

# FAN7346

## 4-Channel LED Current Balance Controller

### Features

- Linear Balance Control for 4-Channel LED Arrays
- Wide LED String Voltage Range:  $\leq 100V$
- Wide  $V_{CC}$  Voltage: 10.5V to 35V
- External Linear Regulation Switch: MOSFET or BJT
- Internal Voltage Regulator for Feedback
- Monitoring Drain-Source Voltage of External Switch
- Precision Current Accuracy Trimmed to 1.5%
- Supports External PWM Dimming - Positive
- Supports Wide Dimming Ratio: 0.5%~100%
- Adaptive Linear Regulation Method
- Generate Integrated Feedback Signal for Primary Controller (Current Feedback + PWM Dimming)
- High Efficiency by Primary Side Direct Feedback
- Thermal Shutdown (Auto-Recovery)
- Over-Voltage Regulation
- Channel Individual Open-LED Protection
- Channel Individual Short-LED Protection
- Channel Individual Over-Current Protection
- Error Flag Output
- 28-Pin SOIC

### Applications

- LED BLU for LCD TV
- LED BLU for LCD Monitor
- LED Lighting

### Description

The FAN7346 is an LED current-balance controller that controls 4-LED arrays to maintain equal LED current.

The FAN7346 has a high withstanding voltage, so is suitable for edge-type LED BLU and LED Lighting. To minimize components between primary to secondary, the FAN7346 generates a new integrated feedback signal.

The FAN7346 provides various protections, such as over-voltage regulation, open-LED protection, thermal protection, and drain-source voltage protection of regulating switch (the FAN7346 monitors all LED arrays drain-source voltage for protection). To increase system reliability, FAN7346 applies individual string protection. Because FAN7346 integrates so many functions it reduces overall BOM costs.

LED brightness can be linearly varied up to LED current by applying an external Pulse Width Modulated (PWM) signal to the PWM pin.

The FAN7346 is available in a 28-SOIC package.

### Ordering Information

| Part Number | Operating Temperature | Package                                          | Packing Method |
|-------------|-----------------------|--------------------------------------------------|----------------|
| FAN7346M    | -40 to +125°C         | 28-Lead, Small-Outline Integrated Circuit (SOIC) | Rail           |
| FAN7346MX   |                       |                                                  | Tape & Reel    |

## Block Diagram

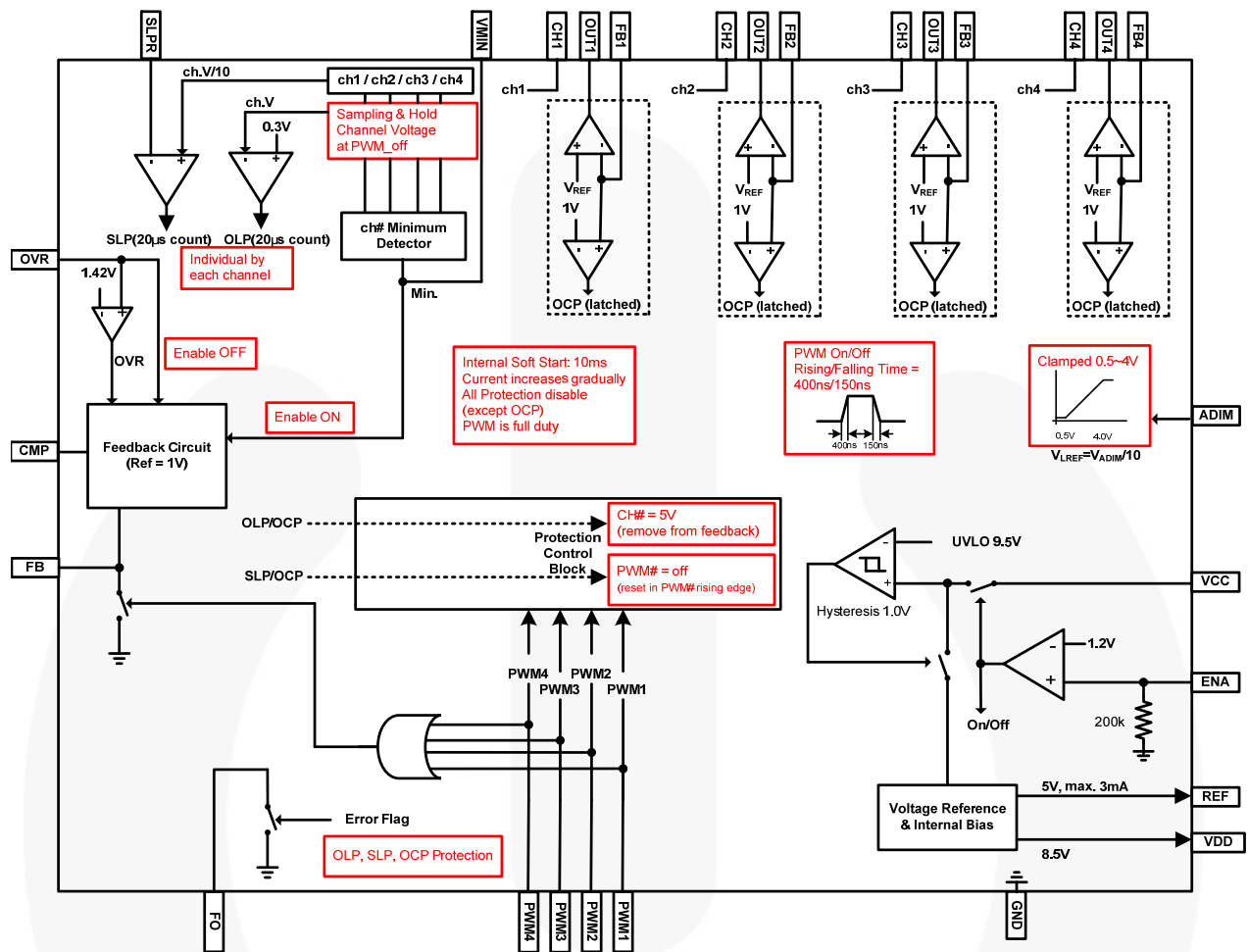


Figure 1. Internal Block Diagram

## Pin Configuration

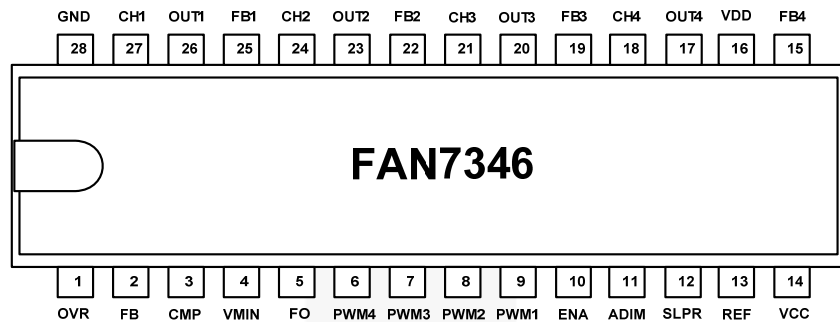


Figure 2. Package Diagram

## Pin Definitions

| Pin # | Name | Description                                                                                                                                                             |
|-------|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | OVR  | This pin is input for over-voltage regulation.                                                                                                                          |
| 2     | FB   | This pin is for feedback of minimum drain voltage of external current regulation switch. This pin is externally connected to the cathode of the feedback photo-coupler. |
| 3     | CMP  | This pin is for compensation of the minimum channel voltage feedback.                                                                                                   |
| 4     | VMIN | Synchronous signal of channel drain-voltage. If multiple controllers are operated, this pin must be tied together. In single operation, this pin must be open.          |
| 5     | FO   | This pin is fault output. In case of OLP, SLP, and OCP; this pin is connected to ground.                                                                                |
| 6     | PWM4 | PWM dimming signal input pin of channel 4.                                                                                                                              |
| 7     | PWM3 | PWM dimming signal input pin of channel 3.                                                                                                                              |
| 8     | PWM2 | PWM dimming signal input pin of channel 2.                                                                                                                              |
| 9     | PWM1 | PWM dimming signal input pin of channel 1.                                                                                                                              |
| 10    | ENA  | Enable input.                                                                                                                                                           |
| 11    | ADIM | This pin is for the reference voltage of the LED current feedback voltage.                                                                                              |
| 12    | SLPR | This pin is for setting the reference of channel over-voltage protection (short-LED protection).                                                                        |
| 13    | REF  | This pin is the reference output. Voltage is 5V; current capability is 3mA.                                                                                             |
| 14    | VCC  | This pin is the supply voltage of the controller.                                                                                                                       |
| 15    | FB4  | This pin is for current sensing feedback of channel 4.                                                                                                                  |
| 16    | VDD  | Internal gate driver power supply voltage. A large capacitor (1 $\mu$ F~2 $\mu$ F) must be connected from this pin to ground.                                           |
| 17    | OUT4 | This pin is for gate signal to the external balance FET of channel 4.                                                                                                   |
| 18    | CH4  | This pin is for drain voltage of the external balance FET of channel 4.                                                                                                 |
| 19    | FB3  | This pin is for current sensing feedback of channel 3.                                                                                                                  |
| 20    | OUT3 | This pin is for gate signal to the external balance FET of channel 3.                                                                                                   |
| 21    | CH3  | This pin is for drain voltage of the external balance FET of channel 3.                                                                                                 |
| 22    | FB2  | This pin is for current sensing feedback of channel 2.                                                                                                                  |
| 23    | OUT2 | This pin is for gate signal to the external balance FET of channel 2.                                                                                                   |
| 24    | CH2  | This pin is for drain voltage of the external balance FET of channel 2.                                                                                                 |
| 25    | FB1  | This pin is for current sensing feedback of channel 1.                                                                                                                  |
| 26    | OUT1 | This pin is for gate signal to the external balance FET of channel 1.                                                                                                   |
| 27    | CH1  | This pin is for drain voltage of the external balance FET of channel 1.                                                                                                 |
| 28    | GND  | This pin is the ground.                                                                                                                                                 |

## 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.

| Symbol        | Parameter                                        | Min. | Max. | Unit |
|---------------|--------------------------------------------------|------|------|------|
| $V_{IN}$      | IC Supply Voltage                                | 10.5 | 35.0 | V    |
| $T_A$         | Operating Temperature Range                      | -40  | +125 | °C   |
| $T_J$         | Operating Junction Temperature                   |      | +150 | °C   |
| $T_{STG}$     | Storage Temperature Range                        | -65  | +150 | °C   |
| $\theta_{JA}$ | Thermal Resistance Junction-Air <sup>(1,2)</sup> |      | 70   | °C/W |
| $P_D$         | Power Dissipation                                |      | 1.4  | W    |

### Notes:

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

## Pin Breakdown Voltage

| Pin # | Name | Value | Unit | Pin # | Name | Value | Unit |
|-------|------|-------|------|-------|------|-------|------|
| 1     | OVR  | 6     | V    | 15    | FB4  | 6     | V    |
| 2     | FB   | 6     |      | 16    | VDD  | 17    |      |
| 3     | CMP  | 6     |      | 17    | OUT4 | 17    |      |
| 4     | VMIN | 6     |      | 18    | CH4  | 100   |      |
| 5     | FO   | 6     |      | 19    | FB3  | 6     |      |
| 6     | PWM4 | 6     |      | 20    | OUT3 | 17    |      |
| 7     | PWM3 | 6     |      | 21    | CH3  | 100   |      |
| 8     | PWM2 | 6     |      | 22    | FB2  | 6     |      |
| 9     | PWM1 | 6     |      | 23    | OUT2 | 17    |      |
| 10    | ENA  | 6     |      | 24    | CH2  | 100   |      |
| 11    | ADIM | 6     |      | 25    | FB1  | 6     |      |
| 12    | SLPR | 6     |      | 26    | OUT1 | 17    |      |
| 13    | REF  | 6     |      | 27    | CH1  | 100   |      |
| 14    | VCC  | 35    |      | 28    | GND  |       |      |

## Electrical Characteristics

For typical values;  $T_A = 25^\circ\text{C}$ ,  $V_{IN} = 12\text{V}$ , and  $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ , 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>Under-Voltage Lockout Section (UVLO)</b>                                  |                                    |                                            |      |               |      |                 |
| $V_{th}$                                                                     | Start Threshold Voltage            |                                            | 8.5  | 9.5           | 10.5 | V               |
| $V_{thys}$                                                                   | Start Threshold Voltage Hysteresis |                                            | 0.5  | 1.0           | 1.5  | V               |
| $I_{st}$                                                                     | Startup Current                    | $V_{IN}=8\text{V}$                         |      | 100           | 300  | $\mu\text{A}$   |
| $I_{op}$                                                                     | Operating Supply Current           | $V_{IN}=12\text{V}$ , Not Switching        |      | 1             | 3    | mA              |
| <b>ON/OFF Section</b>                                                        |                                    |                                            |      |               |      |                 |
| $V_{on}$                                                                     | On-State Input Voltage             |                                            | 1.4  |               | 5.0  | V               |
| $V_{off}$                                                                    | Off-State Input Voltage            |                                            |      |               | 0.7  | V               |
| $R_{ENA}$                                                                    | Pull-Down Resistor                 |                                            | 130  | 200           | 270  | k $\Omega$      |
| <b>Reference Section (Recommend 1<math>\mu\text{F}</math> X7R Capacitor)</b> |                                    |                                            |      |               |      |                 |
| $V_{REF}$                                                                    | 5V Regulation Voltage              | $I_{REF}=0\text{mA}$                       | 4.9  | 5.0           | 5.1  | V               |
| $V_{R-LINE}$                                                                 | 5V Line Regulation                 | $10 \leq V_{IN} \leq 35\text{V}$           |      |               | 50   | mV              |
| $V_{R-LOAD}$                                                                 | 5V Load Regulation                 | $0 \leq I_{REF} \leq 3\text{mA}$           |      |               | 50   | mV              |
| $V_{DD}$                                                                     | 8.5V Regulation Voltage            | $V_{IN}=12\text{V}$                        | 8.0  | 8.5           | 9.0  | V               |
| <b>LED Current Section</b>                                                   |                                    |                                            |      |               |      |                 |
| $V_{FBX}$                                                                    | CH LED Current Reference Voltage   | $V_{ADIM}=2\text{V}$                       | 194  | 200           | 206  | mV              |
| $V_{LREF}$                                                                   | LED Current Reference Voltage      | $0.5\text{V} \leq V_{ADIM} \leq 4\text{V}$ |      | $V_{ADIM}/10$ |      | V               |
| $V_{ADIM-CLAMPH}$                                                            | ADIM Voltage HIGH Clamping Voltage | $V_{IN}=12\text{V}$                        | 3.84 | 4.00          | 4.16 | V               |
| $V_{ADIM-CLAMPL}$                                                            | ADIM Voltage LOW Clamping Voltage  | $V_{IN}=12\text{V}$                        | 0.45 | 0.50          | 0.55 |                 |
| $B_{CH}$                                                                     | Current Balance Between Channels   | $V_{ADIM}=2\text{V}$                       | -1.5 |               | 1.5  | %               |
| <b>Headroom Voltage Feedback Section</b>                                     |                                    |                                            |      |               |      |                 |
| $V_{FBR}$                                                                    | Feedback Reference Voltage         |                                            | 0.95 | 1.00          | 1.05 | V               |
| $I_{leak}$                                                                   | Channel Leakage Current            | PWM ON, $V_{CH}=1\text{V}$                 | 0    |               | 100  | $\mu\text{A}$   |
|                                                                              |                                    | PWM OFF, $V_{CH}=30\text{V}$               | 0    |               | 2    | $\mu\text{A}$   |
| $A_v$                                                                        | Open-Loop Gain <sup>(3)</sup>      | $V_{VMIN}=1\text{V}$                       |      | 65            |      | dB              |
| $G_m$                                                                        | Error Amplifier Transconductance   | $V_{VMIN}=1.5\text{V}$                     | 140  | 180           | 220  | $\mu\text{mho}$ |
| $I_{sin}$                                                                    | Output Sink Current                | $V_{VMIN}=0\text{V}$                       | 70   | 120           | 170  | $\mu\text{A}$   |
| $I_{sur}$                                                                    | Output Source Current              | $V_{VMIN}=2\text{V}$                       | 70   | 120           | 170  | $\mu\text{A}$   |

Continued on the following page...

**Electrical Characteristics** (Continued)

For typical values;  $T_A = 25^\circ\text{C}$ ,  $V_{IN} = 12\text{V}$ , and  $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$ , 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>PWM Dimming Section</b> |                                                       |                                                             |      |      |      |                  |
| $V_{\text{bdim(ON)}}$      | PWM Dimming On Voltage                                |                                                             | 2    |      | 5    | V                |
| $V_{\text{bdim(Off)}}$     | PWM Dimming Off Voltage                               |                                                             | 0    |      | 0.8  | V                |
| $f_{\text{bdim}}$          | PWM Dim Input Frequency Range <sup>(3)</sup>          | On Duty Ratio=1%                                            | 100  |      | 500  | Hz               |
| $t_{\text{bdimR}}$         | PWM Dim On Rising Time <sup>(3)</sup>                 | Ext. Switch $Q_g=4.3\text{nC}$                              |      | 400  |      | ns               |
| $t_{\text{bdimF}}$         | PWM Dim Off Falling Time <sup>(3)</sup>               | Ext. Switch $Q_g=4.3\text{nC}$                              |      | 150  |      | ns               |
| <b>Soft-Start Section</b>  |                                                       |                                                             |      |      |      |                  |
| $t_{\text{SS}}$            | Soft-Start Time <sup>(3)</sup>                        | $V_{\text{OVR}}=1\text{V}$ , $I_{\text{LED}}: 0$ to Maximum |      | 10   |      | ms               |
| <b>Protection Section</b>  |                                                       |                                                             |      |      |      |                  |
| $V_{\text{TH,OVR}}$        | OVR Threshold Voltage                                 |                                                             | 1.35 | 1.42 | 1.49 | V                |
| $V_{\text{TH,OCF}}$        | OCF Threshold Voltage                                 |                                                             | 0.95 | 1.00 | 1.05 | V                |
| $T_{\text{OCF}}$           | OCF Shutdown Time <sup>(3)</sup>                      |                                                             |      | 10   |      | $\mu\text{s}$    |
| $V_{\text{TH,SLP}}$        | SLP Threshold Voltage                                 | $V_{\text{SLPR}}=1\text{V}$                                 | 9.5  | 10.0 | 10.5 | V                |
| $T_{\text{D,SLP}}$         | SLP Delay <sup>(3)</sup>                              |                                                             |      | 20   |      | $\mu\text{s}$    |
| $T_{\text{D,OLP}}$         | OLP Delay <sup>(3)</sup>                              |                                                             |      | 20   |      | $\mu\text{s}$    |
| $V_{\text{TH,OLP}}$        | OLP Threshold Voltage                                 |                                                             | 0.27 | 0.30 | 0.33 | V                |
| $T_{\text{TRIP}}$          | Internal Thermal Protection Threshold <sup>(3)</sup>  |                                                             |      | 150  |      | $^\circ\text{C}$ |
| $T_{\text{TYH}}$           | Internal Thermal Protection Hysteresis <sup>(3)</sup> |                                                             |      | 25   |      | $^\circ\text{C}$ |
| <b>Output Section</b>      |                                                       |                                                             |      |      |      |                  |
| $V_{\text{GH}}$            | NMOS Gate High Voltage                                | $V_{\text{IN}}=12\text{V}$                                  | 8.0  | 8.5  | 9.0  | V                |
| $V_{\text{GL}}$            | NMOS Gate Low Voltage                                 | $V_{\text{IN}}=12\text{V}$                                  |      | 0    |      | V                |
| $V_{\text{G,UVLO}}$        | NMOS Gate Voltage with UVLO Activated                 | $V_{\text{IN}}=7\text{V}$                                   |      |      | 0.3  | V                |
| $I_{\text{G,SOURCE}}$      | NMOS Gate Drive Source Current                        | $V_{\text{IN}}=12\text{V}$                                  | 50   | 150  | 250  | mA               |
| $I_{\text{G,SINK}}$        | NMOS Gate Drive Sink Current                          | $V_{\text{IN}}=12\text{V}$                                  | 300  | 500  | 700  | mA               |

**Note:**

3. These Parameters, although guaranteed, are not 100% tested in production.

## Typical Performance Characteristics

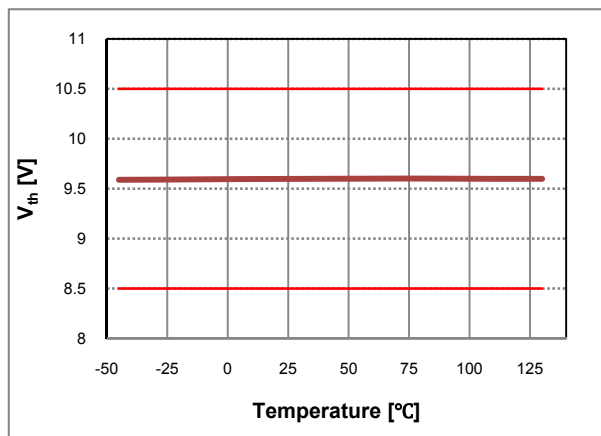


Figure 3. Start Threshold Voltage vs. Temperature

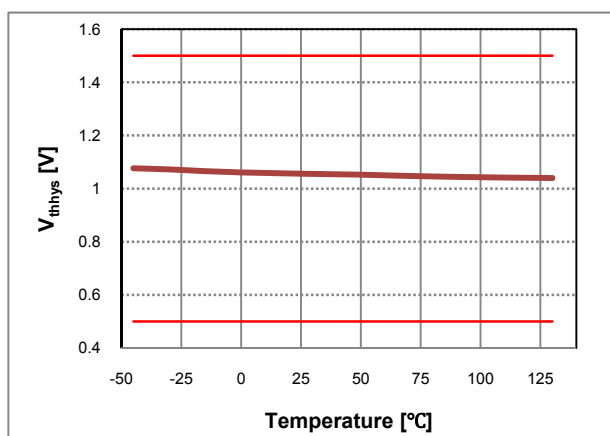


Figure 4. Start Threshold Voltage Hysteresis vs. Temperature

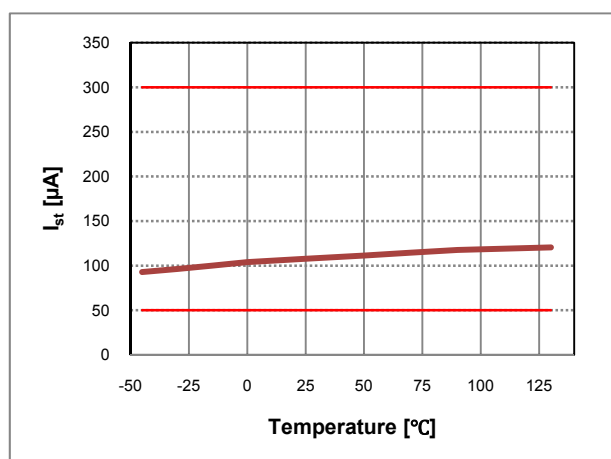


Figure 5. Startup Current vs. Temperature

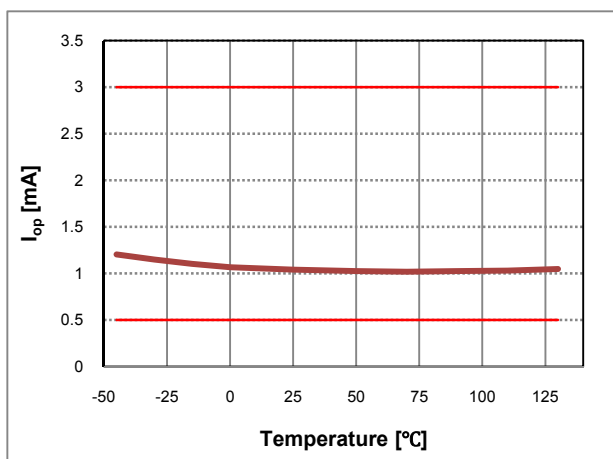


Figure 6. Operating Current vs. Temperature

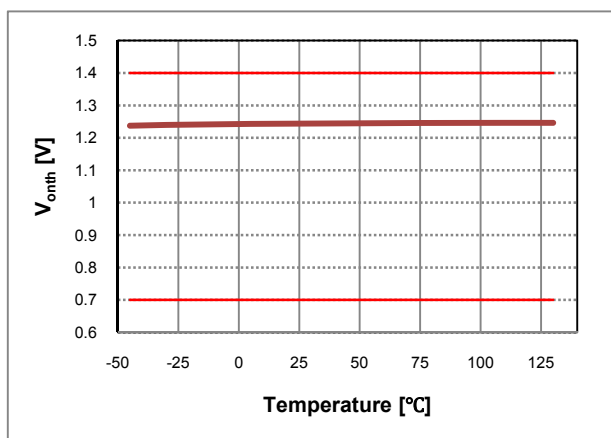


Figure 7. Enable Threshold Voltage vs. Temperature

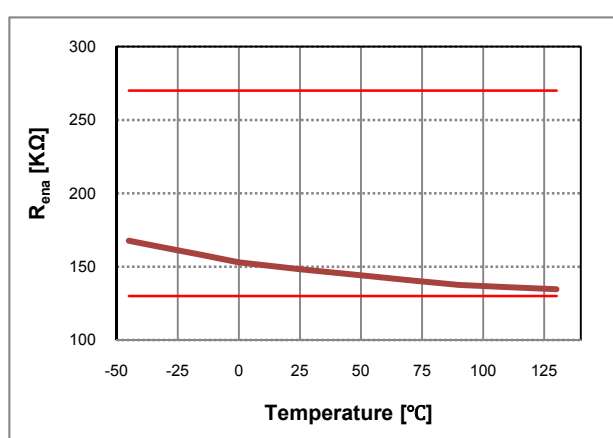


Figure 8. Pull-Down Resistor vs. Temperature

## Typical Performance Characteristics (Continued)

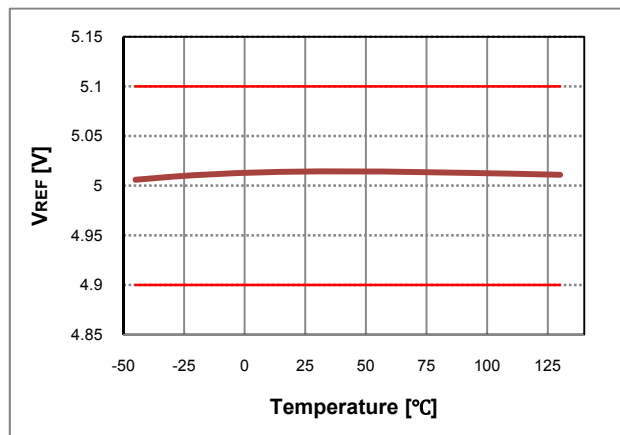


Figure 9. 5V Regulation Voltage vs. Temperature

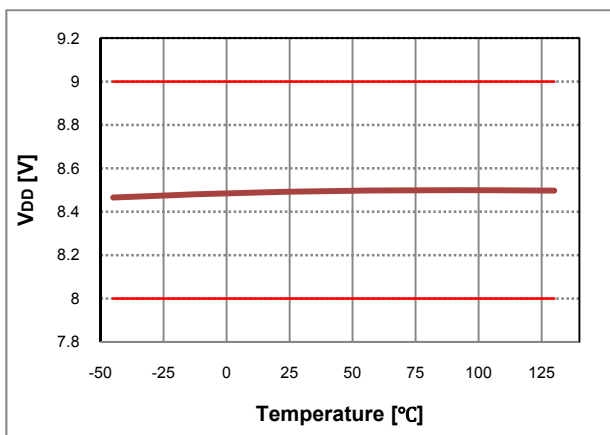


Figure 10. 8.5V Regulation Voltage vs. Temperature

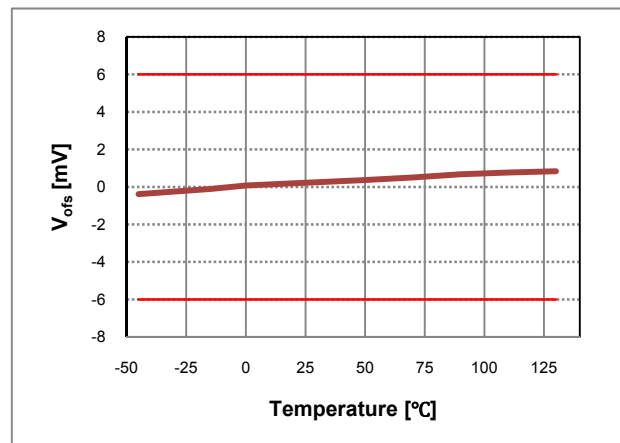


Figure 11. Offset of CH LED Current Reference Voltage vs. Temperature

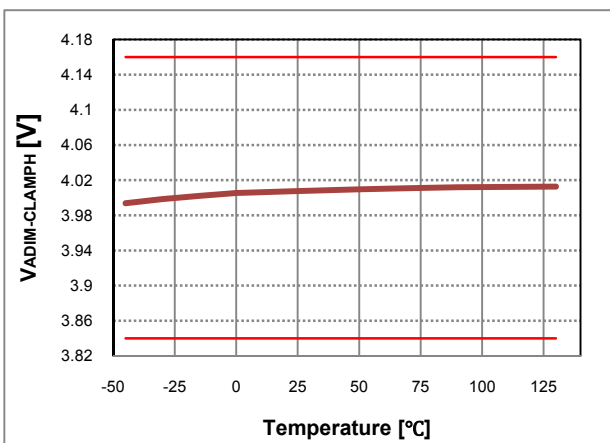


Figure 12. ADIM HIGH Clamping Voltage vs. Temperature

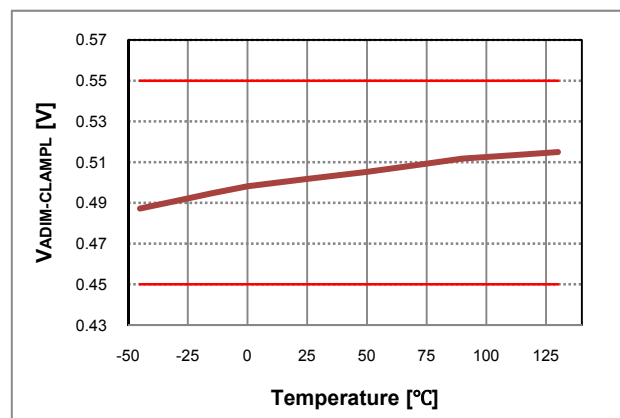


Figure 13. ADIM LOW Clamping Voltage vs. Temperature

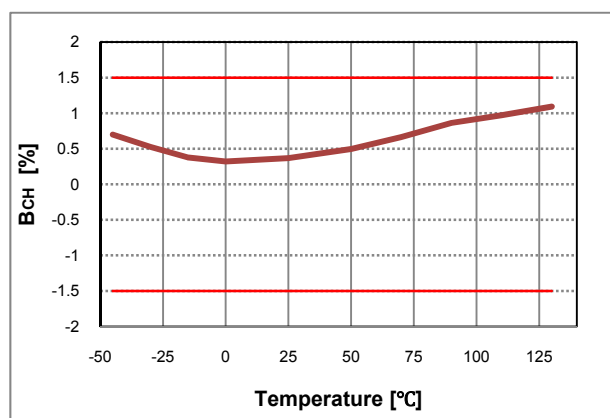


Figure 14. Current Balance Between Channels vs. Temperature



## Typical Performance Characteristics (Continued)

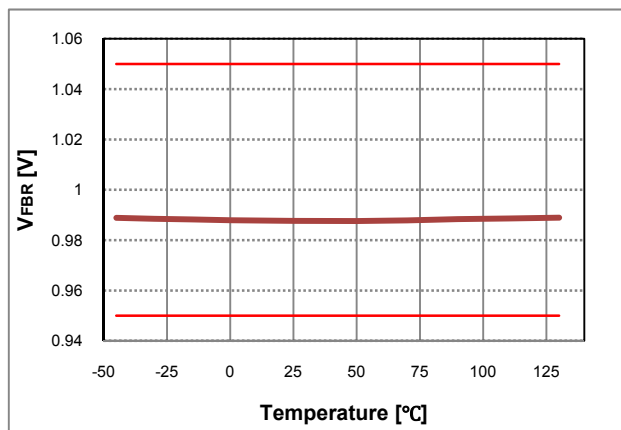


Figure 15. Feedback Reference Voltage vs. Temperature

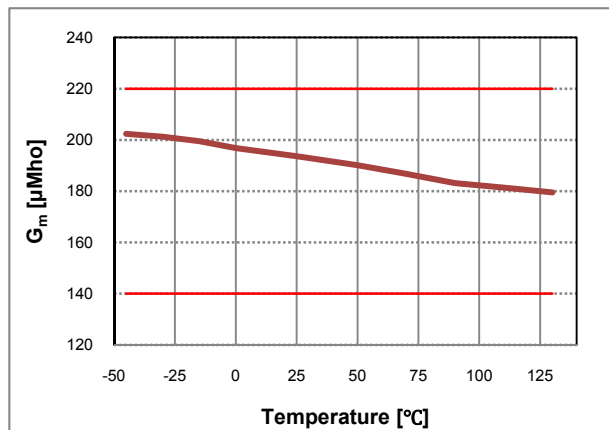


Figure 16. Error Amplifier Transconductance vs. Temperature

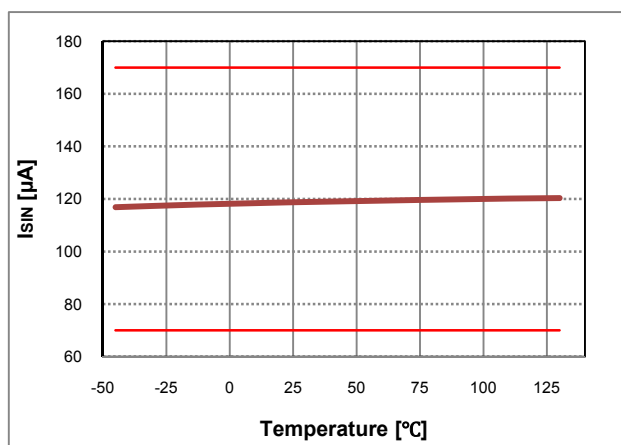


Figure 17. Error Amplifier Output Sink Current vs. Temperature

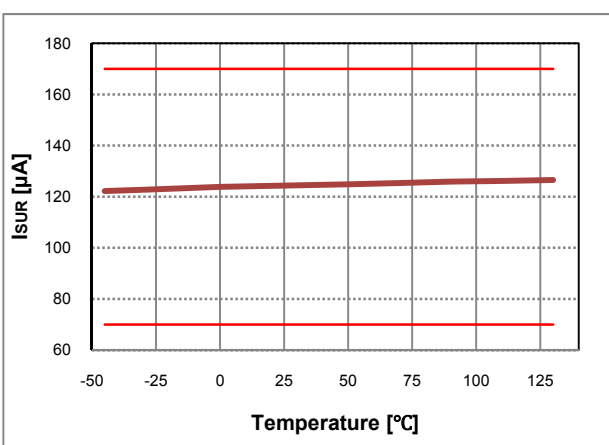


Figure 18. Error Amplifier Output Source current vs. Temperature

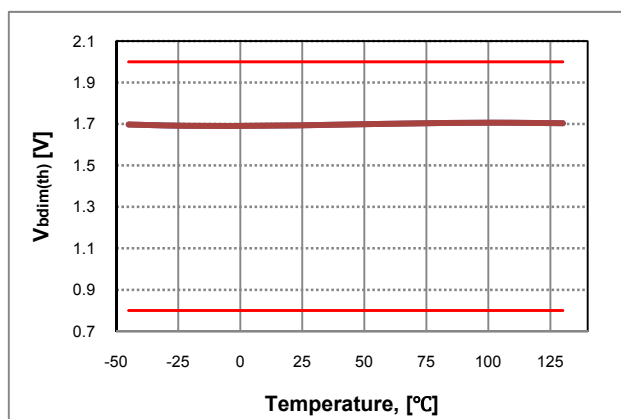


Figure 19. PWM Dimming On Threshold Voltage vs. Temperature

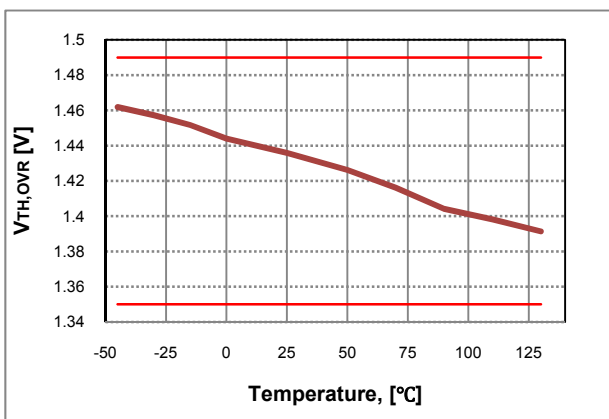


Figure 20. OVR Threshold Voltage vs. Temperature

## Typical Performance Characteristics (Continued)

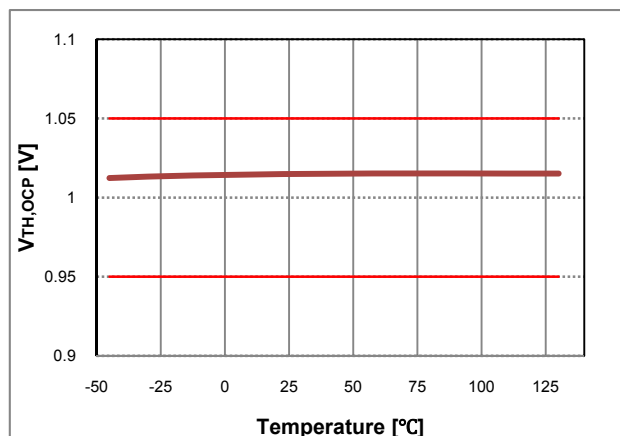


Figure 21. OCP Threshold Voltage vs. Temperature

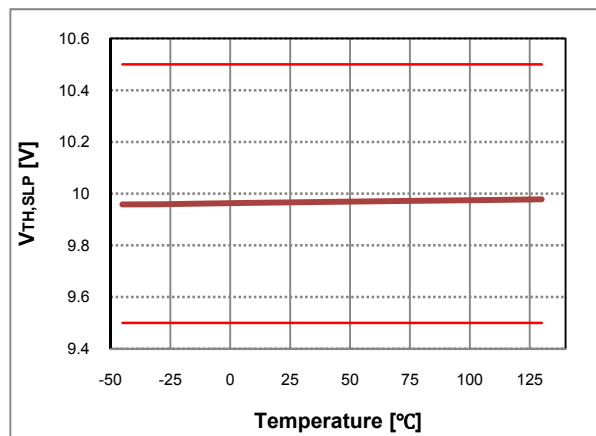


Figure 22. SLP Threshold Voltage vs. Temperature

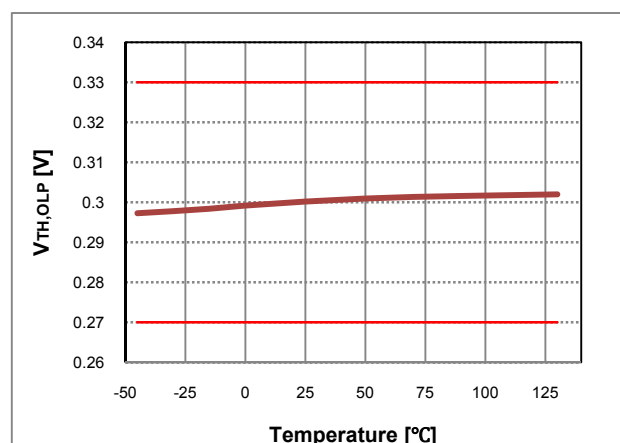


Figure 23. OLP Threshold Voltage vs. Temperature

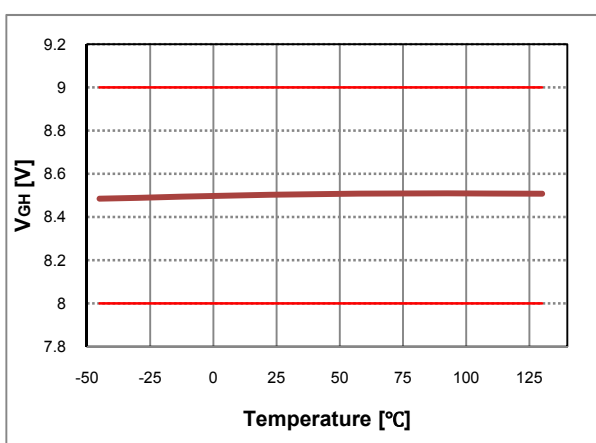


Figure 24. NMOS Gate High Voltage vs. Temperature

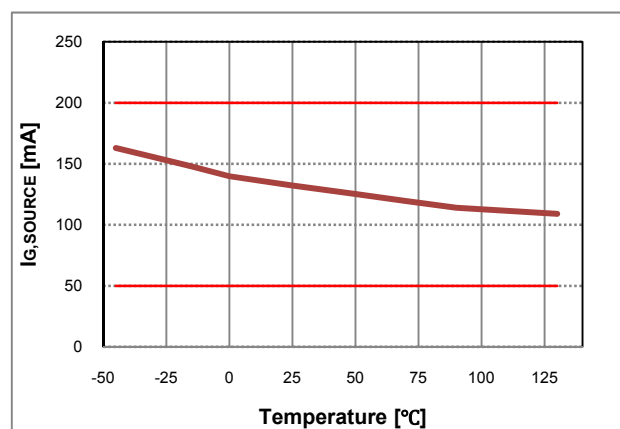


Figure 25. NMOS Gate Drive Source Current vs. Temperature

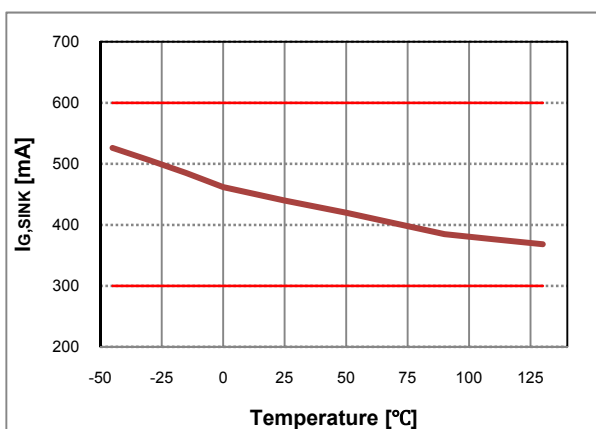


Figure 26. NMOS Gate Drive Sink Current vs. Temperature

## Functional Description

The FAN7346 is a high-efficiency 4-channel LED driver. It can drive a 4-channel LED string with four external balance switches. It provides an integrated feedback for a DC-DC controller on the secondary side or on the flyback / LLC controller of the primary side.

Due to the high withstanding voltage of the sensing pin for drain voltage of external switch, the FAN7346 can be used in high-voltage LED string operation without any clamping circuit. Both MOSFET and transistor can be used as external balance switch, so the FAN7346 can drive a high-current LED string.

For four-string operation, the FAN7346 supports four individual PWM signal input pins. The FAN7346 can be operated by parallel connection mode.

For a primary-side direct-power control system, the FAN7346 supports an advanced power sequence and soft-start timing. LED driving voltage can be set before LED ignition for a reliable LED backlight ignition.

The FAN7346 supports various and programmable protections; Short-LED Protection (SLP), Open-LED Protection (OLP), Over-Current Protection (OCP), and Over-Voltage Regulation (OVR). Except OCP, all protection are auto-recovery / auto-restart. Except OVR, all protections are channel-individual protection. In case of SLP, OLP and OCP; even if some strings are in protection condition, other strings continues to operating for higher system reliability.

Figure 27 shows the work-flow of startup sequence.

### 1. Startup

When  $V_{CC}$  voltage is higher than UVLO threshold voltage, internal 5V regulation output is operated. At the same time, feedback starts to control OVR voltage as 1V. If OVR voltage is lower than 1V, feedback is pulled up. If OVR voltage is higher than 1V, feedback is pulled down.

After enable is applied, the FAN7346 begins soft-start procedure. The FAN7346 checks if OVR voltage is higher than 0.9V. If OVR voltage is lower than 0.9V, soft-start function is not started. If OVR voltage is higher than 0.9V, the FAN7346 starts LED current balance and soft-start. The LED current of each string is increased gradually for 10ms, which is fixed soft-start timing. During soft-start timing, SLP and OLP are disabled.

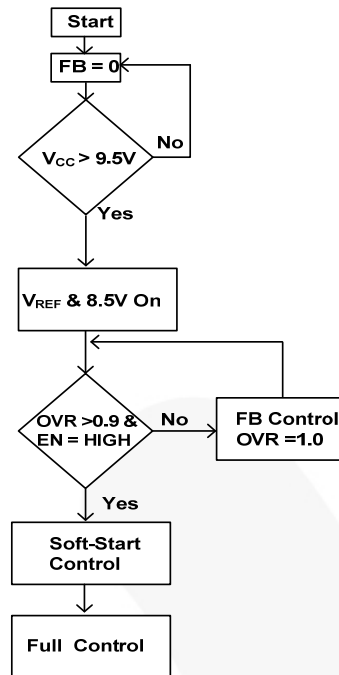


Figure 27. Startup Sequence

### 2. Feedback

After soft-start, the FAN7346 starts feedback drain-voltage of external balance switch.

Drain voltage of each channel is sensed on the CHx pin. CHx means any of the CH1 / CH2 / CH3 / CH4 pins. Minimum drain voltage is selected between four CHx voltages. The FAN7346 feeds back drain voltage to control minimum drain voltage at 1V.

If minimum drain voltage is higher than 1V, FB is pulled LOW. If minimum drain voltage is lower than 1V, FB is pulled HIGH.

Feedback response can be controlled by adding a resistor and capacitor to the CMP pin.

### 3. Analog Dimming

In the FAN7346, LED current can be modified by changing ADIM voltage.

LED current is controlled by the FBx pin voltage. FBx means any of the FB1 / FB2 / FB3 / FB4 pins. External current balance switch is operating in the saturation region to control LED current. Sensed voltage on the FBx pin is compared with internal reference voltage and the controller supplies a gate / base signal for the external current balance switch.

Internal reference voltage is decided by ADIM voltage. The formula for LED current calculation is:

$$I_{LED} = \frac{V_{ADIM}}{10 \times R_{SENSE}} \quad (1)$$

ADIM voltage is clamped internally from 0.5V to 4V. If ADIM voltage is lower than 0.5V, it is clamped as 0.5V. If ADIM voltage is higher than 4V, it is clamped as 4V.

#### 4. PWM Dimming

The FAN7346 has four PWM dimming signal pins. Each PWM dimming pin controls an LED string.

If PWM dimming voltage is higher than 2V, an external balance switch is turned on and conducts constant current operation. If PWM dimming voltage is lower than 0.8V, an external balance switch is turned off and blocks LED current.

During PWM dimming off, open-LED protection and short-LED protection is disabled.

CHx drain voltage is sampled during PWM dimming on and held during PWM dimming off to maintain drain voltage regardless of dimming on/off signal.

#### 5. Short-LED Protection (SLP)

To sense a short-LED condition, the FAN7346 uses the drain voltage of external balance switch. If some LEDs are shorted, its LED forward voltage is lower than other LED strings, so the drain voltage of the external balance switch is higher than other drain voltage.

SLP threshold voltage can be programmed by SLPR (Short-LED Protection Reference) voltage. Internal SLP threshold voltage is calculated as:

$$V_{SLP\_TH} = 10 * V_{SLPR} \quad (2)$$

Minimum SLP threshold voltage is 0V and maximum SLP threshold voltage is 45V.

SLP is a channel-individual protection. If any string is in SLP condition, the SLP strings is turned off and other string operate normally.

If the sensed-drain voltage (CHx voltage) is higher than the programmed threshold voltage for 20μs, CHx goes into short-LED protection, which forces the corresponding channel to turn off. To increase reliability, the SLP channel is restarted in the next PWM dimming signal rising timing. After restarting, the FAN7346 checks the drain voltage. If the drain voltage is higher than the SLP threshold voltage for 20μs, the switch is turned off. If drain voltage is lower, the channel is restored to normal operation. Shorted LED channel operation is minimum duty PWM dimming with a 20μs dimming on period. During 100% full duty PWM dimming, auto restart is not activated.

Figure 28 shows the SLP operation. As soon as  $SLPR * 10$  (blue line) is lower than CHx voltage, CHx is forced into minimum duty dimming operation.

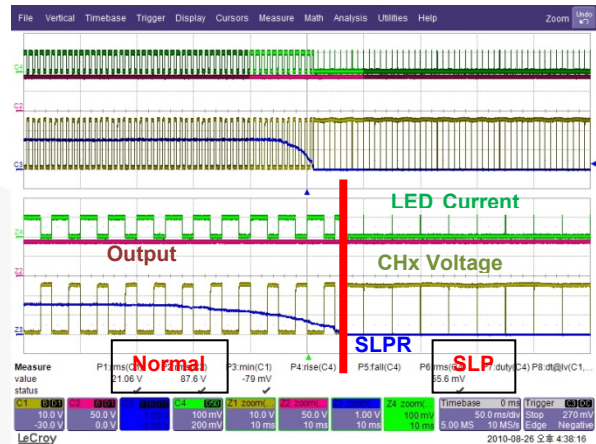


Figure 28. Short-LED Protection Operation

#### 6. Open LED Protection (OLP)

To sensing open-LED condition, the FAN7346 use the drain voltage of an external balance switch. If an LED string is open, the drain voltage of external balance switch is grounded, and the FAN7346 can detect open-LED condition. OLP threshold voltage is 0.3V.

If CHx voltage is lower than 0.3V for 20μs, its drain-voltage feedback is pulled up to 5V. This means the open LED string is eliminated from minimum drain voltage feedback loop. Without OLP, if minimum drain voltage is 0V, drain voltage feedback forces the FB signal to increase output power. This can cause SLP or thermal stress in other channels.

OLP is an auto-recovery protection. As soon as drain voltage is higher than 0.3V, OLP is finished and the drain voltage feedback system is restored.

Figure 29 shows the OLP operation. Before open CH2, CH2 is the headroom channel. (CH2 drain voltage is minimum voltage – 1V.) As soon as open CH2, its drain voltage is 0V, OLP is activated, and CH2 is removed from headroom feedback control loop. CH1 is selected as minimum drain voltage channel, so its drain voltage is controlled as 1V. Reconnecting CH2 string, restores normal operation.

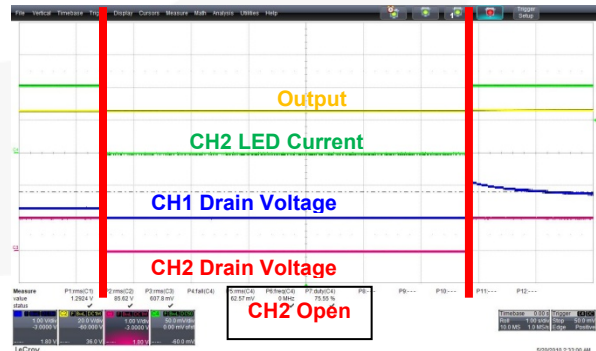


Figure 29. Open-LED Protection Operation

## 7. Over-Voltage Regulation (OVR)

To prevent LED driving voltage from exceeding the withstanding voltage of system components, the FAN7346 controls LED driving voltage with OVR pin voltage. The FAN7346 senses output LED driving voltage through the OVR pin voltage. Resistor divided output voltage is applied to the OVR pin voltage.

In FAN7346, OVR voltage uses two kinds of feedback and control: and regulating output voltage during enable off and clamping output voltage during enable on.

When ENA pin is LOW, the FAN7346 controls FB voltage to maintain OVR voltage as 1.0V. Through this output voltage control during ENA off, the FAN7346 reaches adequate LED driving voltage before turning ENA on.

After ENA pin is HIGH, OVR pin voltage is used for over-voltage regulation. If OVR pin voltage is lower than 1.42V, the FB pin voltage follows headroom control to maintain minimum voltage of drain voltages as 1V. If OVR pin voltage is higher than 1.42V, the FAN7346 controls FB (FB is pulled LOW). Through feedback regulation, OVR pin voltage cannot exceed 1.42V.

## 8. Over-Current Protection (OCP)

Through over-current protection, the FAN7346 can protect external balance switches from shorted over-

current damage. To sense over-current condition, the FAN7346 monitors FBx (FB1~FB4) pin voltage.

If FBx voltage is higher than 1V for 20 $\mu$ s, CHx is considered an over-current condition. After sensing OCP condition, CHx dimming switch is turned off.

OCP is channel individual and latched protection. If one channel is in OCP condition, other channels keep operating. OCP channel is restarted after UVOL is reset.

## 9. Error Flag (FO)

To make error flag signal, the FAN7346 uses the FO pin. FO pin is open-drain type.

During normal operation, the FO pin is open. If using an external pull-up resistor, this signal is HIGH.

If used OLP / OCP / SLP protection, the FO pin is connected to ground. If using an external pull-up resistor, this signal is LOW.

If a single channel is in protection condition, error-flag signal is detected. Only if all channels are operating normally is the FO pin pulled HIGH.

## Short Lamp Protection

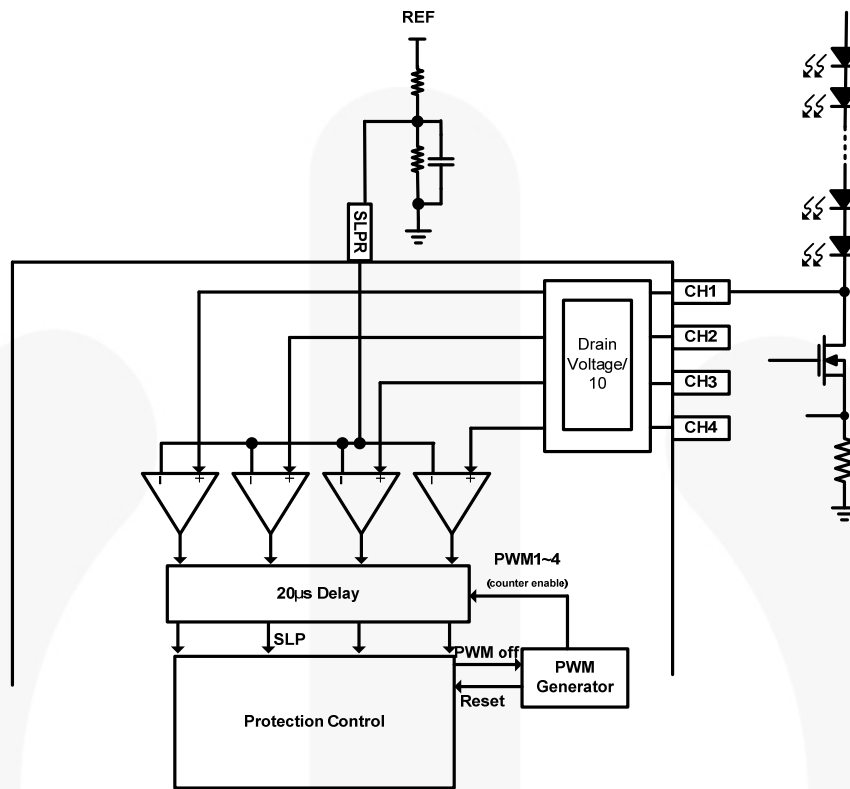


Figure 30. Block Diagram of Short LED Protection

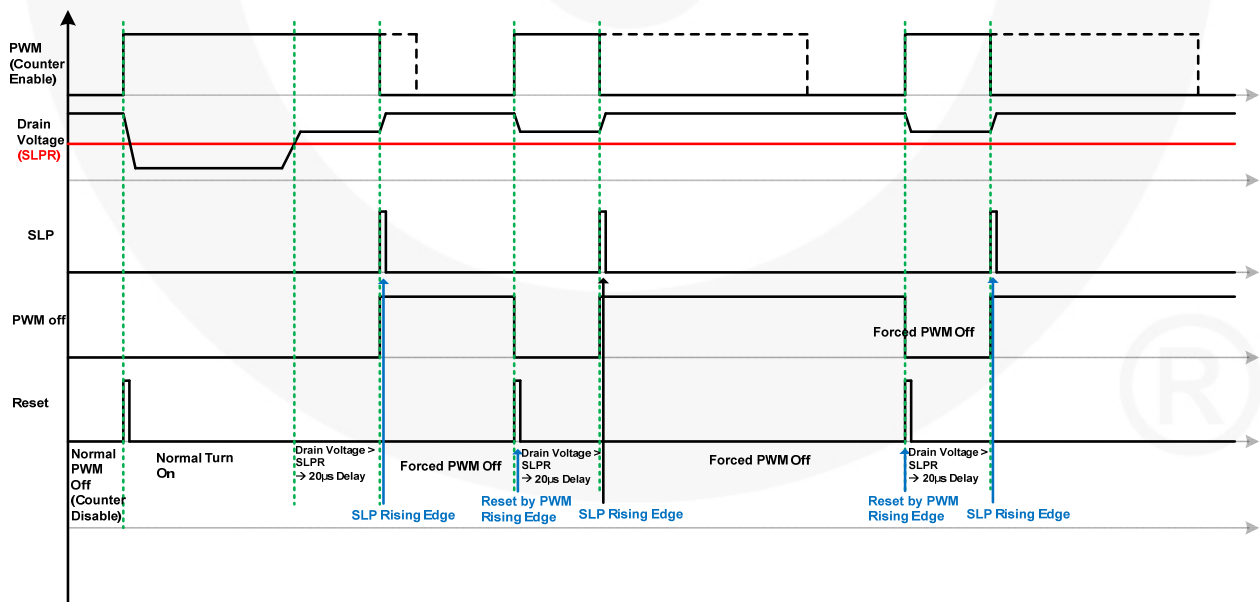
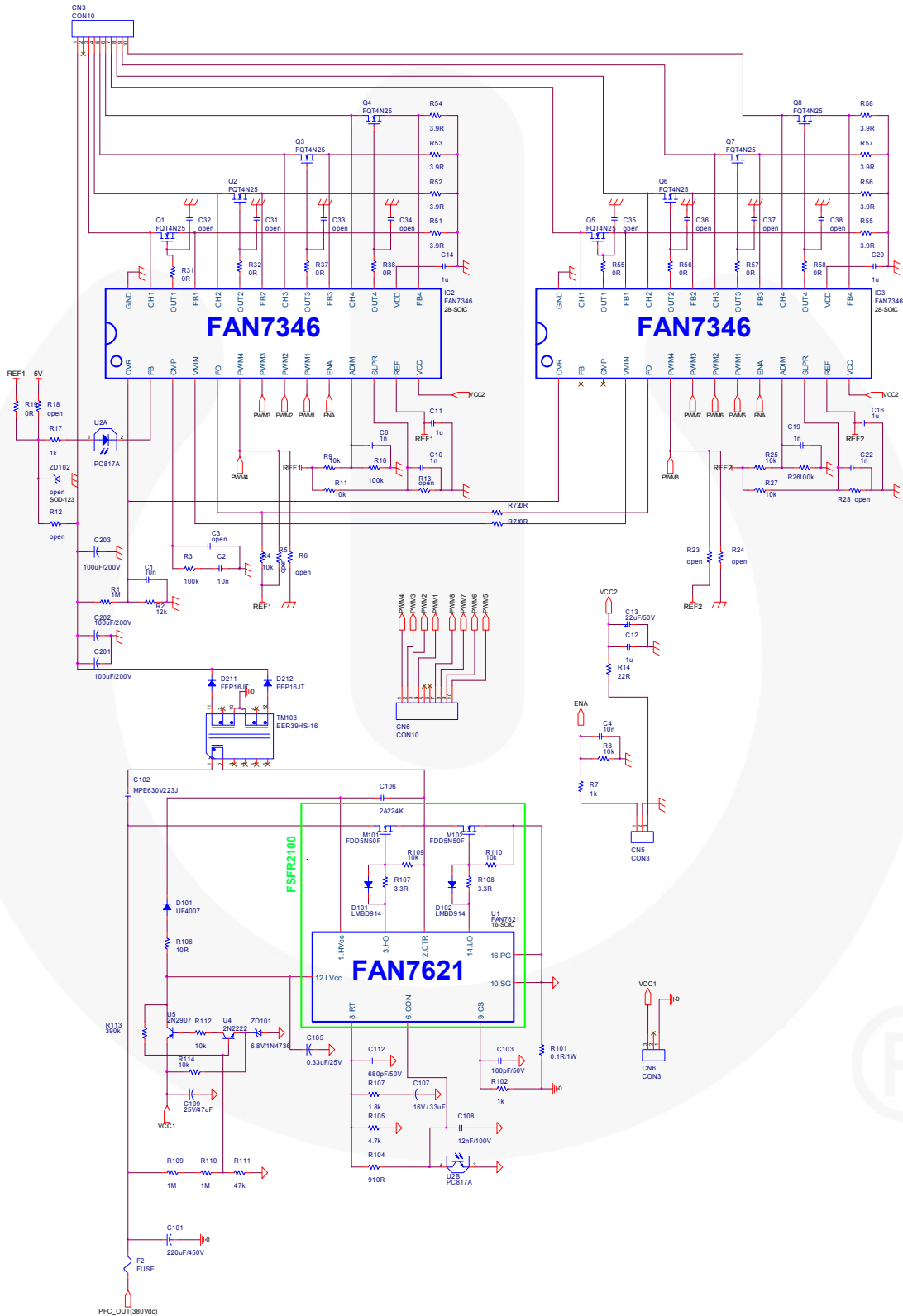


Figure 31. Timing Diagram of Short LED Protection

# Typical Application Circuit (Backlight)

| Application       | Device  | Input Voltage Range | LED String             |
|-------------------|---------|---------------------|------------------------|
| 32~46 Inch LED TV | FAN7346 | 380V                | 8-String / 90V / 100mA |



# Typical Application Circuit (Lighting) (Continued)

| Application  | Device  | Input Voltage Range | LED String |
|--------------|---------|---------------------|------------|
| LED Lighting | FAN7346 | 380V                | 4-String   |

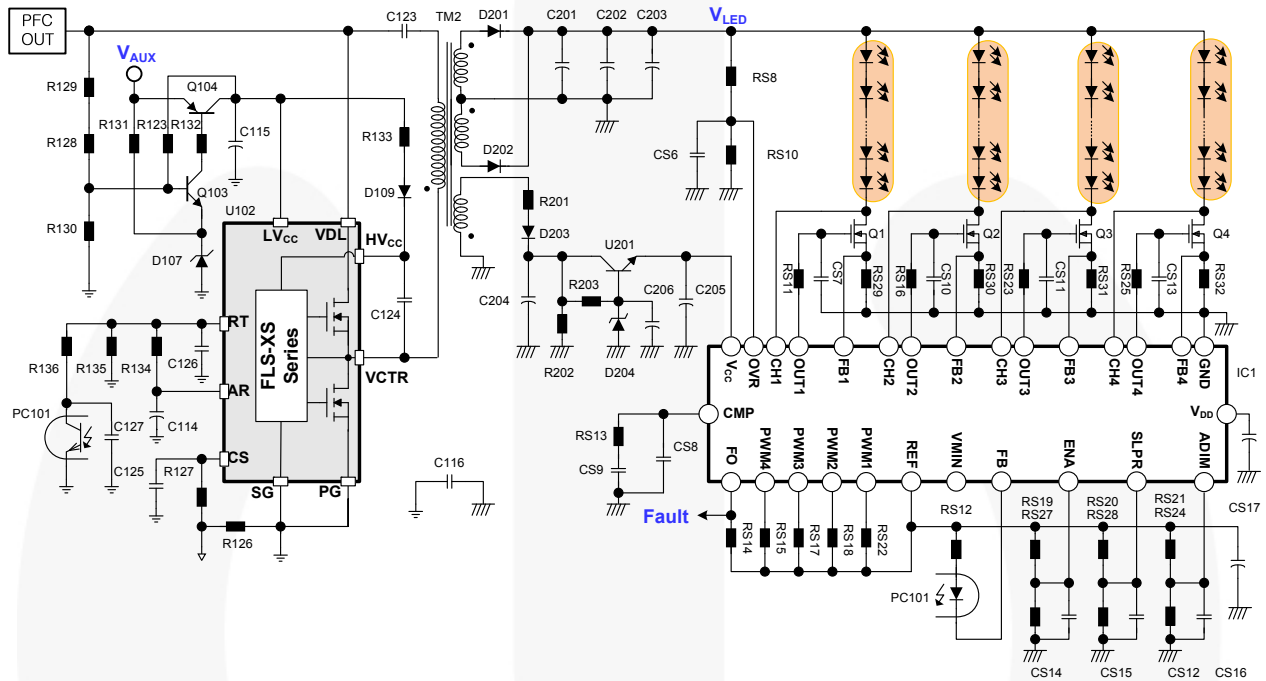


Figure 33. LED Lighting Driver



**FAN7346 Master**

**FAN7346 Slave**

**Need three pins for parallel connection:**

1.  $V_{MIN}$  (Drain Minimum Voltage)
2. OVR
3. FO

## Physical Dimensions

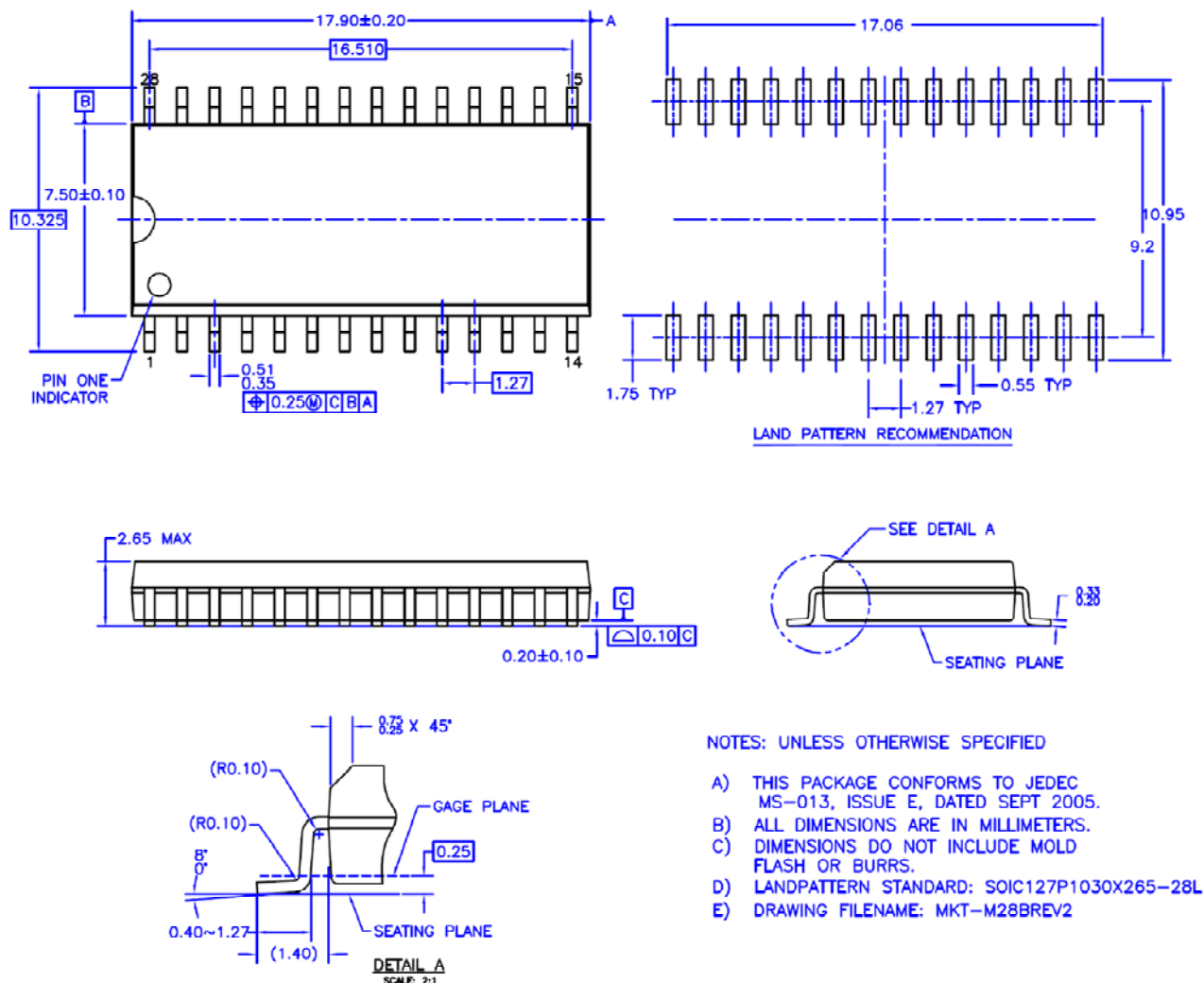


Figure 35. 28-Lead, Small-Outline Integrated Circuit (SOIC), JEDEC MS-013, 0.300-Inch, Wide Body

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