Range                |   | 0    |      | 3    | V               |
| $V_O$                                | Output Voltage Range                            |   | 0.7  |      | 4.0  | V               |
| <b>Oscillator Section</b>            |   |   |      |      |      |                 |
| $f_{osc}$                            | Boost Oscillator Frequency                      | Minimum   |      | 50   |      | kHz             |
|                                      |   | $R_T=100\text{ k}\Omega$                                | 190  | 200  | 210  |                 |
|                                      |   | Maximum   |      | 300  |      |                 |
| $D_{max}$                            | Maximum Duty Cycle <sup>(4)</sup>               |   | 86   | 90   | 94   | %               |
| <b>Reference Section</b>             |   |   |      |      |      |                 |
| $V_{REF}$                            | 5 V Regulation Voltage                          |   | 4.9  | 5.0  | 5.1  | V               |
| $V_{REF,Line}$                       | 5 V Line Regulation                             |   |      |      | 25   | mV              |
| $V_{REF,Load}$                       | 5 V Load Regulation                             | $0<I_L<3\text{ mA}$                                     |      |      | 25   | mV              |
| <b>PWM Dimming Section</b>           |   |   |      |      |      |                 |
| $V_{PDIM,L}$                         | PWM Dimming Input Low Voltage                   |   |      |      | 0.8  | V               |
| $V_{PDIM,H}$                         | PWM Dimming Input High Voltage                  |   | 2    |      | 5    | V               |
| $R_{PDIM}$                           | PWM Dimming Pull-Down Resistance                |   | 100  | 160  | 220  | k $\Omega$      |
| <b>FET Section (for Dimming)</b>     |   |   |      |      |      |                 |
| $BV_{DSS}$                           | Drain-Source Breakdown Voltage <sup>(4)</sup>   | $V_{CC}=0\text{ V}, I_D=250\text{ }\mu\text{A}$         | 200  |      |      | V               |
| $I_{DSS}$                            | Zero-Gate-Voltage Drain Current <sup>(4)</sup>  | $V_{DS}=250\text{ V}, T_A=25^\circ\text{C}$             |      | 1    | 30   | $\mu\text{A}$   |
| $R_{DS(ON)}$                         | Drain-Source On-State Resistance                | $V_{GS}=10\text{ V}, I_D=1\text{ A}$                    |      | 0.7  | 1.0  | $\Omega$        |
| $C_{ISS}$                            | Input Capacitance <sup>(4)</sup>                | $V_{DS}=25\text{ V}, V_{GS}=0\text{ V}, f=1\text{ MHz}$ |      | 173  | 225  | pF              |
| $C_{OSS}$                            | Output Capacitance <sup>(4)</sup>               | $V_{DS}=25\text{ V}, V_{GS}=0\text{ V}, f=1\text{ MHz}$ |      | 30   | 40   | pF              |

Continued on the following page...

**Electrical Characteristics** (Continued)

For typical values,  $T_A = 25^\circ\text{C}$  and  $V_{CC} = 15\text{ V}$ , unless otherwise specified. Specifications to  $-25^\circ\text{C} \sim 85^\circ\text{C}$  are guaranteed by design based on final characterization results.

| Symbol                                  | Parameter  | Condition                | Min.                | Typ.                  | Max.                | Unit             |
|---|--|--------------------------|---------------------|-----------------------|---------------------|------------------|
| <b>Output Section (Boost / Dimming)</b> |  |                          |                     |                       |                     |                  |
| $V_{DRV}$                               | Gate Output Voltage  | $V_{CC}=15\text{ V}$     | 10.8                | 11.8                  | 12.8                | V                |
| $V_{UV}$                                | Gate Output Voltage Before Startup                           |                          | -0.5                |                       | 0.5                 | V                |
| $I_{dsur}$                              | Gate Output Drive-Source Current <sup>(4)</sup>              |                          | 80                  | 180                   | 280                 | mA               |
| $I_{dsin}$                              | Gate Output Drive-Sink Current <sup>(4)</sup>                |                          | 80                  | 180                   | 280                 | mA               |
| $t_{rh}$                                | Gate Output Rising Time (Boost) <sup>(4)</sup>               | $C_L=2.0\text{ nF}$      |                     | 200                   |                     | ns               |
| $t_{fl}$                                | Gate Output Falling Time (Boost) <sup>(4)</sup>              | $C_L=2.0\text{ nF}$      |                     | 120                   |                     | ns               |
| <b>Current Sense Section</b>            |  |                          |                     |                       |                     |                  |
| $t_{blank}$                             | Leading-Edge Blanking <sup>(4)</sup>                         |                          | 150                 | 300                   | 450                 | ns               |
| $t_{delay,cl}$                          | Delay to Output of Current-Limit Comparator <sup>(4)</sup>   |                          |                     |                       | 180                 | ns               |
| $V_{offset,clc}$                        | Offset Voltage of Current-Limit Comparator <sup>(4)</sup>    |                          | -20                 |                       | 20                  | mV               |
| <b>Slope Compensation Section</b>       |  |                          |                     |                       |                     |                  |
| $I_{slope}$                             | Ramp Generator Current                                       |                          | 36                  | 45                    | 54                  | $\mu\text{A}$    |
| $R_{slope}$                             | Slope Compensation Resistor <sup>(4)</sup>                   |                          |                     | 5                     |                     | k $\Omega$       |
| <b>Soft-Start Section</b>               |  |                          |                     |                       |                     |                  |
| $t_{ss}$                                | Soft-Start Period <sup>(4)</sup>                             | $f_{osc}=200\text{ kHz}$ |                     | 3                     |                     | ms               |
| <b>Protection Section</b>               |  |                          |                     |                       |                     |                  |
| $t_{d,ovp,tr}$                          | Delay for Triggering Over-Voltage Protection <sup>(4)</sup>  |                          | 15                  | 20                    | 25                  | $\mu\text{s}$    |
| $t_{d,ovpr}$                            | Delay for Releasing Over-Voltage Protection <sup>(4)</sup>   |                          | 10                  | 14                    | 18                  | $\mu\text{s}$    |
| $t_{d,ocp}$                             | Delay for Over-Current Protection <sup>(4)</sup>             |                          |                     | 1                     |                     | $\mu\text{s}$    |
| $t_{AR}$                                | Auto-Restart Time for Over-Current Protection <sup>(4)</sup> | $f_{osc}=200\text{ kHz}$ |                     | 640                   |                     | $\mu\text{s}$    |
| $t_{d,olp}$                             | Delay for Triggering Open-LED Protection <sup>(4)</sup>      |                          | 3                   | 5                     | 7                   | $\mu\text{s}$    |
| $t_{d,olp}$                             | Delay for Open-LED Protection                                | $f_{osc}=200\text{ kHz}$ |                     | 40.96                 |                     | ms               |
| $V_{th,ovp}$                            | Over-Voltage Protection Threshold Voltage                    |                          | 2.85                | 3.00                  | 3.15                | V                |
| $V_{hys,ovp}$                           | Over-Voltage Protection Voltage Hysteresis                   |                          |                     | 0.1                   |                     | V                |
| $V_{th,csocp}$                          | Boost Switch Current-Limit Threshold Voltage                 |                          | 0.45                | 0.50                  | 0.55                | V                |
| $V_{th,ocp}$                            | LED Over-Current Protection Threshold Voltage                |                          | 1.4<br>(Min. Clamp) | $4.0 \times V_{ADIM}$ | 4.0<br>(Max. Clamp) | V                |
| $V_{th,olp}$                            | Open-LED Protection Threshold Voltage <sup>(4)</sup>         |                          | 0.15                | 0.20                  | 0.25                | V                |
| $T_{SD}$                                | Thermal Shutdown Temperature <sup>(4)</sup>                  |                          | 140                 | 150                   | 160                 | $^\circ\text{C}$ |
| $T_{HYS}$                               | Thermal Shutdown Hysteresis <sup>(4)</sup>                   |                          |                     | 20                    |                     | $^\circ\text{C}$ |

**Note:**

4. These parameters, although guaranteed, are not tested in production.

## Typical Performance Characteristics

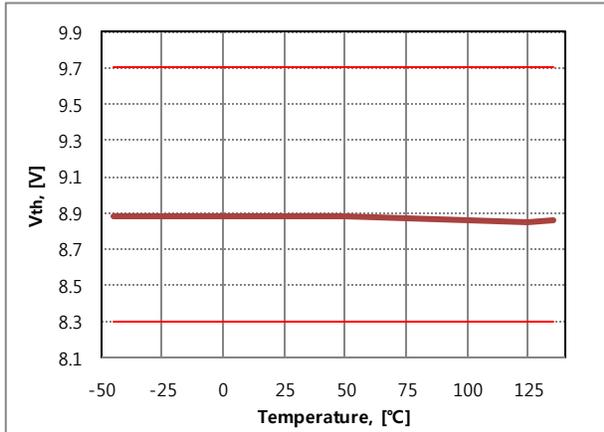


Figure 3. Start Threshold Voltage vs. Temperature

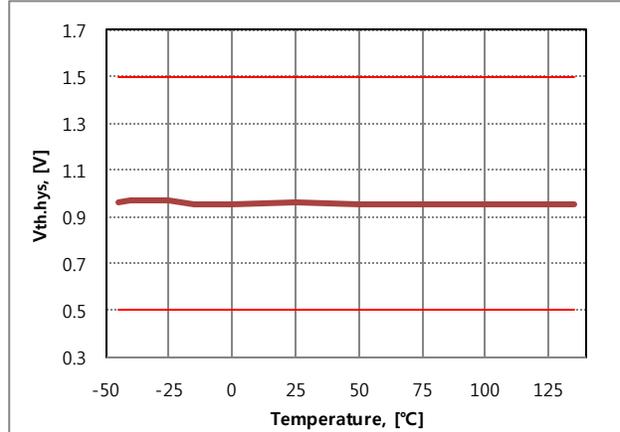


Figure 4. Start Threshold Voltage Hysteresis vs. Temperature

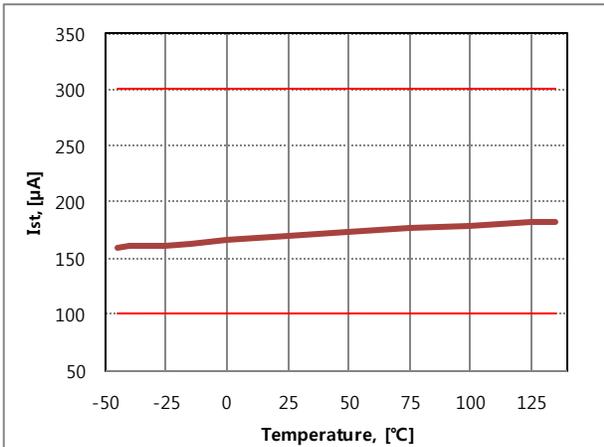


Figure 5. Standby Current vs. Temperature

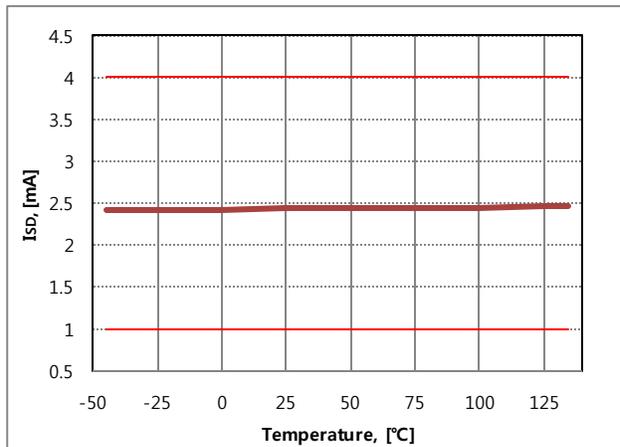


Figure 6. Shutdown Mode Supply Current vs. Temperature

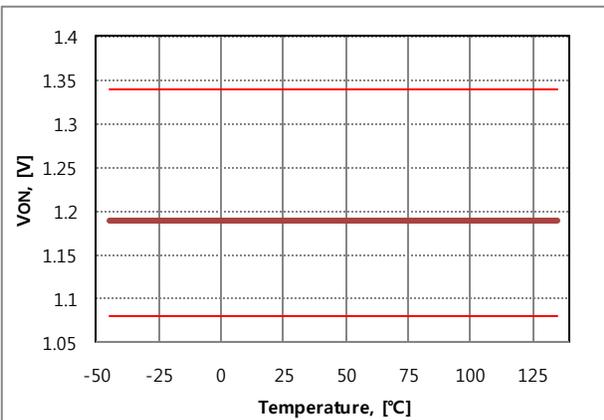


Figure 7. On-State Input Voltage vs. Temperature

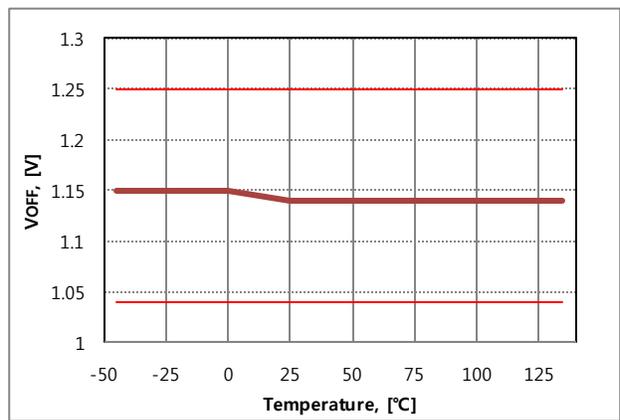


Figure 8. Off-State Input Voltage vs. Temperature

## Typical Performance Characteristics (Continued)

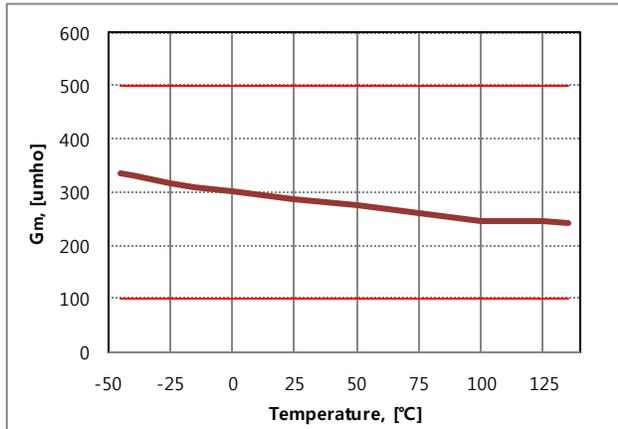


Figure 9. Error Amplifier Transconductance vs. Temperature

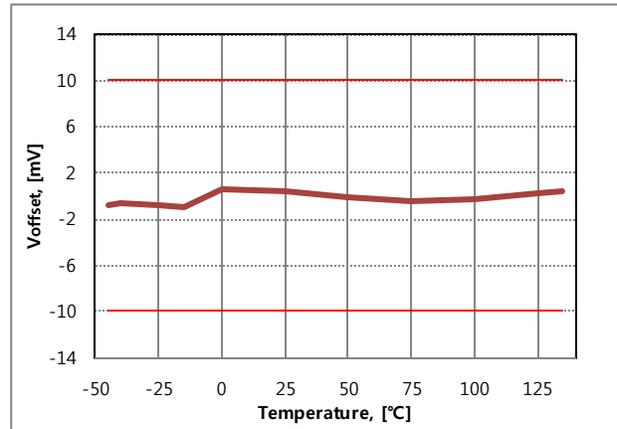


Figure 10. Input Offset Voltage vs. Temperature

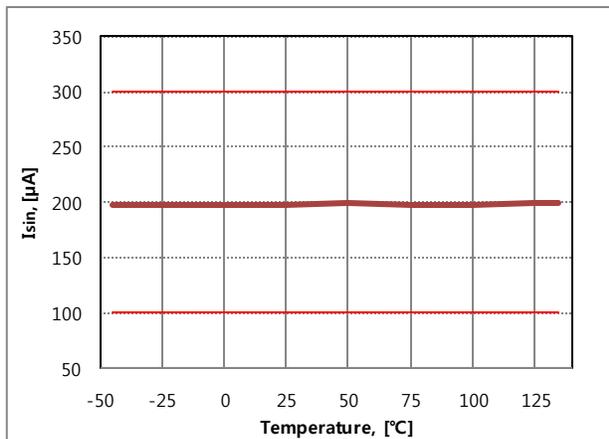


Figure 11. CMP Sink Current vs. Temperature

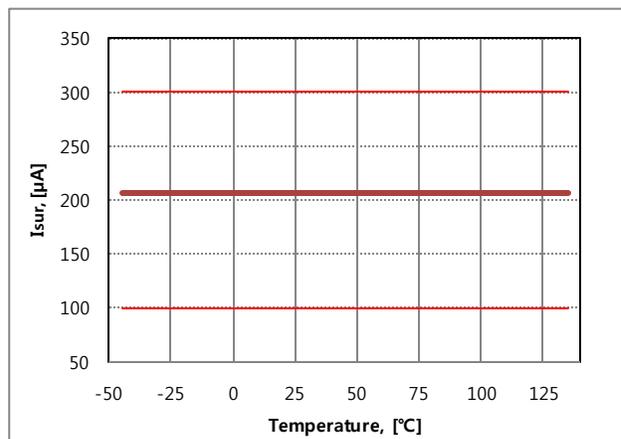


Figure 12. CMP Source Current vs. Temperature

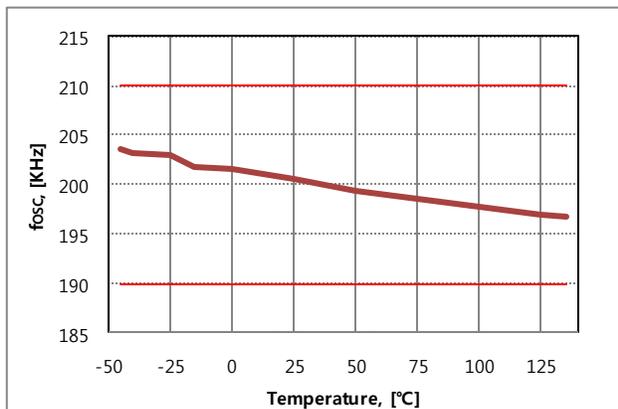


Figure 13. Boost Oscillator Frequency vs. Temperature

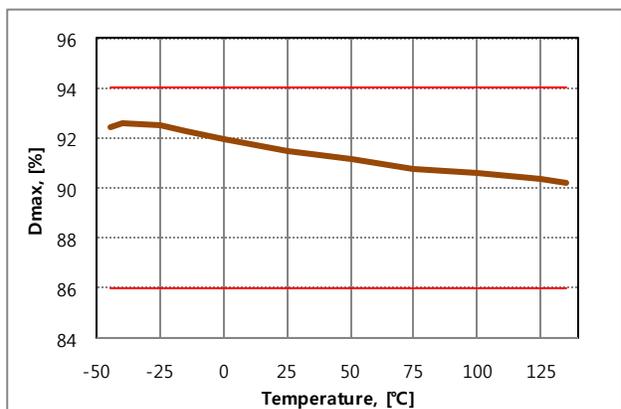
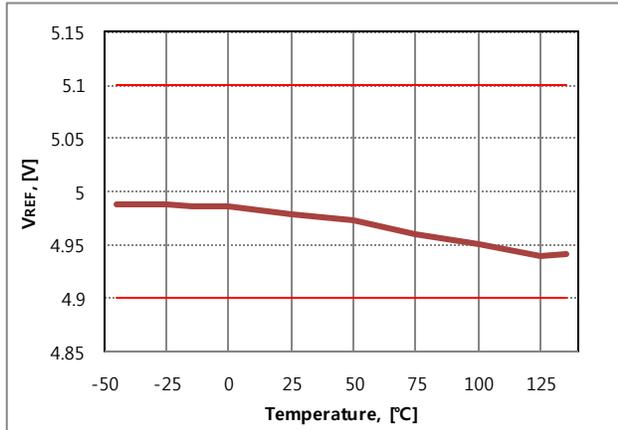
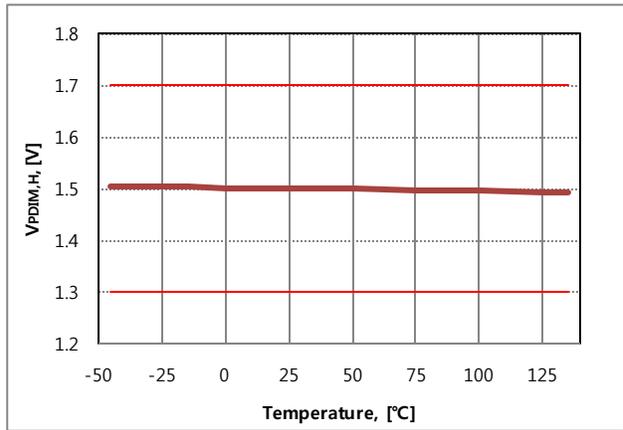


Figure 14. Maximum Duty Cycle vs. Temperature

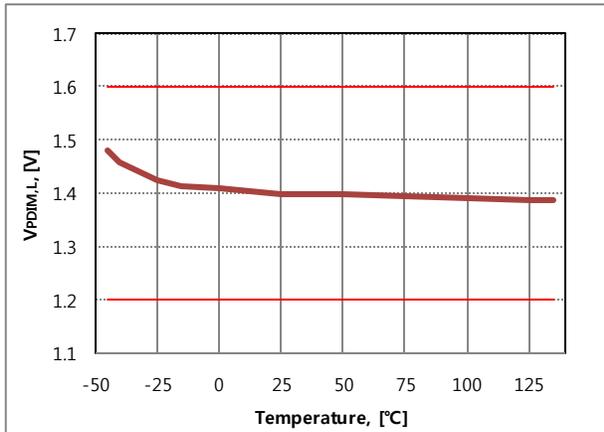
**Typical Performance Characteristics** (Continued)



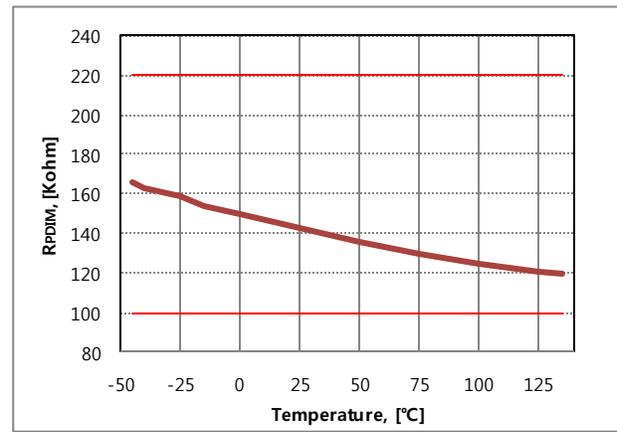
**Figure 15. 5 V Regulation Voltage vs. Temperature**



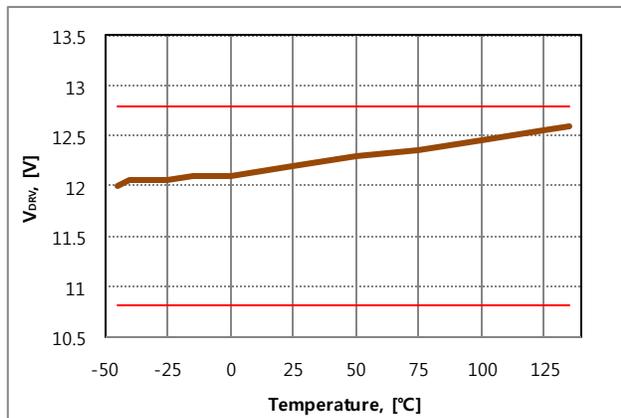
**Figure 16. PWM Dimming Input High Voltage vs. Temperature**



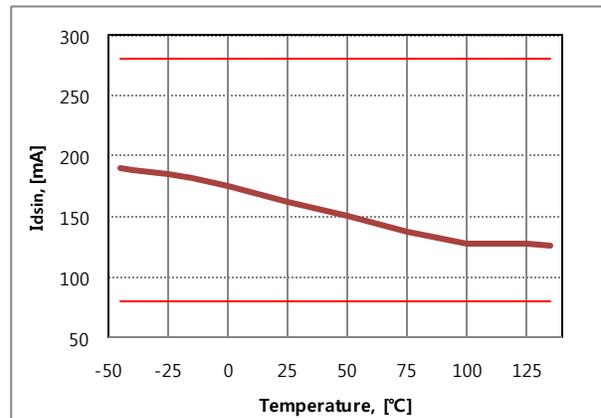
**Figure 17. PWM Dimming Input Low Voltage vs. Temperature**



**Figure 18. PWM Dimming Pull-Down Resistance vs. Temperature**



**Figure 19. Gate Output Voltage vs. Temperature**



**Figure 20. Gate Output Drive Sink Current vs. Temperature**

Typical Performance Characteristics (Continued)

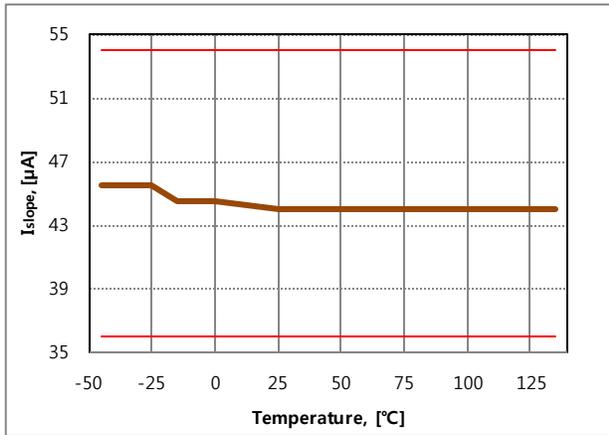


Figure 21. Ramp Generator Current vs. Temperature

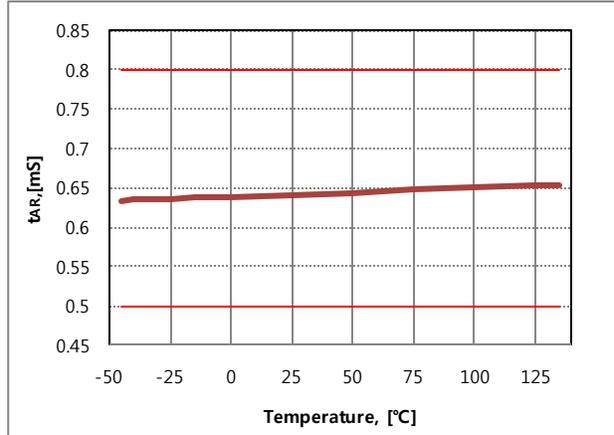


Figure 22. Auto-Restart Time for OC vs. Temperature

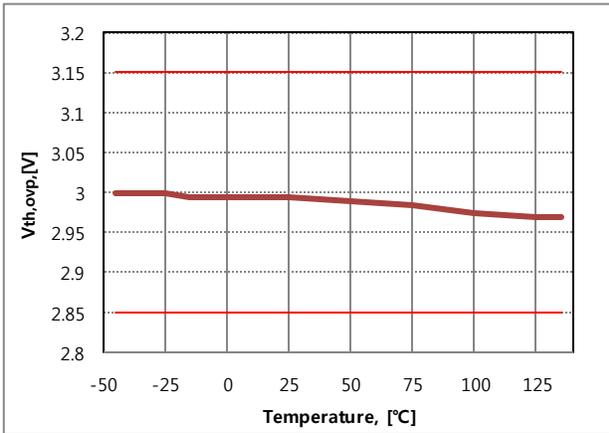


Figure 23. OVP Threshold Voltage vs. Temperature

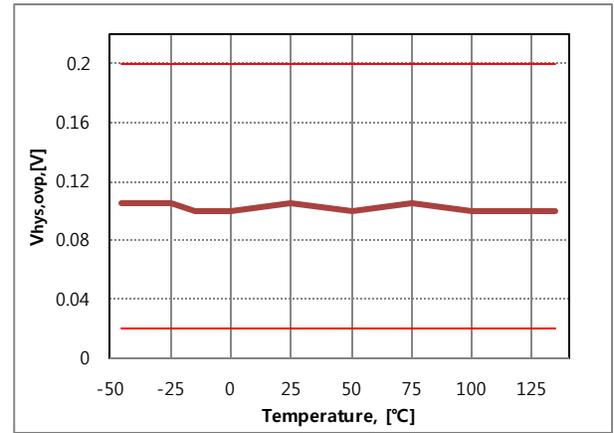


Figure 24. OVP Hysteresis Voltage vs. Temperature

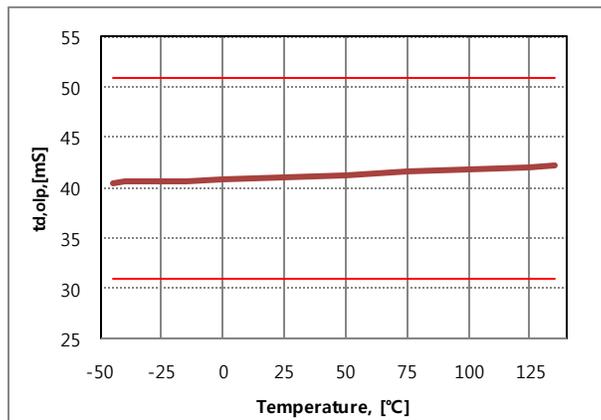


Figure 25. Delay for Over-Current Protection vs. Temperature

## Functional Description

The FAN73402 operates as a constant-current source for driving high-current LEDs. It uses Current-Mode control with programmable slope compensation to prevent subharmonic oscillation.

The IC provides open-LED protection, over-voltage protection, and over-current protection for improved system reliability. The IC internally generates a FAULT OUT signal with a delay in case an abnormal LED string condition occurs. PWM dimming and analog dimming functions can be implemented independently. Internal soft-start prevents inrush current flowing into output capacitor at startup.

### V<sub>CC</sub> Under-Voltage Lockout (UVLO)

An internal regulator provides the regulated 5V used to power the IC. The Under-Voltage Lockout (UVLO) turns off the IC in the event of the voltage dropping below the specific threshold level. The UVLO circuit inhibits powering the IC until a voltage reference is established, up to predetermined threshold level.

### Enable

Applying voltage higher than 1.22 V (typical) to the ENA pin enables the IC. Applying voltage lower than 1.15 V (typical) to the ENA pin disables the IC. If ENA pin voltage is higher than 1.22 V (typical) and V<sub>CC</sub> is higher than 9.0 V (typical), the IC starts to supply the 5 V reference voltage from V<sub>CC</sub>.

### Oscillator (Boost Switching Frequency)

Boost switching frequency is programmed by the value of the resistor connected from the RT pin to ground. RT pin voltage is set to 2V. The current through the RT pin resistor determines the boost switching frequency according to formula:

$$f_{\text{OSC}} = \frac{1}{(46.5 \times \text{RT}[\text{k}\Omega] + 350) \times 10^{-6}} \text{ [kHz]} \quad (1)$$

### Soft-Start Function at Startup

During initial startup, the switching device can be damaged due to the over-current coming from the input line by the negative control. This can result in the initial overshoot of the LED current. Therefore, during initial startup, the soft-start control gradually increases the duty cycle so that the output voltage can rise smoothly to control inrush current and overshoot.

FAN73402 adapts the soft-start function in the boost converter stage. During soft-start period, boost switch turn-on duty is limited by the clamped CMP voltage. The soft-start period is dependent on the boost switching frequency, which is determined by the RT resistor (Equation (1)). Soft-start period is set to be cumulative time when the BDIM (PWM dimming) signal is HIGH:

$$t_{\text{SS}} = 600 / f_{\text{OSC}} \text{ [seconds]} \quad (2)$$

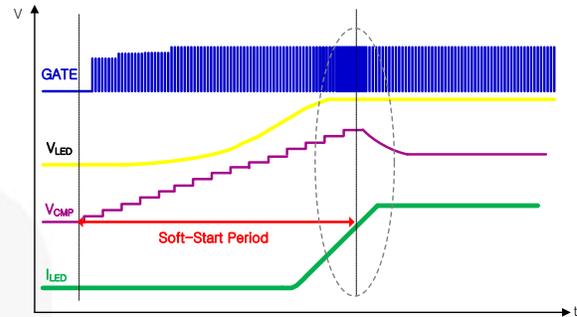


Figure 26. Soft-Start Waveforms

### LED Current Setting

During the boost converter operating periods, the output LED current can be set by equation:

$$I_{\text{LED}} = \frac{\text{ADIM}(V)}{R_{\text{SENSE}} + 60\text{m}\Omega} \quad (3)$$

where ADIM(V) is ADIM pin applied voltage and, R<sub>SENSE</sub> is the sensing resistor value.

### Note:

- An additional 60 mΩ comes from an internal wire bonding resistor. To calculate LED current precisely, consider the wire bonding resistor.

### Analog Dimming and PWM Dimming

Analog dimming (ADIM) is achieved by varying the voltage level at the ADIM pin. This can be implemented either with a potentiometer from the VREF pin or from an external voltage source and a resistor divider circuit. The ADIM voltage level is adjusted to be the same as the feedback level (V<sub>SENSE</sub>). A V<sub>ADIM</sub> range from 0.3 V to 3 V is recommended.

PWM dimming (BDIM) helps achieve a fast PWM dimming response in spite of the shortcomings of the boost converter. The PWM dimming signal controls three nodes in the IC: gate signal to the switching FET, gate signal to the dimming FET, and output connection of the transconductance amplifier. When the PWM dimming signal is HIGH, the gates of the switching FET and dimming FET are enabled. At the same time, the output of the transconductance op-amp is connected to the compensation network. This allows the boost converter to operate normally.

### Dynamic Contrast Ratio

The Dynamic Contrast Ratio (DCR) means the maximum contrast ratio achievable by adjusting the amount of light (dimming) of the screen using the backlight during an extremely short period of time. FAN73402 can normally drive the LED backlight under 0.1% dimming duty cycle at 200 Hz dimming frequency. Even operating at 5 μs dimming MOSFET turn-on time and extremely low dimming duty, FAN73402 can operate LEDs with normal peak current level.

## Internal Dimming MOSFET

A dimming MOSFET (200 V N-channel MOSFET) is incorporated in the FAN73402. The power transistor is produced using Fairchild's proprietary, planar stripe, DMOS technology. This advanced technology is tailored to minimize on-state resistance ( $R_{DS(on)}=1.0\ \Omega$ ) to provide superior switching performance. This device is suited for high-efficiency SMPS and shows desirable thermal characteristic during operation. To prevent initial LED current overshoot at low  $V_{ADIM}$  levels, gate resistance of the internal dimming FET is designed as  $5\ k\Omega$ .

## Feedback Loop Compensation

Stable closed-loop control can be accomplished by connecting a compensation network between COMP and GND. The compensation needed to stabilize the converter can be a Type-I circuit (a simple integrator) or a Type-II circuit (an integrator with an additional pole-zero pair). The type of the compensation circuit required is dependent on the phase of the power stage at the crossover frequency.

FAN73402 adopts a Type-II compensator circuit.

## Programmed Current Control

FAN73402 uses Current-Mode control. Current-Mode control loops: an outer feedback loop that senses output voltage (current) and delivers a DC control voltage to an inner feedback loop, which senses the peak current of the inductor and keeps it constant on a pulse-by-pulse basis. One of the advantages of the Current-Mode control is line/load regulation, which is corrected instantaneously against line voltage changes without the delay of an error amplifier.

## Programmable Slope Compensation

When the power converter operates in Continuous Conduction Mode (CCM), the current programmed controller is inherently unstable when duty is larger than 50%, regardless of the converter topology. The FAN73402 uses a Peak-Current-Mode control scheme with programmable slope compensation and includes an internal transconductance amplifier to accurately control the output current over all line and load conditions.

An internal  $R_{slope}$  resistor ( $5\ k\Omega$ ) connected to sensing resistor,  $R_S$ , and an external resistor,  $R_1$ , can control the slope of  $V_{SC}$  for the slope compensation. Although the normal operating mode of the power converter is DCM, the boost converter operates in CCM in the case of rapid LED current increase. As a result, slope compensation is an important feature.

The value of an external series resistor ( $R_1$ ) can be programmed. In normal DCM operation,  $5\ k\Omega$  is recommended.

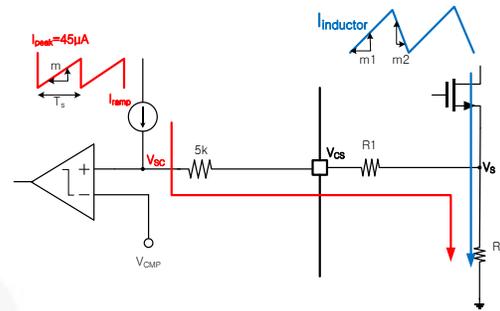


Figure 27. Slope Compensation

## Cycle-by-Cycle Over-Current Protection

In boost topology, the switch can be damaged in abnormal conditions (inductor short, diode short, output short). It is always necessary to sense the switch current to protect against over-current failures. Switch failures due to excessive current can be prevented by limiting  $I_d$ .

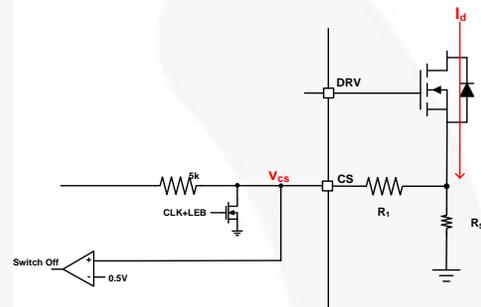


Figure 28. Cycle-by-Cycle OCP Circuit

When the voltage drops at  $R_1$  and  $R_S$  exceed a threshold of approximately  $0.5\ V$ , the power MOSFET over-current function is triggered after minimum turn-on time or LEB time ( $300\ ns$ ).

The peak voltage level at CS terminal:

$$V_{CS,peak} = 45\mu \times (R_1 + R_S) \times DT_S + I_d \times R_S \quad (4)$$

Choose the boost switch current-sensing resistor ( $R_{CS}$ ):

$$R_{CS} \geq \frac{0.25}{I_{L,peak}} \quad (5)$$

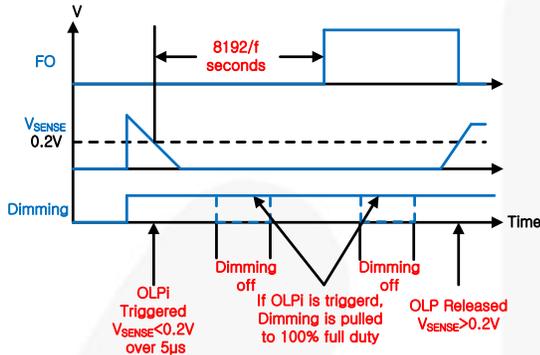
## Open-LED Protection (OLP)

After the first PWM dimming-HIGH signal, the feedback sensing resistor ( $R_{SENSE}$ ) starts sensing the LED current. If the feedback voltage of the SENSE pin drops below  $0.2\ V$ , the OLP triggers to generate an error flag signal. Because OLP can be detected only in PWM dimming-HIGH; if OLP detecting time is over  $5\ \mu s$ , PWM dimming signal is pulled HIGH internally regardless of external dimming signal. If OLP signal continues over blanking time, an error flag signal is triggered.

OLP blanking time is dependent on the boost switch frequency, per Equation 6. FAULT OUT signal is made through the FAULT pin, which needs to be connected  $5\ V$  reference voltage through a pull-up resistor. In normal operation, the FAULT pin voltage is pulled down to ground. In OLP condition, the FAULT pin voltage is pulled HIGH.

$$t_{d.olp} = 8192 / f_{OSC} \text{ [seconds]} \quad (6)$$

In system operation, OLP is triggered in only direct-short condition. Direct short means that some point of the LED string is shorted to set ground. In direct-short condition, the boost controller cannot control the LED current and a large current flows into the LED string directly from input power. To prevent this abnormal condition, the FAULT signal is used to turn off input power or the total system. FAULT signal is only triggered in OLP condition.



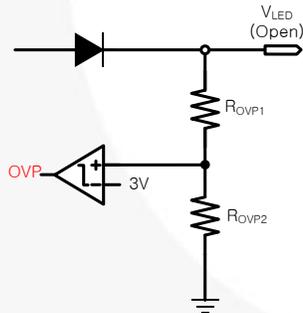
**Figure 29. Open-LED Protection**

**Note:**

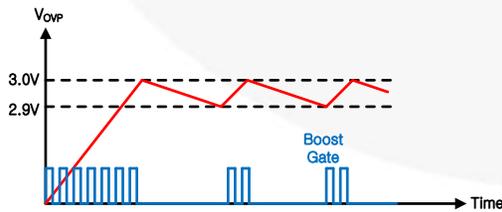
- In LED-open load condition, OVP is triggered ahead of OLP.

### Over-Voltage Protection (OVP)

Over-voltage protection is triggered when the voltage of the external output voltage reaches 3 V. After triggering OVP, the dimming switch and boost switch are turned off. The protection signal is recovered when the output voltage divider is below 2.9 V.



**Figure 30. Over-Voltage Trip Point**



**Figure 31. OVP Trigger and Release**

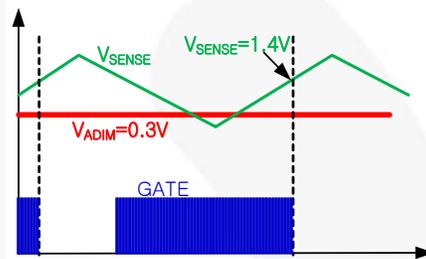
### LED Over-Current Protection (OCP)

The primary purpose of the over-current protection function is to protect the internal dimming MOSFET from excessive current. The OCP is triggered when the feedback voltage meets the clamping level (1.4 V ~ 4 V) of the ADIM voltage x4. At 1 µs delay after the OCP is triggered, the IC turns off both the boost FET and dimming FET and restarts the gate signal every  $t_{AR}$  automatically.  $t_{AR}$  can be calculated as:

$$t_{AR} = 128 / f_{OSC} \text{ [seconds]} \quad (7)$$

When  $V_{ADIM}=0.3 \text{ V}$  ( $V_{ADIM} \times 4=1.2 \text{ V}$ ).

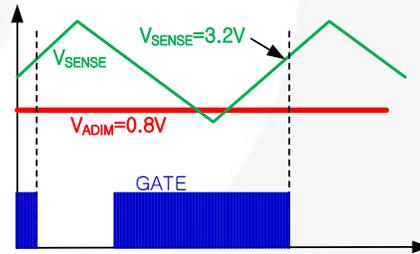
- OCP threshold level is set to 1.4 V.
- OCP is triggered at feedback voltage level = 1.4 V.



**Figure 32. OCP Waveforms at  $V_{ADIM}=0.3 \text{ V}$**

When  $V_{ADIM}=0.8 \text{ V}$  ( $V_{ADIM} \times 4=3.2 \text{ V}$ ).

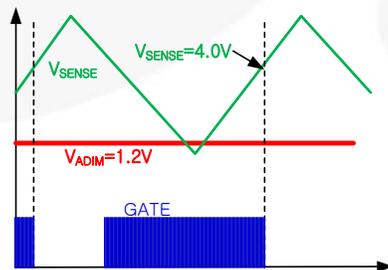
- OCP threshold level is set to 3.2 V.
- OCP is triggered at  $V_{SENSE} = 3.2 \text{ V}$ .



**Figure 33. OCP Waveforms at  $V_{ADIM}=0.8 \text{ V}$**

When  $V_{ADIM}=1.2 \text{ V}$  ( $V_{ADIM} \times 4=4.8 \text{ V}$ ).

- OCP threshold level is set to 4.0 V.
- OCP is triggered at  $V_{SENSE} = 4.0 \text{ V}$ .



**Figure 34. OCP Waveforms at  $V_{ADIM}=1.2 \text{ V}$**

## Typical Application Circuit (Boost Topology for LED Backlight)

| Application      | Input Voltage Range     | Rated Output Power | Output Current (Rated Voltage) | LED              |
|------------------|-------------------------|--------------------|--------------------------------|------------------|
| LED Backlight TV | 90 V <sub>DC</sub> ±10% |                    | 250 mA (160 V)                 | 48-LEDs/1-String |

### Features

- High Efficiency
- Constant Current Boost Converters
- High-Voltage, High-Current LED Driving

### Typical Application Circuit

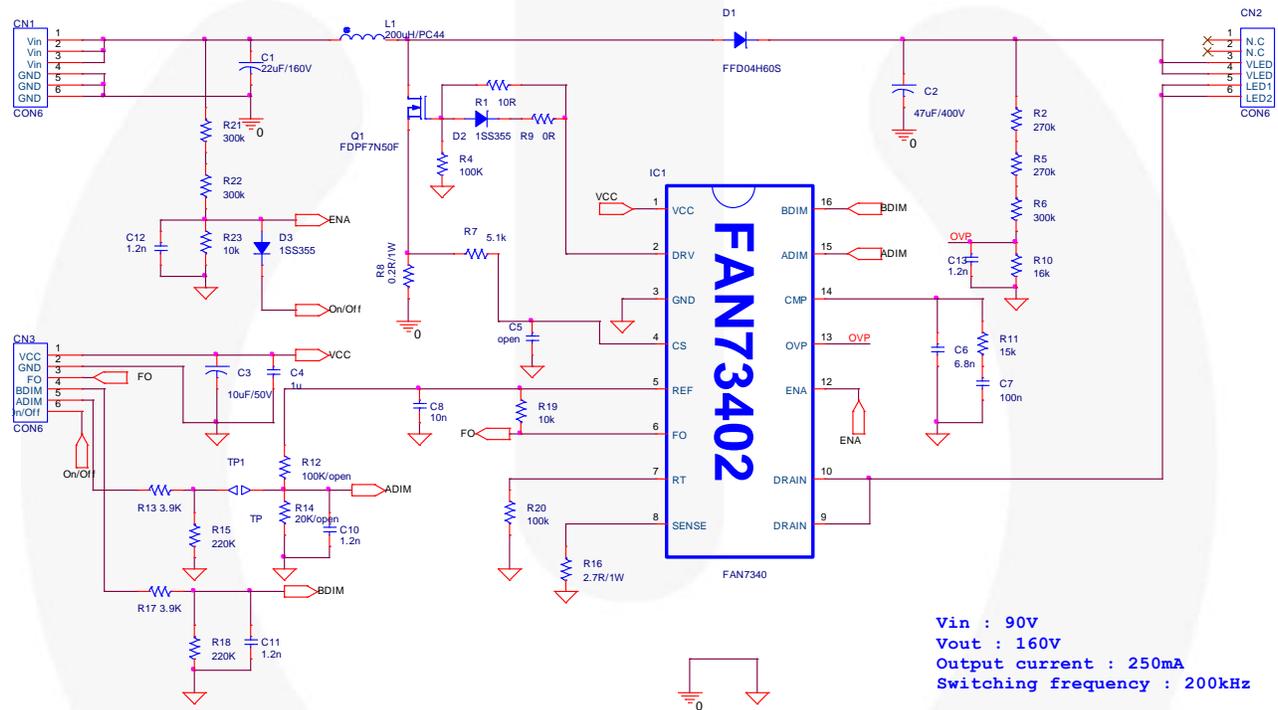


Figure 35. Typical Application Circuit

Physical Dimension

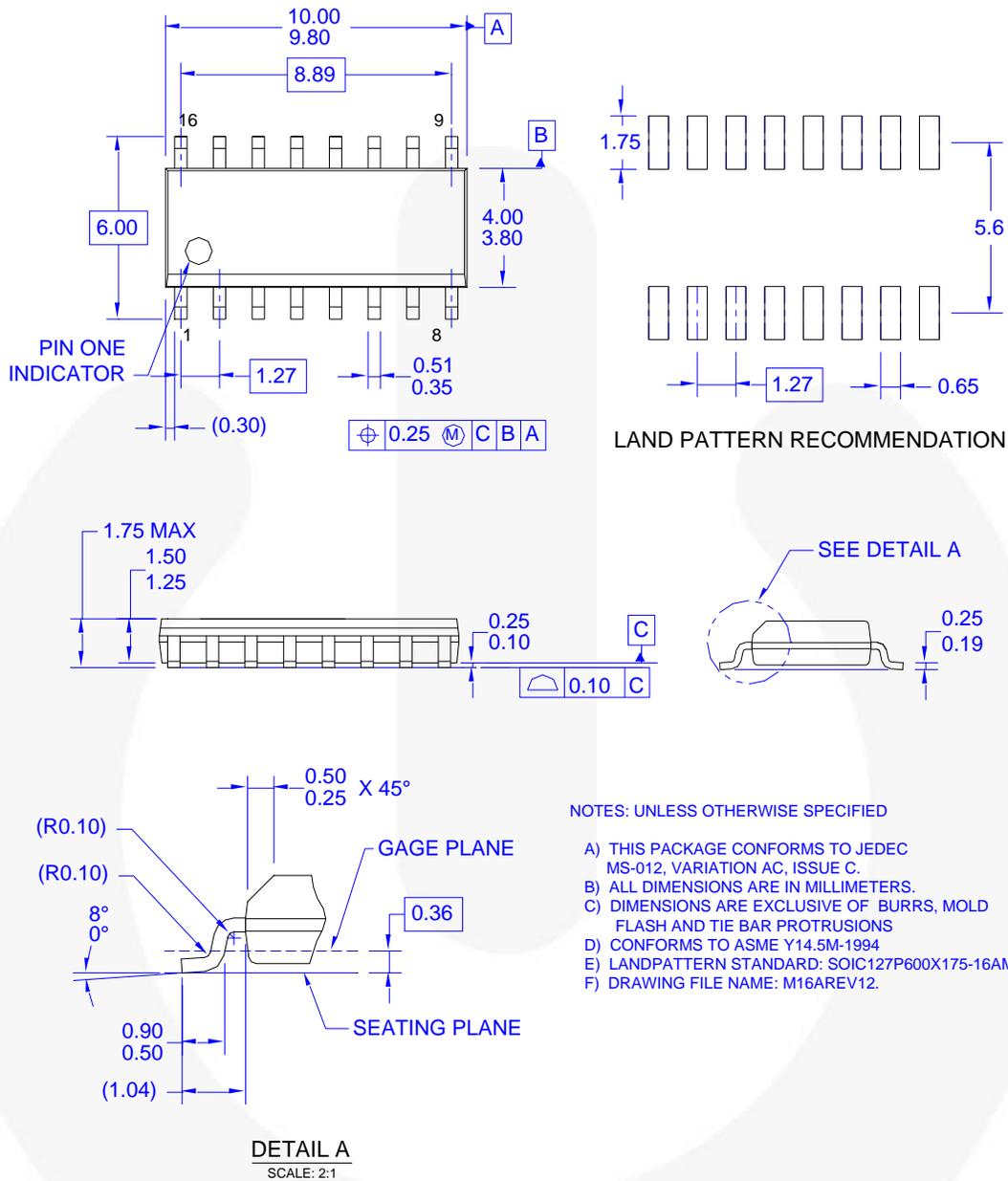


Figure 36. 16-Lead, Small Outline Integrated Circuit (SOIC)

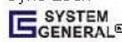
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