HT7953
White LED Backlight Driver

Features

- Allowable max input voltage: 26V
- Built-in Power MOSFET
- Output voltage up to 40V driving 10 series LEDs – LED $V_{f(max)}$=3.5V per string – absolute max rating up to 44V
- Channel Phase Shift PWM Dimming
- Direct PWM Dimming without Phase Shift
- Operate up to 11 strings LED at $V_{f(max.)}$=3.3V condition
- Low string feedback voltage: 0.5V at 80mA LED current
- Switching frequency: 200kHz/400kHz
- 6-string constant current output
- LED current adjustable from 60mA to 80mA
- ±2.5% current matching between strings
- Dimming control using PWM
- 1% minimum dimming duty-cycle at 2kHz
- Built- in Soft start
- LED failure detection: open and short circuit
- Capacitor type: ceramic
- Protection: OVP, OTP, UVLO, LX current limit
- 48-Pin 7x7x1.0mm TQFP-EP package

Applications

- LED backlights for LCD monitor and LCD TV

General Description

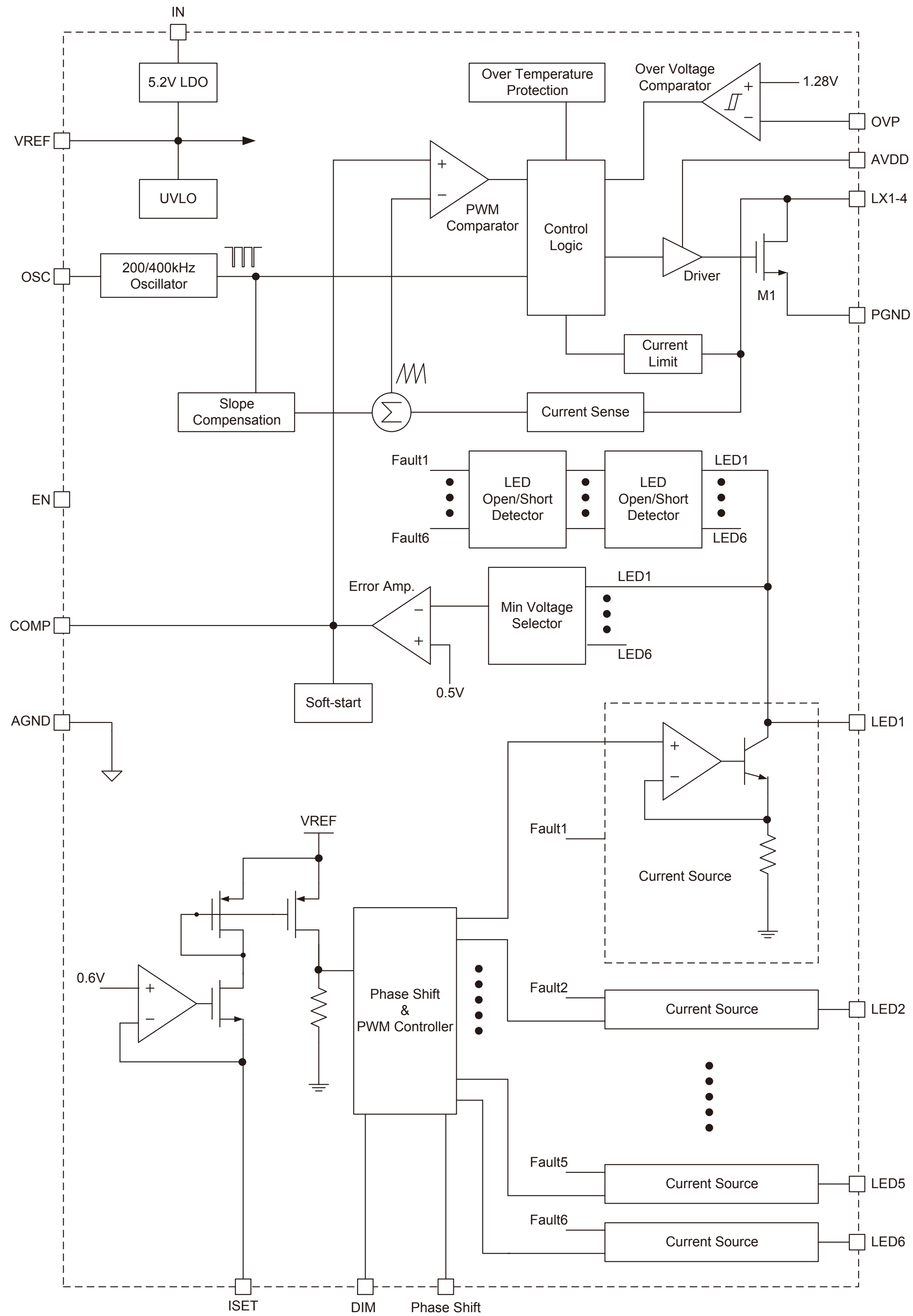
The HT7953 is a high efficiency DC-DC controller drives a number of WLEDs connected in series/parallel configuration and has a wide input voltage range from 10V to 26V, and adjustable 60mA to 80mA WLED current by external resistor. In total, the device can support up to 66 WLED.

In addition, six current sink regulators provide ±2.5% high precision current matching between strings. The brightness can be adjusted by external PWM up to 2kHz. Once an open/short string is detected, the string is disabled while other strings operate normally.

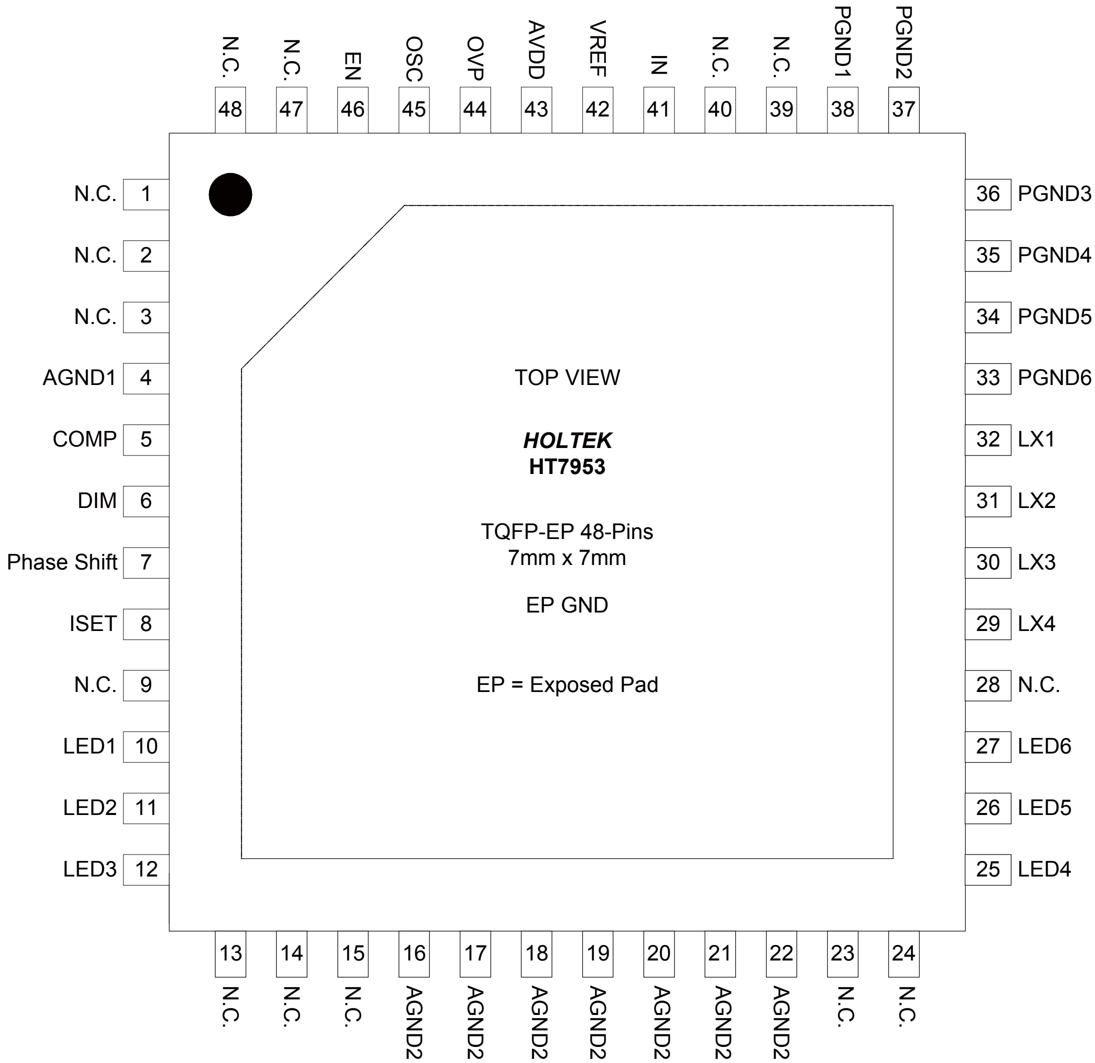
Other protecting includes soft-start, under voltage lockout, programmable over voltage protection, WLED current limit, switch current limit and thermal shutdown.

The HT7953 is packaged with a tiny footprint package of 48-Pin 7x7x1.0mm TQFP-EP package.

Block Diagram



Pin Assignment



Pin Description

PIN	Name	Description
1~3, 9, 13~15, 23, 24, 28, 37~40, 47, 48	N.C.	No Connect.
4,16~22	AGND	Analog Ground.
5	COMP	Error Amplifier Output. A simple RC series between this pin and AGND is needed to compensate the loop of the boost regulator.
6	DIM	Dimming Input. PWM control pin for LED backlight strings.
7	Phase Shift	When this pin is connect VREF or floating, with Channel Phase Shift PWM Dimming. When this pin is connect AGND, without Channel Phase Shift PWM Dimming
8	ISET	Full Scale LED Current Adjustment Pin. By selecting the resistor connected from this pin to AGND.
10~12 25~27	LED1, LED2, LED3, LED4, LED5, LED6,	LED current sink. It is the open-drain output of an internal regulator, and can sink up to 80mA. If unused, leave it open.
29~32	LX1, LX2, LX3, LX4	Switching Node. Drain of the internal Power MOSFET. Connect the inductor and the schottky diode to LX1, LX2, LX3 and LX4 node.
33~36	PGND	Power Ground. Power MOSFET return path.
41	IN	Input Voltage. From 10V to 26V, bypass IN to AGND directly at the pin with 0.1uF or greater ceramic capacitor.
42	VREF	Internal 5.2V LDO Output. Bypass to AGND with a 10uF or greater ceramic capacitor.
43	AVDD	Power MOSFET Gate Drive Supply. Bypass AVDD to AGND with a ceramic capacitor of 10uF or greater.
44	OVP	Over Voltage Protection. Used to set the desired OVP threshold by an external divider. The detector threshold is 1.23V (typ.). and VOVP=VOUT+3V
45	OSC	Oscillator Frequency Selection. Connect OSC to VREF to set the converter's oscillator frequency to 200kHz. Connect OSC to AGND to set the frequency to 400kHz.
46	EN	Enable Input. When low or left open, the device is turned off. If tied high, the device is active.
—	EP	Exposed Pad. Connection to PGND plane of the PCB.

Absolute Maximum Ratings

IN, EN 31V

LED1~LED8, LX1, LX2 ....44V

AVDD, OVP...6V

Operating Temperature Range .... -40°C ~ +85°C

Maximum Junction Temperature ....+150°C

LED Current..100mA

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

Electrical Characteristics

Refer to circuit of Figure 1, EN =V_{IN} = 18V, AV_{DD} = V_{REF}, Ta=25°C, unless otherwise specified. (Note 2)

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Supply Selection					
IN Input Voltage	—	10	—	26	V
IN Quiescent Current	EN=V_{REF}	—	5	—	mA
	EN=GND	—	—	10	μA
VREF Output Voltage	6.0V < V_{IN} < 26V, (Only for internal circuit used)	5.00	5.20	5.45	V
VREF UVLO Threshold	Rising edge, typical hysteresis=85mV	3.60	3.80	4.00	V
Boost Selection					
Switching Frequency	OSC=AGND	280	400	520	kHz
	OSC=V_{REF}	140	200	260	MHz
LX_Internal MOSFET Current Limit	—	—	2.7	—	A
LX_Internal MOSFET $R_{DS(ON)}$	—	—	0.3	—	Ω
Maximum Duty Cycle	—	—	94	—	%
Control Selection					
Enable High Level Threshold Voltage	—	2	—	—	V
Enable Low Level Threshold Voltage	—	—	—	0.8	
Dimming PWM Frequency	—	—	2	—	kHz
Dimming PWM High Level Threshold	—	2	—	—	V
Dimming PWM Low Level Threshold	—	—	—	0.8	
LED_Selection					
LED_Current	R_{ISET}=19K	74	80	86	mA
LED_Current Regulation Between Strings	I_{LED}=80mA	—	±2.5	±5.0	%
LED_Open Detector Threshold	LED_=Open	150	200	250	mV
LED_Short Detector Threshold	LED_=V_{OUT}	5.2	5.6	6.0	V
OVP Threshold Voltage	—	1.21	1.28	1.35	V
Thermal Selection					
Thermal Shutdown Temperature	—	—	160	—	°C
Thermal Shutdown Hysteresis	—	—	50	—	

Note: Specifications over the -40°C to 85°C operating temperature range are assured by design.

Typical Application Circuit

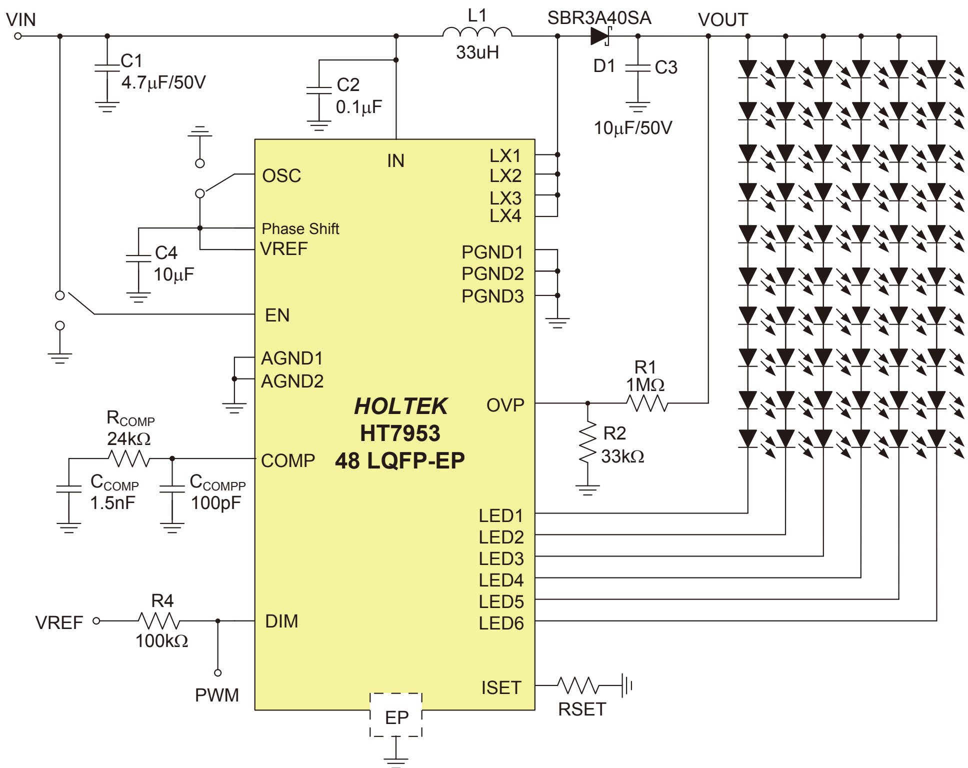


Figure 1

Functional Description

VIN Under-Voltage Lockout – UVLO

The device contains an Input Under Voltage Lockout (UVLO) circuit. The purpose of the UVLO circuit is to ensure that the input voltage is high enough for reliable operation. When the input voltage falls below the under voltage threshold, the internal MOSFET switch will be turned off. If the input voltage rises beyond the under voltage lockout hysteresis, it can return to the original operating situation and does not required to be powered on again. The UVLO threshold is set below the minimum input voltage of 3.8V to avoid any transient VIN drops under the UVLO threshold causing the converter to turn off.

Current Limit Protection

The device has a cycle-by-cycle current limit to protect the internal power MOSFET. If the inductor current reaches the current limit threshold of 3.2A, the MOSFET will be turned off. It is import to note that this current limit will not protect the output from excessive current if the output is short circuited. If an output short circuit has occurred, excessive current can damage both the inductor and diode.

Output Voltage Protection

Over-Voltage Protection

The device includes an over-voltage protection function. If the one of ISEN pins is shorted to ground or an LED is disconnected from the circuit, the voltage on the ISEN pin will fall to zero and the internal power MOSFET will switch with its full duty cycle. This may cause the output voltage to exceed its maximum voltage rating, possibly damaging the device and external components. The internal over-voltage protection circuitry turns off the power MOSFET and shuts down the device as soon as the output voltage exceeds the V_{OVP} threshold. As a result, the output voltage falls to the level of the input supply voltage. The device remains in this shutdown mode until the V_{OVP} is less than its setup threshold.

LED Open Detector Protection

The device includes an LED open protection function. If any one of ISEN pins is disconnected from the LED load, the device will stop driving the ISEN pin, automatically ignoring the open pin. The LED current of the other ISEN pins will not be influenced by any open ISEN pin. When the open ISEN pins are re-connected to the LED load, there will be no current. These ISEN pins will remain disabled until the power is recycled.

LED Short Detector Protection

The device includes an LED short circuit protection function. If more than 2~3 LEDs are short circuited on any ISEN pin or the voltage level of the ISEN pin is greater than 5.6V, the device will turn off that ISEN pin and automatically ignore the shorted pin. The LED current of other ISEN pins will not be influenced by any shorted ISEN pins. If even only one ISEN pin remains operational due to shorts on other pins, it will still maintain normal operation. The shorted ISEN pins remain disabled until the power is recycled.

Over-Temperature protection – OTP

An internal thermal shutdown function is included to prevent device damage due to excessive heat and power dissipation. Typically, the thermal shutdown threshold of is 160°C. When the thermal shutdown function is activated, the device stops switching until the temperature falls to below 110°C typically. When this occurs the device resumes switching once again.

Soft Start Function

Converter operation starts immediately after power on. In order to avoid the possibility of large in-rush currents to the load during this power on period, a soft-start function is implemented to prevent this problem from occurring.

Application Information

Inductor Selection

The inductor choice affects steady state operation as well as transient behavior and loop stability. There are three important electrical parameters which need to be considered when choosing an inductor:

- The inductor value
- DCR – copper wire resistance
- The saturation current

Inductor choice is especially important as it is required to ensure the inductor does not saturate under its peak current conditions. The general rule is to keep the inductor current peak-to-peak ripple at approximately 30% of the nominal output current. As a typical example, when using the HT7953 boost converter, operating in both discontinuous and continuous conduction modes, the typical application circuit value of the inductor, L1, would be around 10μH.

Input/Output Capacitor

Output Capacitor

The output capacitor determines the steady state output voltage ripple. In the compensation parameters, the output capacitor is one of the parameters, and if the capacitance is too big or too small, it can cause system instability. Its value must be based on the application circuit recommended output capacitor value. A low ESR ceramic capacitor is required to keep noise to a minimum. A 10μF ceramic capacitor is suitable for typical applications.

Input Capacitor

An input capacitor is required to supply the ripple current to the inductor and is also used to limit the input noise, allowing the device to obtain a stable DC power supply. As the input capacitance is not a compensation parameter there are no stability problems, however a capacitor must always be connected along with an input power supply. For typical applications, a 4.7μF ceramic capacitor is sufficient. This capacitor must be connected very close to the VIN pin and inductor, with short traces for good noise performance.

Schottky Diode

It is recommended to use a Schottky diode with a low forward voltage to minimise power dissipation and therefore maximise the converter efficiency. The average and peak current ratings must be greater than the maximum output current and peak inductor current. There are three important electrical parameters to consider when choosing the diode:

- The diode maximum reverse voltage value must be greater than the maximum output voltage.
- Short recovery time and low forward voltage – use a Schottky diode type.
- Diode current rating should be greater than the maximum load current.

Compensation Components

The COMP pin is the output of the error amplifier and must be properly connected to an external RC network to ensure regulator loop stability. Recommended values are: R_{Comp}=24kΩ, C_{Comp}=1.5nF and C_{compp}=100pF.

Oscillator Frequency Setup

There are two frequency options available. The OSC pin default switching frequency is 1MHz when the pin is unconnected and 500kHz when the pin is connected to ground.

LED current Setup

The LED current can be setup using an external resistor connected from the ISENT pin to ground. The following equation shows how the current is calculated.

This shows how the Led reference current can be setup at LED1~6 and represents the sensed LED current for each string. The LED current regulation between the strings has good acuracy at ±2.5%.

Dimming Control

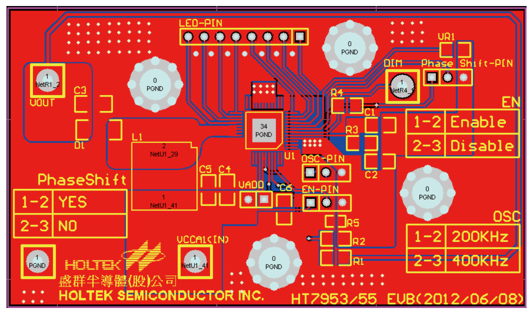
The device includes an external PWM signal dimming control. PWM dimming control is achieved by applying an external PWM signal with a frequency of 100Hz to 10kHz. The high level of this signal must be greater than 2.0V and the low level must be less than 0.8V. A 0% duty cycle corresponds to zero LED current while a 100% duty cycle corresponds to full LED current.

Layout Considerations

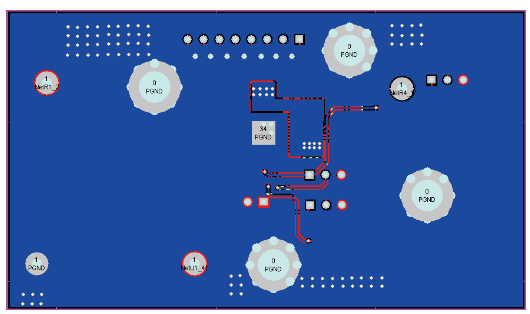
Circuit board layout is a very important consideration for switching regulators if they are to function properly. Poor circuit layout may result in related noise problems. In order to minimise EMI and switching noise, the guidelines should be noted:

- All tracks should be as wide as possible.
- The input and output capacitors, CIN and COUT, should be located close to the VIN, VOUT and GND pins.
- The Schottky diode, D1, and inductor, L1, must be located close to the LX pin.
- The AGND analog ground pins, and PGND power ground pins, must have independent connections, but must be connected together at some final point on the user circuit board.

A recommended PCB layout with component locations is enclosed.

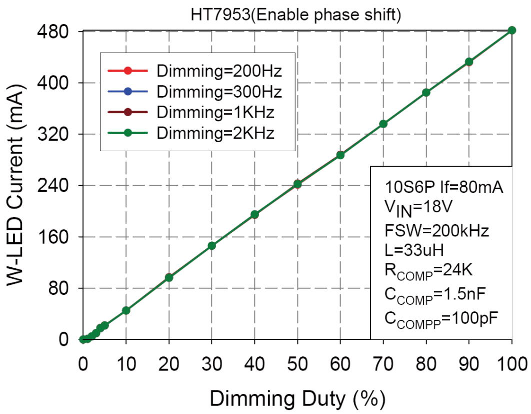


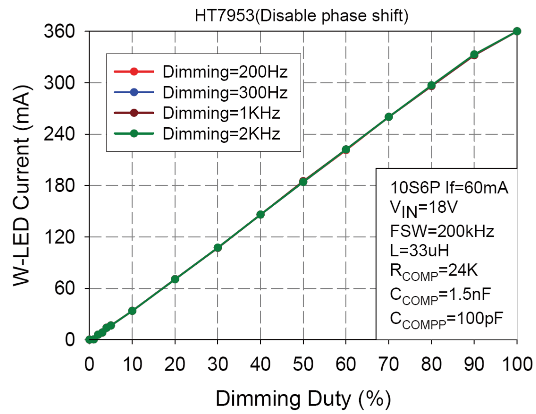
Top Layer

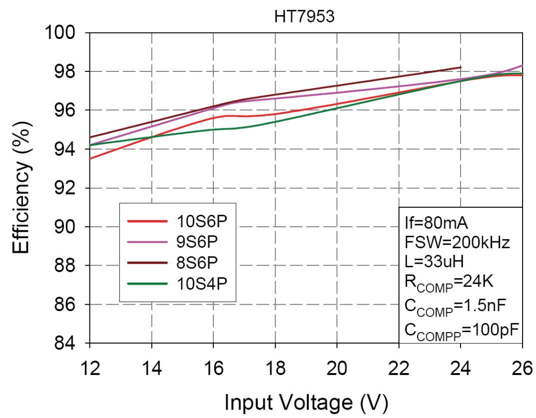


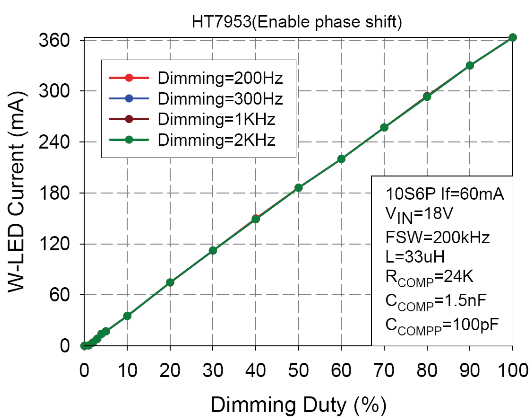
Bottom Layer

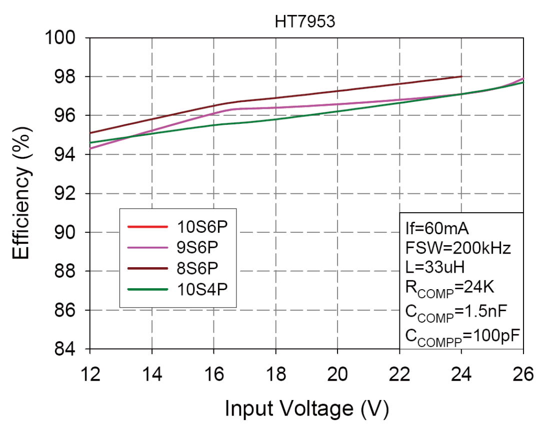
Typical Performance Characteristics

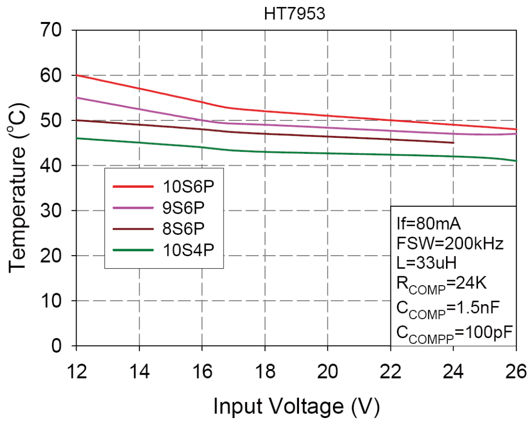


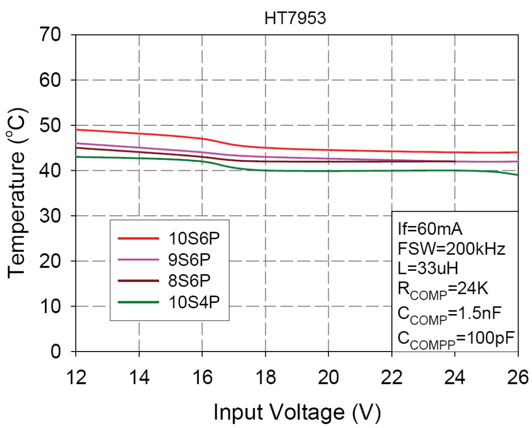


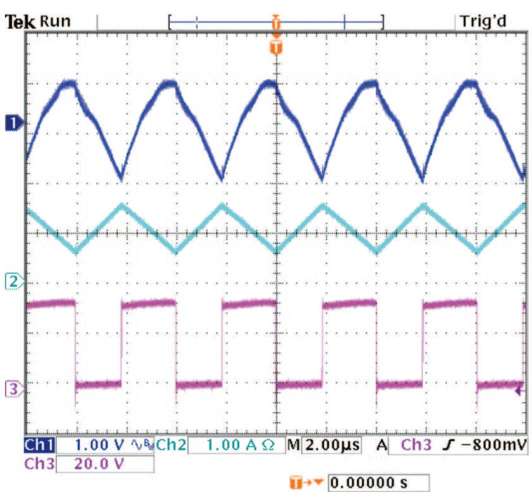










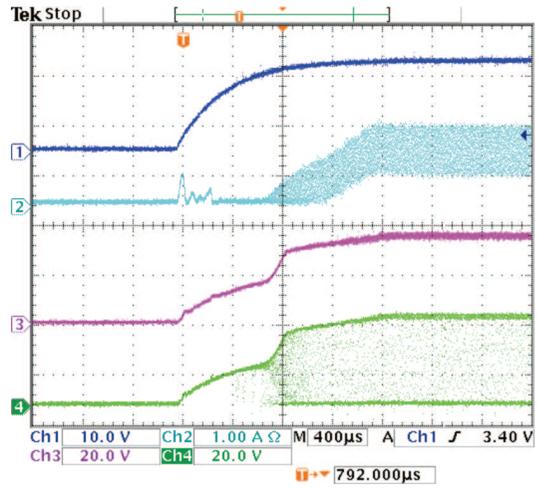


10S6P Basic Waveform

V_{IN}=18V, L=33µH, C_{IN}=4.7µF, C_{OUT}=10µF

(CH1=$V_{OUT(AC)}$, CH2=Inductor Current,

CH3=Switching Pin)

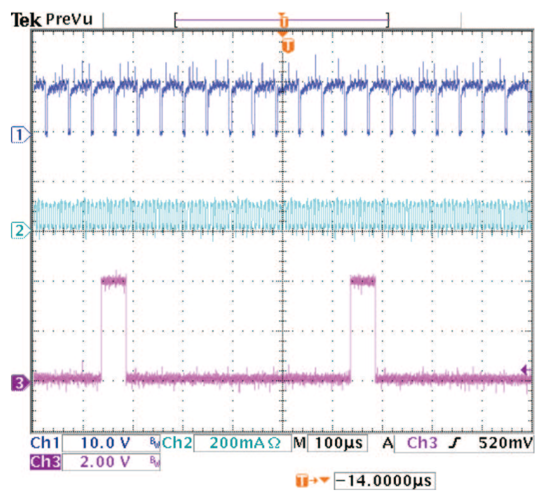


10S6P Start Up Waveform

V_{IN}=18V, L=33µH, C_{IN}=4.7µF, C_{OUT}=20µF

(CH1=V_{IN}, CH2=Inductor Current, CH3=V_{OUT},

CH4=Switching Pin)



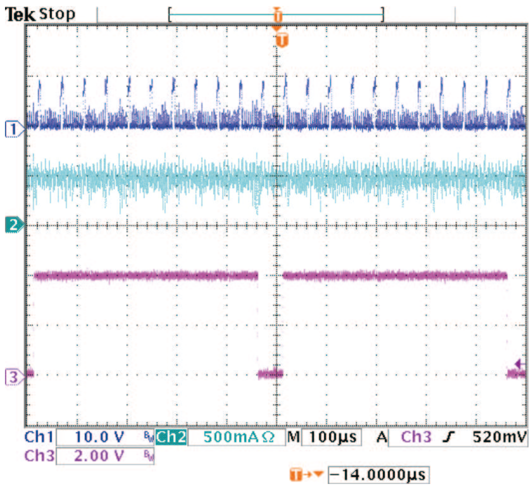
10S6P Dimming Waveform Dimming=2kHz

D=10%, V_{IN}=18V, L=33µH, C_{IN}=4.7µF, C_{OUT}=10µF

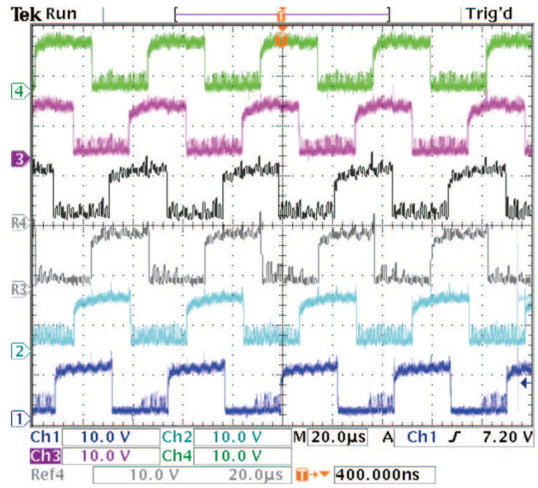
(enable phase shift)

(CH1=one of LED channel Feedback Voltage,

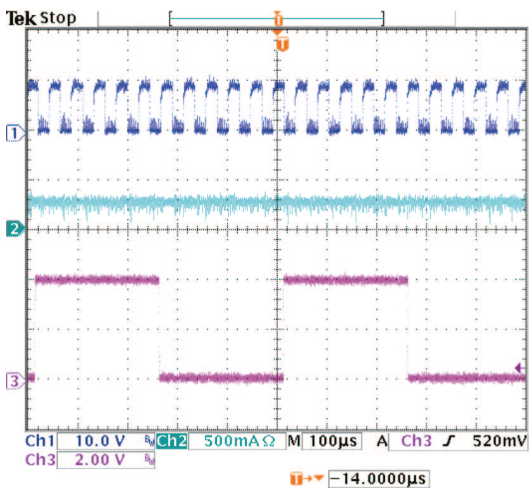
CH2=LED Current, CH3=Dimming Signal)



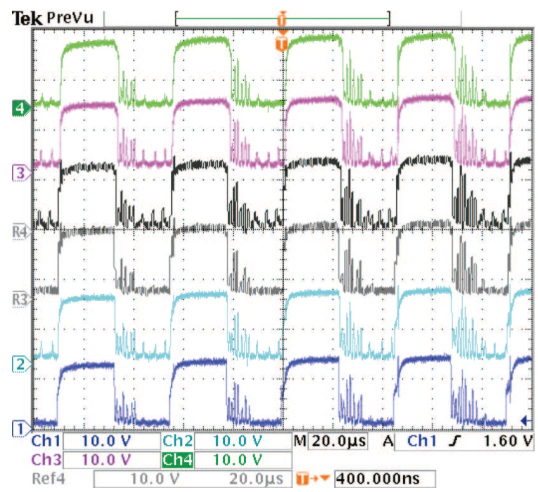
10S6P Dimming Waveform Dimming=2kHz
D=90%, V_{IN}=18V, L=33µH, C_{IN}=4.7µF, C_{OUT}=10µF
(enable phase shift)
(CH1=one of LED channel Feedback Voltage,
CH2=LED Current, CH3=Dimming Signal)



10S6P Feedback Waveform Dimming=2kHz
D=50%, V_{IN}=18V, L=33µH, C_{IN}=4.7µF, C_{OUT}=10µF
(enable phase shift)
(CH1=Feedback1, CH2=Feedbak2 R3=Feedback3,
R4=Feedback4, CH3=Feedback5, CH4=Feedback6)



10S6P Dimming waveform Dimming=2kHz
D=50%, V_{IN}=18V, L=33µH, C_{IN}=4.7µF, C_{OUT}=10µF
(enable phase shift)
(CH1=One of LED Channel Feedback Voltage,
CH2=LED Current, CH3=Dimming Signal)

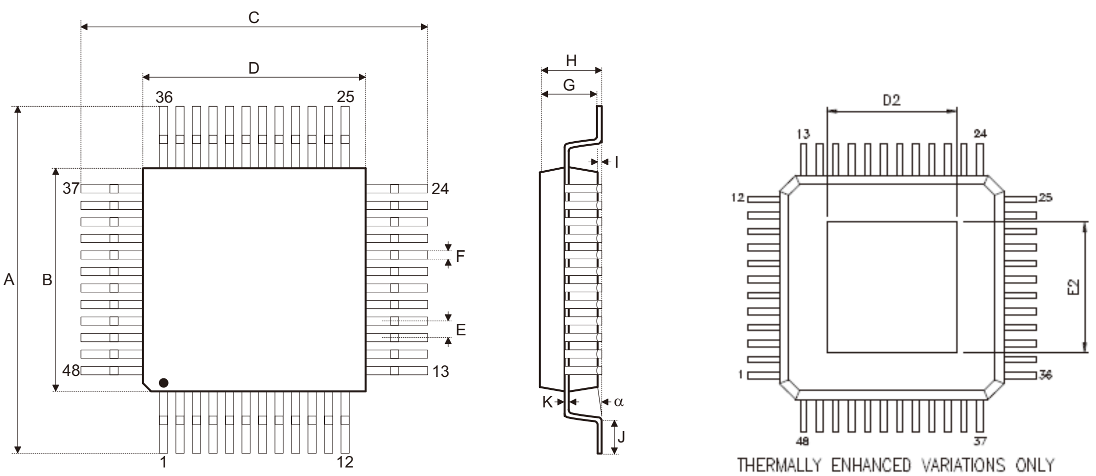


10S6P Feedback Waveform Dimming=2kHz
D=50%, V_{IN}=18V, L=33µH, C_{IN}=4.7µF, C_{OUT}=10µF
(Disable phase shift)
(CH1=Feedback1, CH2=Feedbak2 R3=Feedback3,
R4=Feedback4, CH3=Feedback5, CH4=Feedback6)

Package Information

Note that the package information provided here is for consultation purposes only. As this information may be updated at regular intervals users are reminded to consult the Holtek website (http://www.holtek.com.tw/english/literature/package.pdf) for the latest version of the package information.

48-pin TQFP (7mm×7mm) Outline Dimensions for Thermally Enhance (Exposed Pad)



MS-026

Symbol	Dimensions in inch		
	Min.	Nom.	Max.
A	—	0.354	—
B	—	0.276	—
C	—	0.354	—
D	—	0.276	—
E	—	0.020	—
D2	—	0.160	—
E2	—	0.160	—
F	0.007	—	0.011
G	0.037	0.039	0.041
H	—	—	0.047
I	0.002	0.004	0.006
J	0.018	—	0.030
L	0.004	—	0.008
α	0°	—	7°

Symbol	Dimensions in mm		
	Min.	Nom.	Max.
A	—	9.00	—
B	—	7.00	—
C	—	9.00	—
D	—	7.00	—
E	—	0.50	—
D2	—	4.06	—
E2	—	4.06	—
F	0.17	—	0.27
G	0.95	1.00	1.05
H	—	—	1.20
I	0.05	0.10	0.15
J	0.45	—	0.75
L	0.09	—	0.20
α	0°	—	7°

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