5V/1.37A VCSEL and IR-LED Driver with I²C Interface

Features

- **Wide Input Voltage from 2.7V to 5.5V**
- **Programmable LED Source Current up to 1.37A per 10mA/step**
- **Programmable LED Source Current Slew Rate 10mA/0.5μs to 10mA/64μs**
- **Bypass Mode for Standby Mode**
- **40μA Operation Standby Current**
- **Programmable Ramp-up Time for IR-LED Current**
- **Support Dimming Frequency up to 5KHz**
- **1MHz/2MHz Selectable Switching Frequency**
- **NTC Thermal Protection (TQFN3x3-16)**
- **I²C Interface**
- **Status Indication (TQFN3x3-16)**
- **Short Circuit and Thermal Shutdown Protection**
- **Available in TQFN3x3-16 and WLCSP1.42x1.42**
- **Lead Free Green Devices Available (RoHS Compliant)**

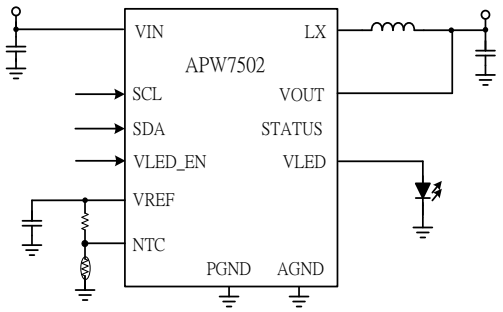
General Description

The APW7502 is a 5V/1.37A, 2MHz buck converter with a 7-bit current DAC to provide a well regulated current source for VCSEL and IR_LED applications. Through I²C interface, the start-up slew rate of the current source can be 8-segment adjustable and the regulated level can be adjusted too from 100mA to 1.37A in 10mA resolution.

The APW7502 integrates protections such as NTC thermal protection, short circuit and over-temperature protection. If NTC fault occurs the device reduces LED driving current and indicates the fault event via STATUS pin(low). When the buck converter output is overloaded or short circuited, the device limits the current at a safety level to prevent catastrophic failure. The over-temperature protection shuts down the device when junction temperature reaches 150°C and will automatically resume operating when junction temperature cools down by 20°C.

The cathode of the flash LED is referenced to GND, which improves thermal performance. The device is available in TQFN3x3-16 and WLCSP1.42x1.42 packages.

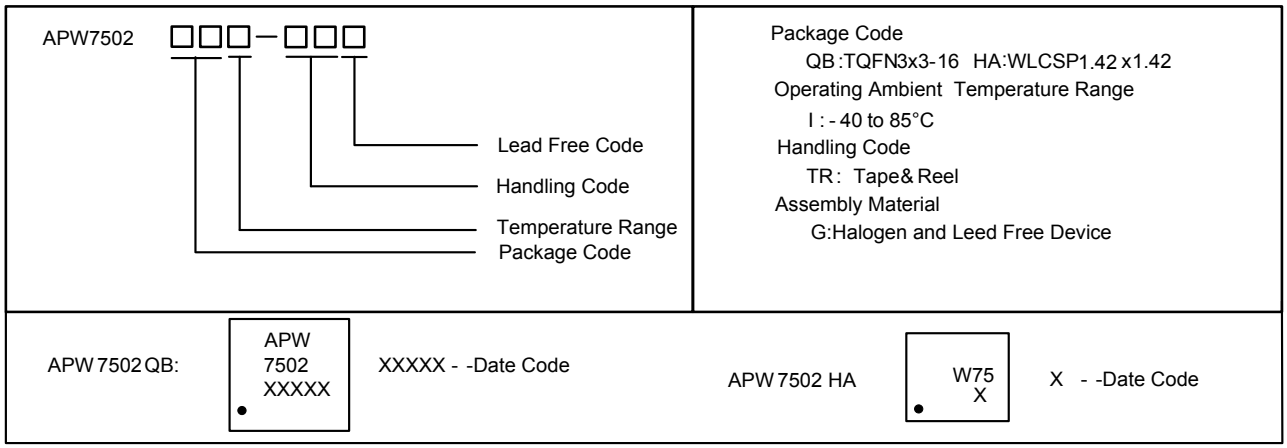
Simplified Application Circuit



Applications

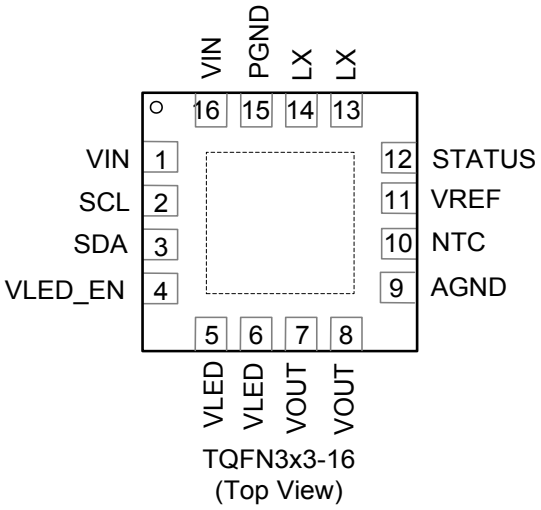
- **IR-LED Driver**
- **VCSEL Driver**

Ordering and Marking Information

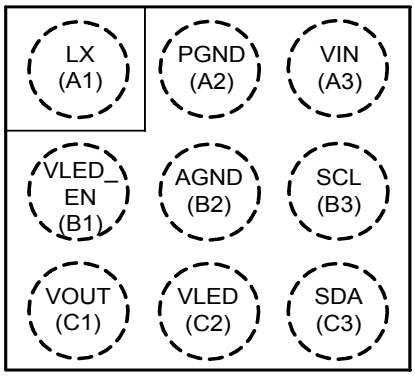


Note: ANPEC lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish; which are fully compliant with RoHS and compatible with both SnPb and lead-free soldiering operations. ANPEC lead-free products meet or exceed the leadfree requirements of IPC/ JEDEC J STD-020C for MSL classification at lead-free peak reflow temperature.

Pin Configuration



TQFN3x3-16
(Top View)



WLCSP1.42x1.42
(Top View)

Absolute Maximum Ratings (Note 1)

Symbol	Parameter		Rating	Unit
V_{IN}	VIN to PGND		-0.3 ~ 7	V
V_{LX}	LX to PGND	>20ns Pulse Width	-0.3 ~ V_{IN}+0.3	V
		<20ns Pulse Width	-3 ~ 8	
Other Pins	VLED, SCL, SDA, VREF, NTC, STATUS and VLED_EN to PGND Voltage		-0.3 ~ 7	V
T_J	Maximum Junction Temperature		150	°C
T_{STG}	Storage Temperature		-65 ~ 150	°C
T_{SDR}	Maximum Lead Soldering Temperature(10 Seconds)		260	°C

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired. Exposure to absolute maximum rating conditions for extended periods may affect device reliability

Thermal Characteristics

Symbol	Parameter		Typical Value	Unit
θ_{JA}	Junction-to-Ambient Resistance in free air (Note 2)	TQFN3x3-16	65	°C/W
θ_{JA}	Junction-to-Ambient Resistance in free air (Note 2)	WLCSP1.42x1.42	165	°C/W

Note 2: θ_{JA} is measured with the component mounted on a high effective thermal conductivity test board in free air. The exposed pad of xxxxx is soldered directly on the PCB.

Recommended Operating Conditions (Note 4)

Symbol	Parameter	Range	Unit
V_{IN}	VIN to GND Voltage	2.7 ~ 5.5	V
I_{OUT}	Converter Output Current	0 ~ 1.37	A
L1	Converter Output Inductor	1~2.2	uH
T_A	Ambient Temperature	-40 ~ 85	℃
T_J	Junction Temperature	-40 ~ 125	℃

Note 4 : Refer to the typical application circuit

Electrical Characteristics

Test Condition: V_{IN}=5V, T_A= -40 to 125°C. Typical values are at T_A=25°C

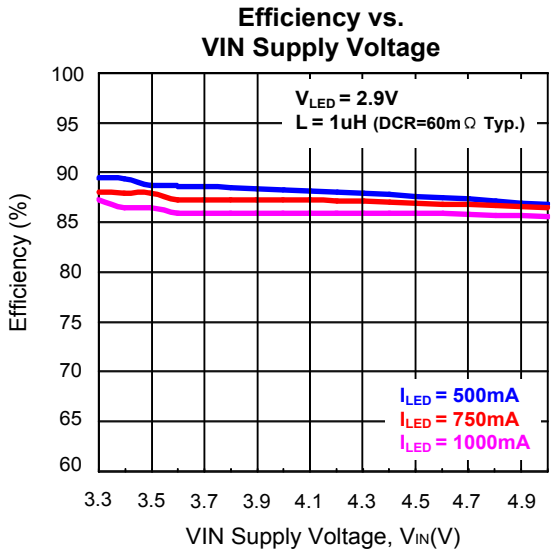
Symbol	Parameter	Test Conditions	APW7502			Unit
			Min	Typ	Max	
Supply Current						
I_{IN}	V_{IN} Shutdown Supply Current	V_{IN}=2.7V to 5.5V at bypass mode, I^2C active, VLED_EN=Low	-	40	60	μA
Power-On-Reset (POR)						
V_{IN_POR}	V_{IN} POR Threshold Voltage	V_{IN} Rising	-	2.5	-	V
	V_{IN} POR Hysteresis Voltage	V_{IN} Falling	-	150	-	mV
NTC Thermal Protection						
V_{REF}	VREF Pin Output Voltage		1.98	2	2.02	V
I_{REF}	VREF Output Current Capability		10	-	-	mA
V_{NTC-R}	NTC Rising Threshold Voltage	VNTC Rising Threshold	1.078	1.1	1.122	V
V_{NTC-F}	NTC Falling Threshold Voltage	VNTC Falling Threshold	0.982	0.9	0.918	V
Power Switch						
F_{SW}	Switching Frequency	PWM Mode Register 0x03: 0000 0000	1.5	2	2.5	MHz
	High-side FET On-Resistance	V_{IN}=3.6V, I_{LX}=0.5A	-	150	180	mΩ
	Low-side FET On-Resistance	V_{IN}=3.6V, I_{LX}=0.5A	-	80	100	mΩ
D_{MAX}	Maximum Converter's Duty		-	-	100	%
VLED_EN Input						
$V_{LED\_EN\_H}$	VLED_EN Rising Threshold Voltage	VLED_EN Rising, V_{IN}=2.7V~6V	1	-	-	V
$V_{LED\_EN\_L}$	VLED_EN Falling Threshold Voltage	VLED_EN Falling, V_{IN}=2.7V~6V	-	-	0.4	V
	Pull down resistance at VLED_EN pin	VLED_EN=5V	-	400	-	kΩ
LED Driver						
I_{LED}	Flash Current Setting	Register 0x00: 0010 1000	475	500	525	mA
V_{OL}	Current Source Headroom Voltage	ILED Source Current=1A at T_A=25°C	-	200	-	mV
R_{UT}	ILED Ramp-up Time	ILED Source Current at 10mA/step Register 0x01: 0000 0000	-	0.5	-	μs
		ILED Source Current at 10mA/step Register 0x01: 0000 0111	-	64	-	μs
R_{DT}	ILED Ramp-down Time	ILED Source Current at 10mA/step	-	0.5	-	μs
	Status Debounce	Status High to low	-	10	-	μs
Protection						
I_{LIM}	High-side FET switch current limit	Register 0x04:0000 0000	1.7	2	2.3	A
T_{OTP}	Thermal Shutdown Threshold	T_J Rising	-	150	-	°C
	Thermal Shutdown Hysteresis	T_J Falling	-	20	-	°C

Electrical Characteristics (Cont.)

Test Condition: T_J= -40 to 125 °C,V_{IN}=V_{INPD}=20V,$V_{ACC(VCC,VCCPD)}$=5V. Typical values are at T_J=25°C

Symbol	Parameter	Test Condition	APW7502			
			Min.	Typ.	Max.	Unit
I²C INTERFACE						
	Consumption Current	Standby Mode	-	100	150	μA
	Input Capacitance	SDA, SCL	-	5	-	pF
V_{IL}	Input Low Voltage	SDA, SCL	-	-	0.5	V
V_{IH}	Input High Voltage	SDA, SCL	1.5	-	-	V
F_{SCL}	SCL Frequency		-	-	400	kHz
t_{HIGH}	SCL High Time		600	-	-	ns
t_{LOW}	SCL Low Time		1300	-	-	ns
t_R	SDA, SCL Rise Time	C_{BUS} = Total Bus Line Capacitance (pF)	20+ 10xC_{BUS}	-	300	ns
t_F	SDA, SCL Fall Time	C_{BUS} = Total Bus Line Capacitance (pF)	20+ 10xC_{BUS}	-	300	ns
$t_{HD:STA}$	START Hold Time	10% of SDA to 90% of SCL	600	-	-	ns
$t_{SU:STA}$	START Setup Time		600	-	-	ns
$t_{HD:DAT}$	Data Input Hold Time		100	-	-	ns
$t_{SU:DAT}$	Data Input Setup Time		100	-	-	ns
$t_{SU:STO}$	STOP Setup Time		600	-	-	ns
t_{BUF}	Bus Free Time		1300	-	-	ns
	Input Spike Suppression	SDA, SCL	-	-	50	ns
$t_{TIMEOUT}$	SDA Reset Low Time		-	-	50	ms

Typical Operating Characteristics

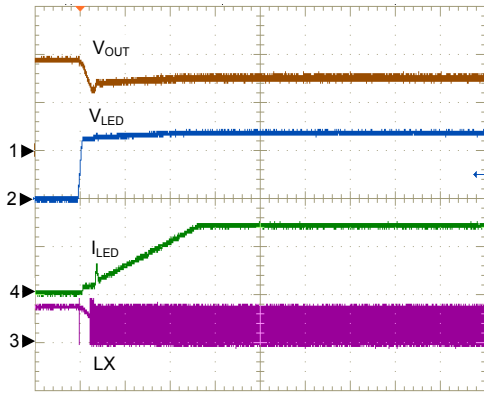


Operating Waveforms

Refer to the typical application circuit 1.1. The test condition is V_{IN}=3.7V, I_{LED}=700mA ,T_A= 25°C unless otherwise specified.

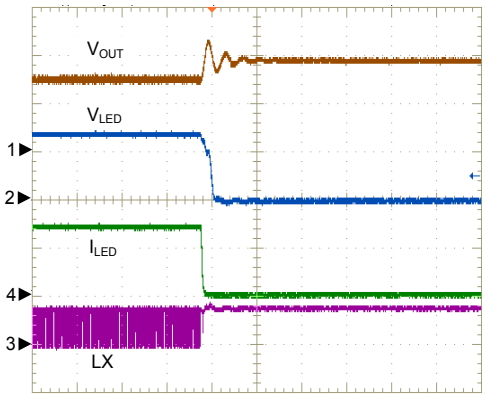
1.1 Buck Mode (V_{IN}=3.7V ,I_{LED}=700mA)

ILED Ramp-up at 4uS Slew Rate



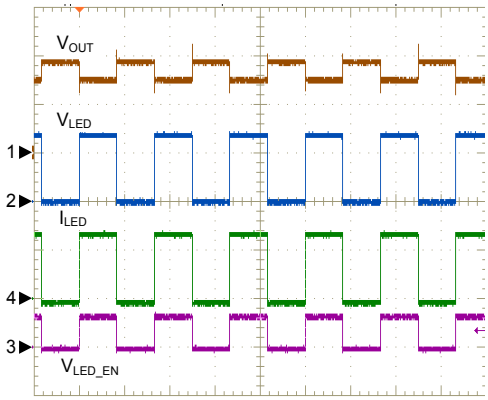
CH1: V_{OUT}, 2V/Div, DC
CH2: V_{LED}, 2V/Div, DC
CH3: LX, 5V/Div, DC
CH4: I_{LED}, 500mA/Div, DC
TIME: 100us/Div

ILED Ramp-down at 0.5uS Slew Rate



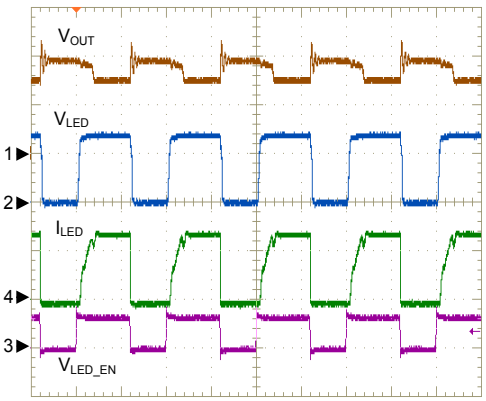
CH1: V_{OUT}, 2V/Div, DC
CH2: V_{LED}, 2V/Div, DC
CH3: LX, 5V/Div, DC
CH4: I_{LED}, 500mA/Div, DC
TIME: 20us/Div

Dimming, 30Hz at 50% duty



CH1: V_{OUT}, 2V/Div, DC
CH2: V_{LED}, 2V/Div, DC
CH3: V_{LED_EN}, 5V/Div, DC
CH4: I_{LED}, 500mA/Div, DC
TIME: 20ms/Div

Dimming, 5KHz at 60% duty



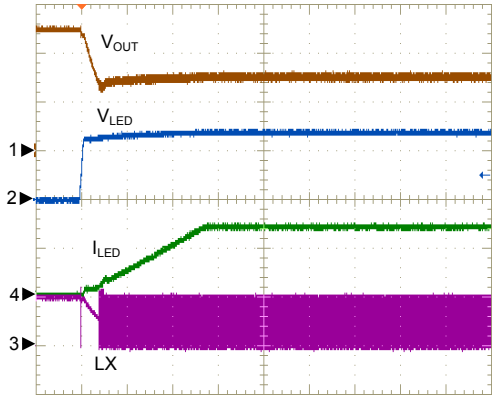
CH1: V_{OUT}, 2V/Div, DC
CH2: V_{LED}, 2V/Div, DC
CH3: V_{LED_EN}, 5V/Div, DC
CH4: I_{LED}, 500mA/Div, DC
TIME: 100us/Div

Operating Waveforms

Refer to the typical application circuit1.1. The test condition is V_{IN}=5V, I_{LED}=700mA ,T_A= 25°C unless otherwise specified.

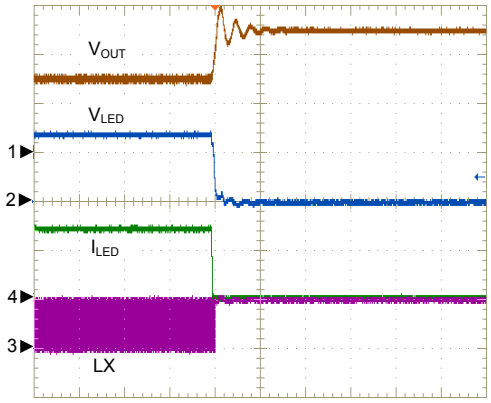
1.1 Buck Mode (V_{IN}=5V ,I_{LED}=700mA)

ILED Ramp-up at 4uS Slew Rate



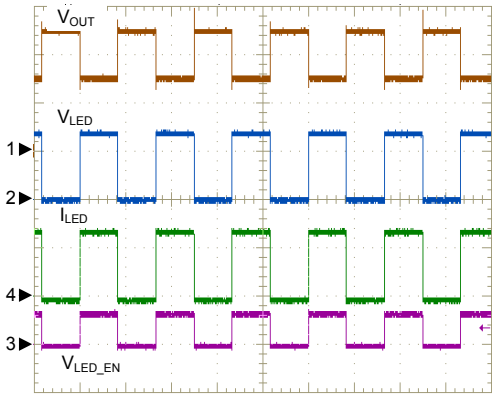
CH1: V_{OUT}, 2V/Div, DC
CH2: V_{LED}, 2V/Div, DC
CH3: LX, 5V/Div, DC
CH4: I_{LED}, 500mA/Div, DC
TIME: 100us/Div

ILED Ramp-down at 0.5uS Slew Rate



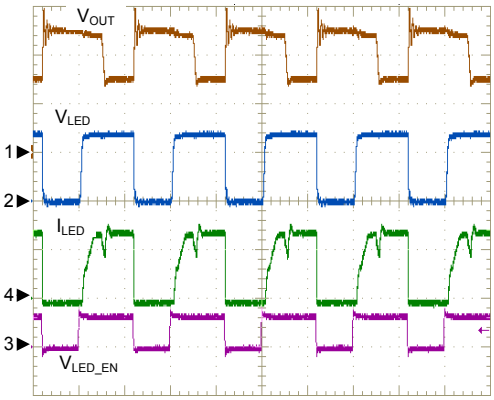
CH1: V_{OUT}, 2V/Div, DC
CH2: V_{LED}, 2V/Div, DC
CH3: LX, 5V/Div, DC
CH4: I_{LED}, 500mA/Div, DC
TIME: 20us/Div

Dimming, 30Hz at 50% duty



CH1: V_{OUT}, 2V/Div, DC
CH2: V_{LED}, 2V/Div, DC
CH3: V_{LED_EN}, 5V/Div, DC
CH4: I_{LED}, 500mA/Div, DC
TIME: 20ms/Div

Dimming, 5KHz at 60% duty



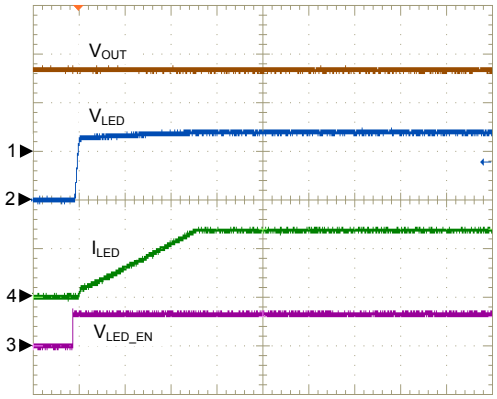
CH1: V_{OUT}, 2V/Div, DC
CH2: V_{LED}, 2V/Div, DC
CH3: V_{LED_EN}, 5V/Div, DC
CH4: I_{LED}, 500mA/Div, DC
TIME: 100us/Div

Operating Waveforms

Refer to the typical application circuit1.2. The test condition is V_{IN}=3.3V, I_{LED}=700mA ,T_A= 25°C unless otherwise specified.

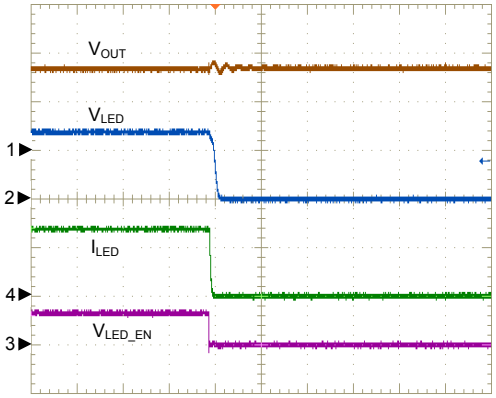
1.2 Bypass Mode (V_{IN}=3.3V ,I_{LED}=700mA)

ILED Ramp-up at 4uS Slew Rate



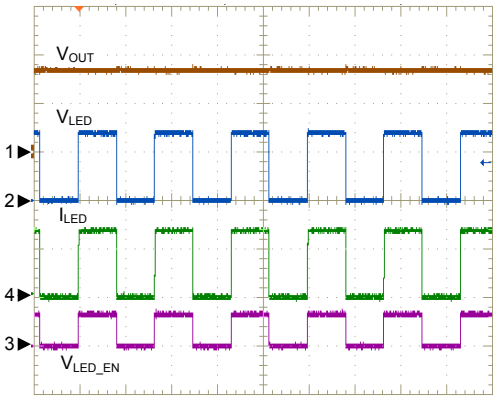
CH1: V_{OUT}, 2V/Div, DC
CH2: V_{LED}, 2V/Div, DC
CH3: V_{LED_EN}, 5V/Div, DC
CH4: I_{LED}, 500mA/Div, DC
TIME: 100us/Div

ILED Ramp-down at 0.5uS Slew Rate



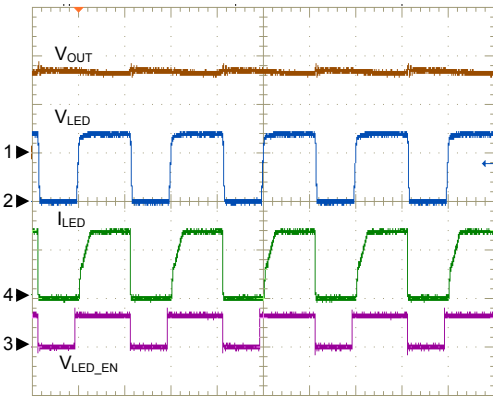
CH1: V_{OUT}, 2V/Div, DC
CH2: V_{LED}, 2V/Div, DC
CH3: V_{LED_EN}, 5V/Div, DC
CH4: I_{LED}, 500mA/Div, DC
TIME: 20us/Div

Dimming, 30Hz at 50% duty



CH1: V_{OUT}, 2V/Div, DC
CH2: V_{LED}, 2V/Div, DC
CH3: V_{LED_EN}, 5V/Div, DC
CH4: I_{LED}, 500mA/Div, DC
TIME: 20ms/Div

Dimming, 5KHz at 60% duty

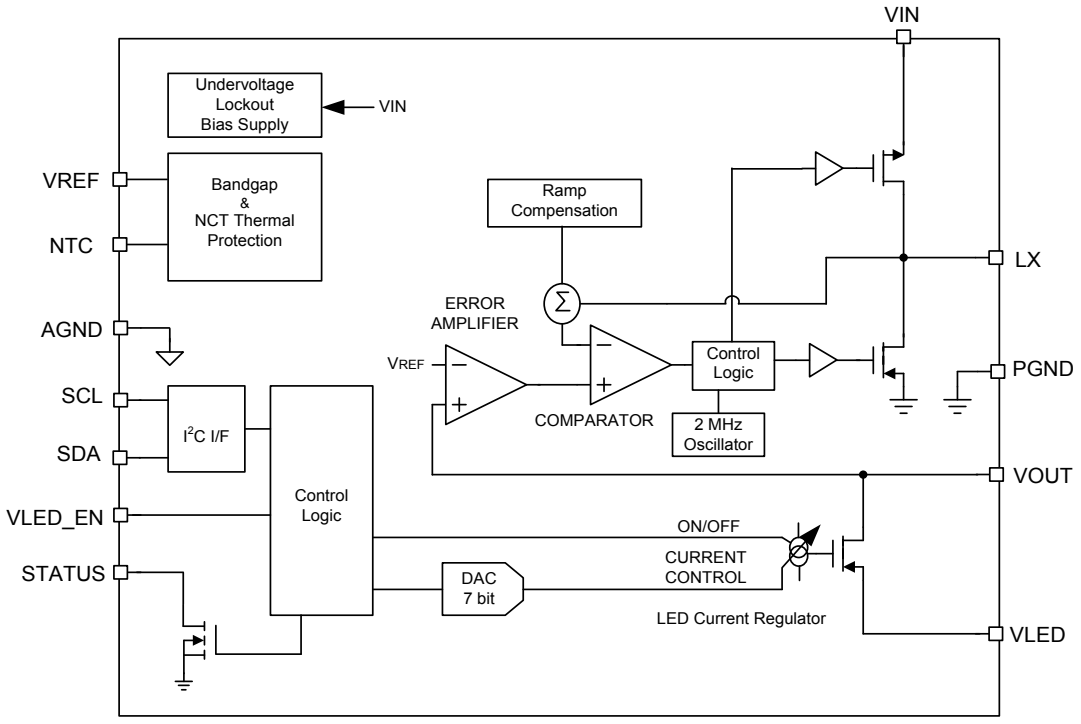


CH1: V_{OUT}, 2V/Div, DC
CH2: V_{LED}, 2V/Div, DC
CH3: V_{LED_EN}, 5V/Div, DC
CH4: I_{LED}, 500mA/Div, DC
TIME: 100us/Div

Pin Descriptions

PIN			Function
TQFN NO.	WLCSP NO.	NAME	
1,16	A3	VIN	Power supply input pin for internal circuitry and power stage.
2	B3	SCL	I^2C Interface.
3	C3	SDA	
4	B1	VLED_EN	Enable input pin. Driving this pin to logic high enables the device.
5,6	C2	VLED	Current source output pin to drive external LED(s). Connect the anode of LED(s) to LED pin.
7,8	C1	VOUT	Buck converter's feedback pin. Connect this pin to the output of buck converter for voltage regulation.
9	B2	AGND	Ground for internal circuitry.
10	-	NTC	Connect a Negative Temperature Coefficient resistor for NTC Thermal Protection.
11	-	VREF	Reference voltage output pin for NTC protection.
12	-	STATUS	An open drain, fault indication output pin. The STATUS is pulled low internally when NTC fault occurs.
13,14	A1	LX	Switching node of buck converter.
15	A2	PGND	Ground for power stage.

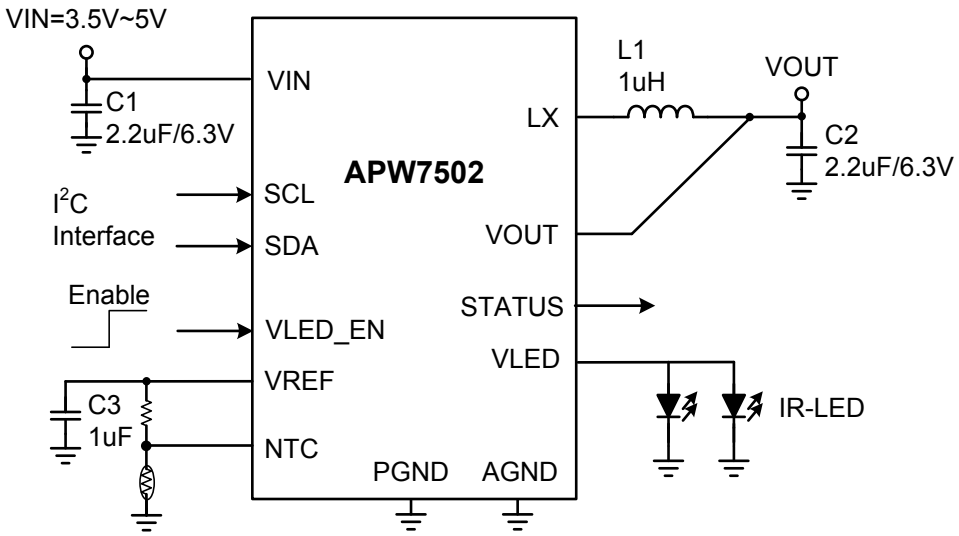
Block Diagram



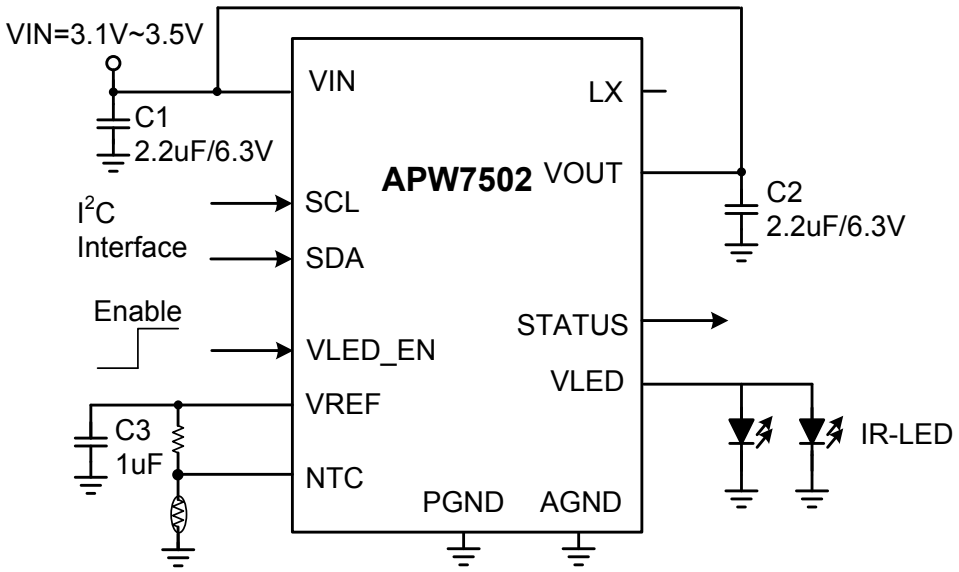
Typical Application Circuit

1 . For IR-LED application

1.1 Buck Mode: VIN-0.5V≥VF(IR-LED)



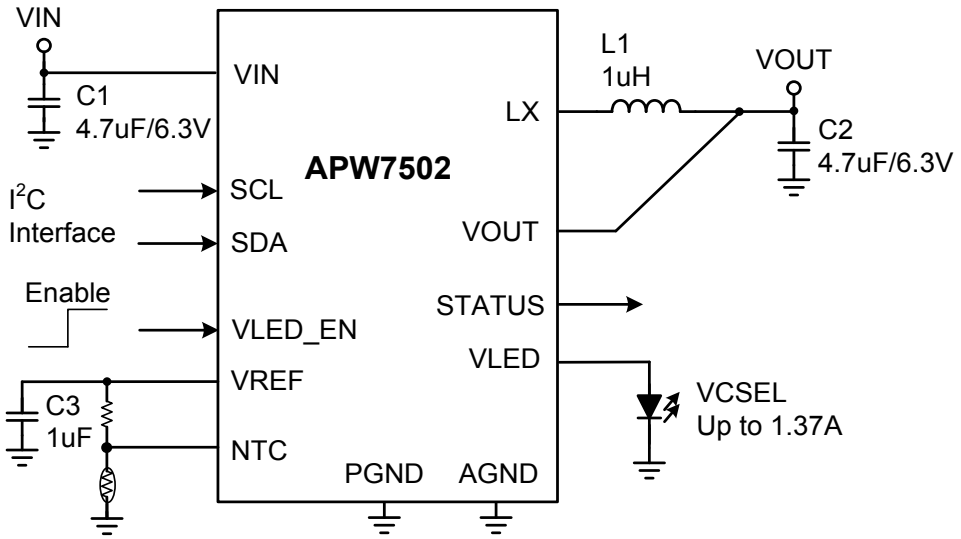
1.2 Bypass Mode: VIN-0.2V≥VF(IR-LED)



Reference	Description	Manufacturer
C1,C2	2.2uF, 6.3V, X5R, 0201 size, GRM033R60J225ME47	Murata
IR-LED	LTE-R28206AS-Q-LP	LiteON

Typical Application Circuit

2. For VCSEL application

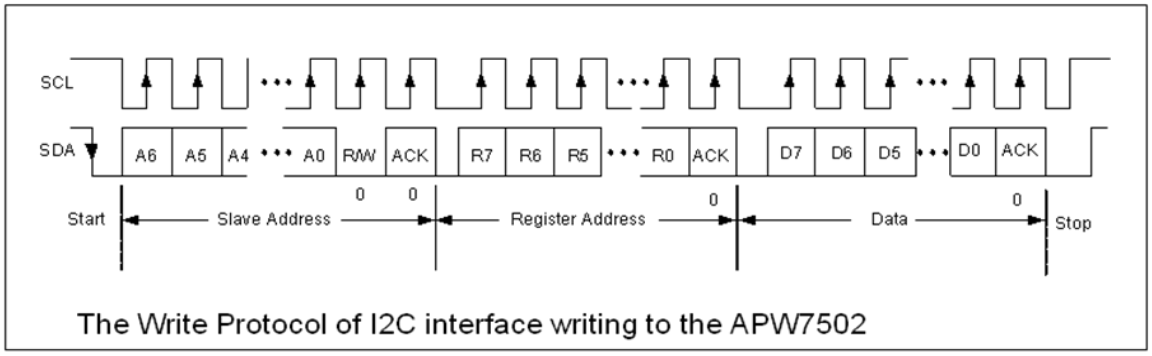


Reference	Description	Manufacturer
C1,C2	4.7uF, 6.3V, X5R, 0201 size, GRM033R60J225ME47	Murata

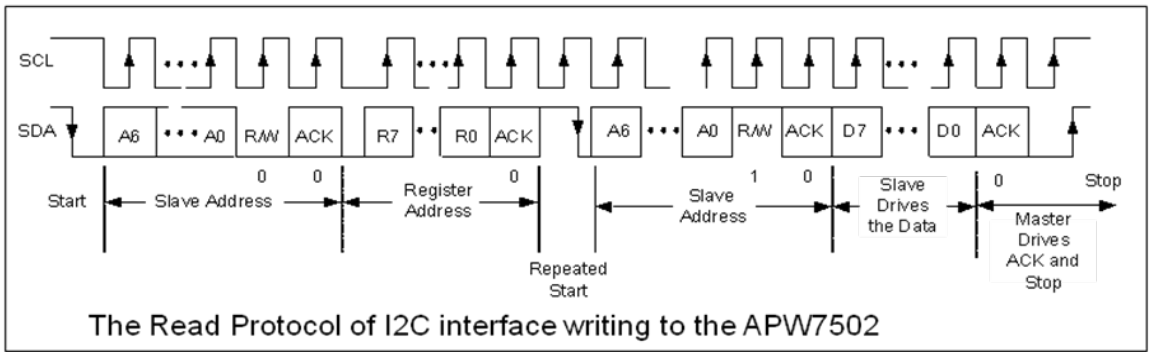
Function Descriptions

I²C Programming

The APW7502's I²C Slave Address is a hard-coded 7 bit address **0000010**. The APW7502 supports the following write and read protocol.



The Write Protocol of I2C interface writing to the APW7502



The Read Protocol of I2C interface writing to the APW7502

Registers Map

NAME	Address	Default	R/W	Data							
ILED Source Current	0x00	0x28	R/W		ILED6	ILED5	ILED4	ILED3	ILED2	ILED1	ILED0
ILED Ramp-up Time	0x01	0x03	R/W						TRUT2	TRUT1	TRUT0
ILED Enable Control	0x02	0x02	R/W						NTC_EN	EN1	EN0
Switching Frequency	0x03	0x00	R/W								FSW
PWM Current Limit	0x04	0x00	R/W								LXCL
Fault Indication	0x05	0x00	R								NTC Thermal
Product Version	0x06	0x00	R						VER2	VER1	VER0

Function Descriptions(Con't)

▪Register name: ILED Source Current

▪Register Address: 0x00

Bit	7	6	5	4	3	2	1	0	
Bit Name	-	ILED6	ILED5	ILED4	ILED3	ILED2	ILED1	ILED0	
Default	0	0	1	0	1	0	0	1	
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Bit Name	Bit Definition								Reset
ILED[6:0]	ILED Source Current Setting 000 0000: 100mA 000 0001: 110mA 000 0010: 120mA 000 0011: 130mA ……. **010 1000: 500mA (default)** ……. 111 1100 : 1340mA 111 1101 : 1350mA 111 1110 : 1360mA 111 1111 : 1370mA								by VIN POR

▪Register name: ILED Ramp-up Time

▪Register Address: 0x01

Bit	7	6	5	4	3	2	1	0	
Bit Name	-	-	-	-	-	TRUT2	TRUT1	TRUT0	
Default	0	0	0	0	0	0	1	1	
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Bit Name	Bit Definition								Reset
TRUT[2:0]	ILED Ramp-up Time Setting 000: 10mA/0.5μS 001: 10mA/1μS 010: 10mA/2μS **011: 10mA/4uS (default)** 100: 10mA/8μS 101: 10mA/16μS 110: 10mA/32μS 111: 10mA/64μS								by VIN POR

▪Register name: ILED Enable Control

▪Register Address: 0x02

Bit	7	6	5	4	3	2	1	0	
Bit Name	-	-	-	-	-	NTC_EN	EN1	EN0	
Default	0	0	0	0	0	0	1	0	
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Bit Name	Bit Definition								Reset
EN[1:0]	ILED Enable Control Setting 01: ILED Source Current Control by I^2C Register 10: **ILED Source Current Control by External EN pin (default)**								by VIN POR
NTC_EN	NTC Enable/Disable Control: **0: NTC Thermal Protection Function Disable (Default)** 1: NTC Thermal Protection Function Enable								by VIN POR

Function Descriptions(Con't)

▪Register name: Switching Frequency

▪Register Address: 0x03

Bit	7	6	5	4	3	2	1	0	
Bit Name	-	-	-	-	-	-	-	FSW	
Default	0	0	0	0	0	0	0	0	
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Bit Name	Bit Definition								Reset
FSW	PWM Switching Frequency Selection: **0: 2MHz (default)** 1: 1MHz								by VIN POR

▪Register name: PWM Current Limit

▪Register Address: 0x04

Bit	7	6	5	4	3	2	1	0	
Bit Name	-	-	-	-	-	-	-	LXCL	
Default	0	0	0	0	0	0	0	0	
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Bit Name	Bit Definition								Reset
LXLC	PWM Current Limit Setting: **0: 2A(default)** 1: 3A								-

▪Register name: Fault Indication

▪Register Address: 0x05

Bit	7	6	5	4	3	2	1	0	
Bit Name	-	-	-	-	-	-	-	NTC_FAULT	
Default	0	0	0	0	0	0	0	0	
Read/Write	R	R	R	R	R	R	R	R	
Bit Name	Bit Definition								Reset
NTC_FAULT	NTC Fault: 0: Normal operation. 1: NTC fault has been occurring or once occurred.								-

▪Register name: Product Version

▪Register Address: 0x06

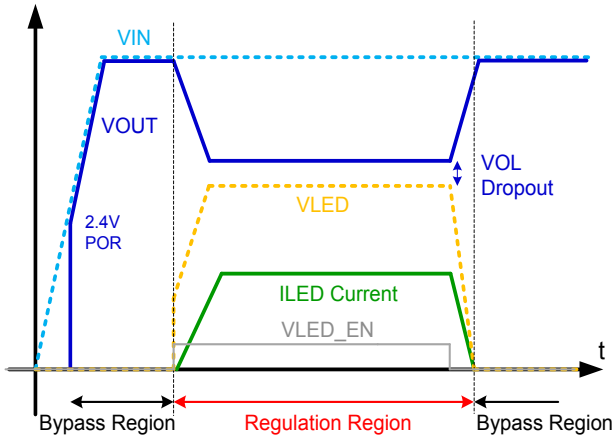
Bit	7	6	5	4	3	2	1	0	
Bit Name	-	-	-	-	-	VER2	VER1	VER0	
Default	0	0	0	0	0	0	0	0	
Read/Write	R	R	R	R	R	R	R	R	
Bit Name	Bit Definition								Reset
VER[2:0]	Product Version: 000: Version A 001: Version B 010: Version C 011: Version D 100: Version E 101: Version F 110: Version G 111: Version H								-

Function Descriptions (Con't)

The APW7502 is a 5V/1.37A, 2MHz buck converter with I²C interface. The output current is well regulated to a fixed level to drive VCSEL or IR_LED. The driving current can be adjusted from 100mA to 1.37A in 10mA resolution.

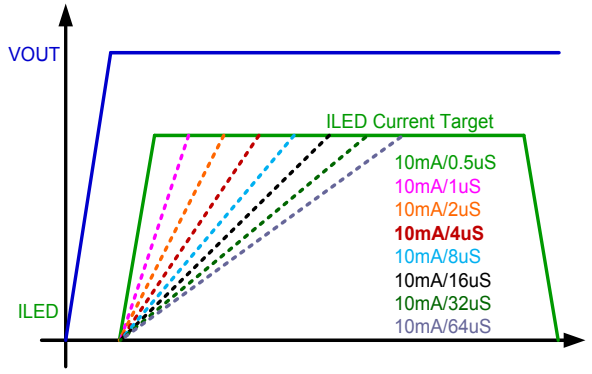
Bypass and Regulation Region

When the device is powered by a valid voltage but not enabled, the device turns the high side MOSFET fully on. In this manner the device can quickly respond to receiving enable input and then provide instant current to drive LED(s). Once enabled, the device controls and regulates its output current to a preset target. Both the ILED start-up slew rate and ILED target are adjustable via I²C interface



ILED Start-up Slew Rate Adjustment

The APW7502 provides ILED start-up slew rate adjustment via I²C interface. There are 8 segments of adjustment range which is from 10mA/0.5μs to 10mA/64μs, as shown as the diagram blow.

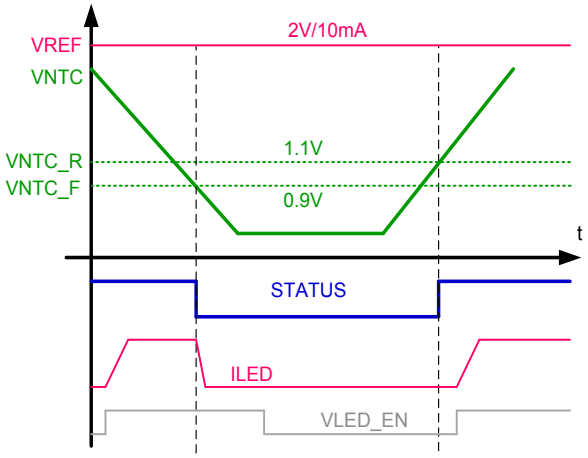


Enable

Pull the VLED_EN above 1V to enable the device and pull VLED_EN pin below 0.4V to disable the device. In shutdown mode, all internal control circuits are turned off. When the device exits shutdown mode, the output has soft-start function as the input voltage startup.

NTC Thermal Protection

The APW7502 adopts an external NTC thermister to monitor temperature (refer to Typical Application Circuit). When the temperature rises, the voltage in NTC pin will fall. As long as the NTC voltage falls to trigger NTC fault threshold, VNTC_F, as indicated in the diagram below, the APW7502 reduces ILED current to 0mA in an effort to alleviate the thermal issue and reports the NTC fault by pulling STATUS to low state until the NTC voltage rises above VNTC_R level. When the NTC fault is not present, the device is able to drive LED(s) in scale with Register 0x00 setting.

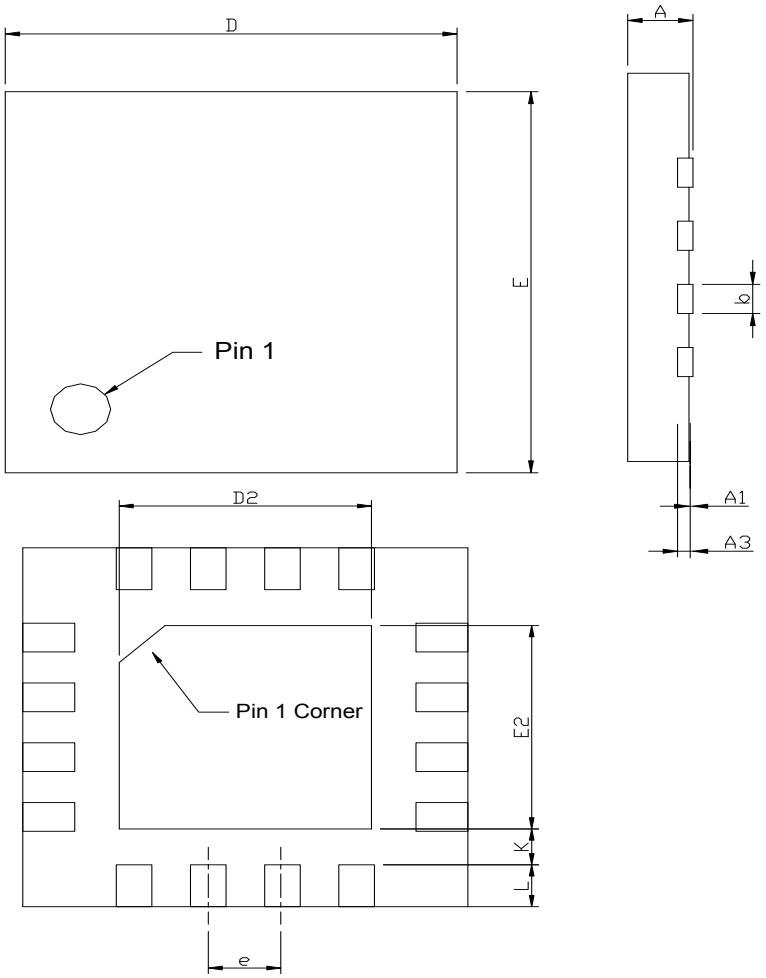


Over-Temperature Protection (OTP)

The over-temperature circuit limits the junction temperature of the APW7502. When the junction temperature exceeds T_J =+150°C, a thermal sensor turns off the power MOSFET, allowing the device to cool down. The thermal sensor allows the converter to start a start-up process and regulate the output voltage again after the junction temperature cools by 20°C

Package Information

TQFN3x3-16

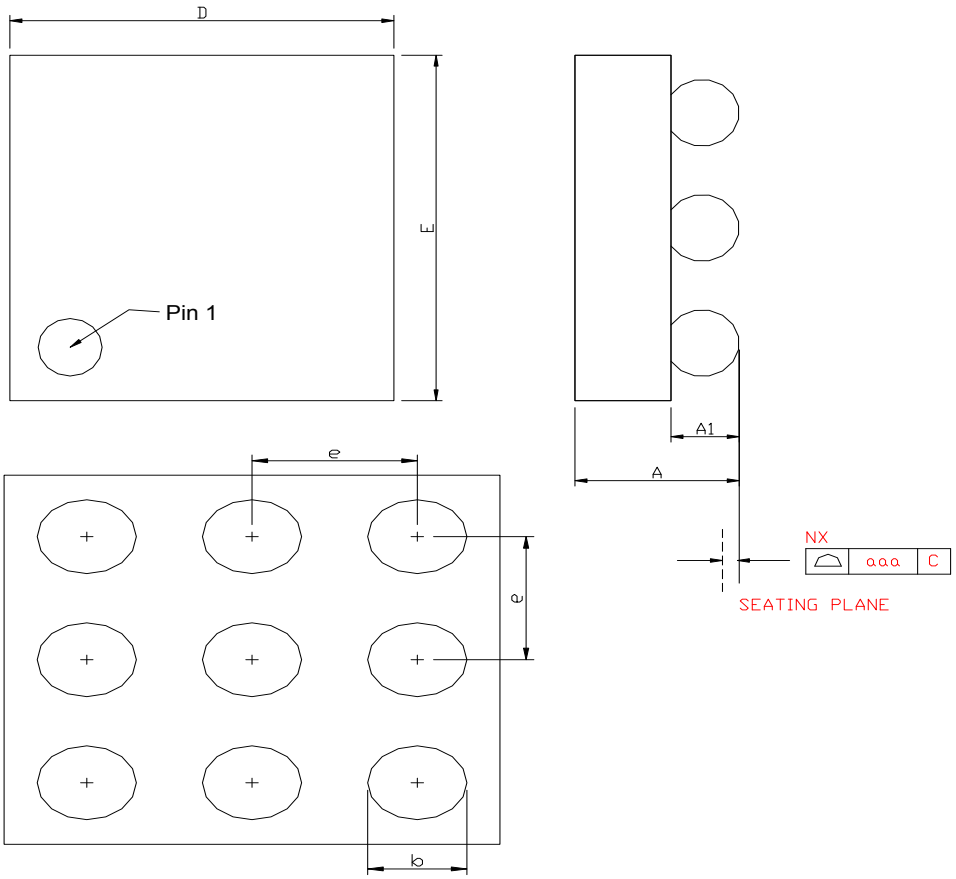


SYMBOL	TQFN3x3-16			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
A3	0.20 REF		0.008 REF	
b	0.18	0.30	0.007	0.012
D	2.90	3.10	0.114	0.122
D2	1.50	1.80	0.059	0.071
E	2.90	3.10	0.114	0.122
E2	1.50	1.80	0.059	0.071
e	0.50 BSC		0.020 BSC	
L	0.30	0.50	0.012	0.020
K	0.20		0.008	

Note: Follow JEDEC MO-220 WEED-4

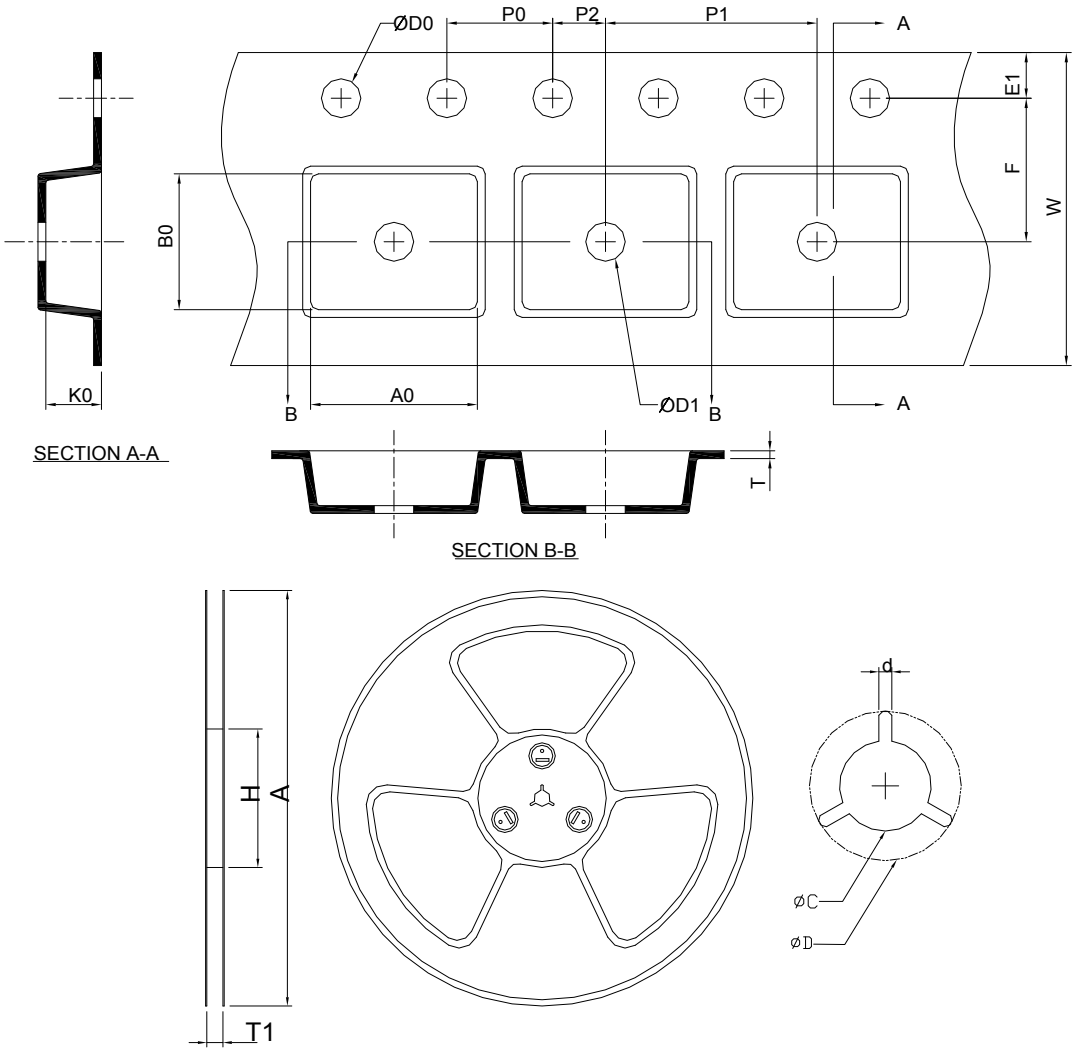
Package Information

WLCSP1.42x1.42



SYMBOL	WLCSP1.42x1.42-9			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		0.60		0.024
A1	0.18	0.22	0.007	0.009
b	0.22	0.30	0.009	0.012
D	1.42	1.50	0.056	0.059
E	1.42	1.50	0.056	0.059
e	0.50 BSC		0.020 BSC	
aaa	0.08		0.003	

Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
TQFN 3x3	330±2.00	50 MIN.	12.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	12.0±0.30	1.75±0.10	5.5±0.05
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.0±0.10	8.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	3.30±0.20	3.30±0.20	1.00±0.20
Application	**A**	**H**	**T1**	**C**	**d**	**D**	**W**	**E1**	**F**
WLCSP1.42x1.42	178.0±2.00	50 MIN.	8.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	8.0±0.30	1.75±0.10	3.5±0.05
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.0±0.10	4.0±0.10	2.0±0.05	1.5+0.10 -0.00	0.5 MIN.	0.6+0.00 -0.40	1.60±0.20	1.60±0.20	0.75±0.20

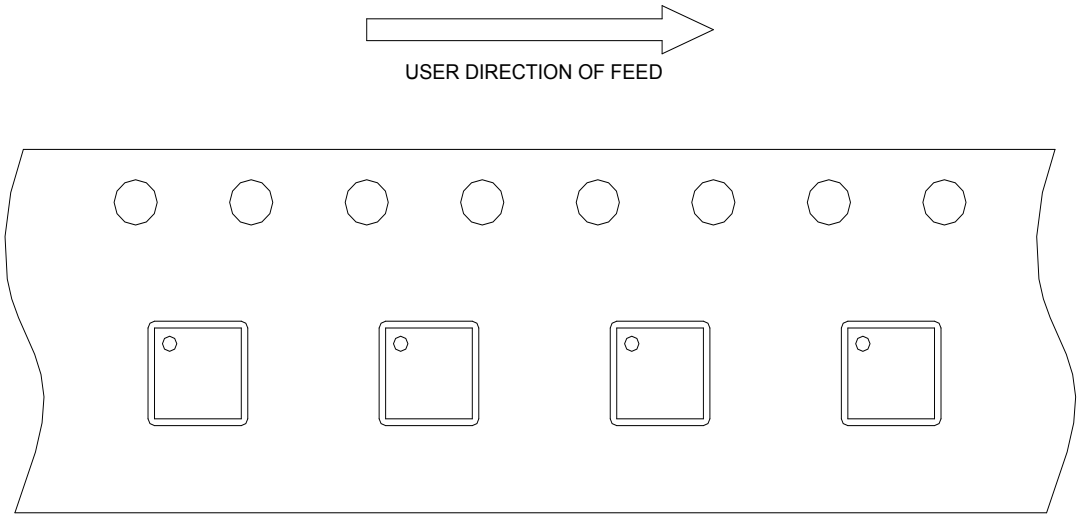
(mm)

Devices Per Unit

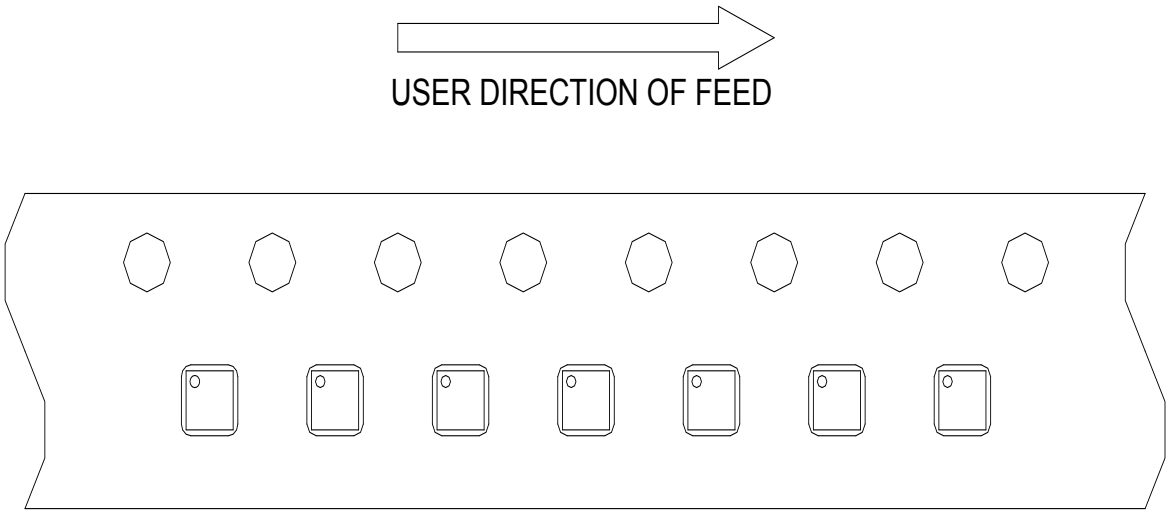
Package type	Packing	Quantity
TQFN 3x3	Tape & Reel	3000
WLCSP(1.42x1.42)	Tape & Reel	3000

Taping Direction Information

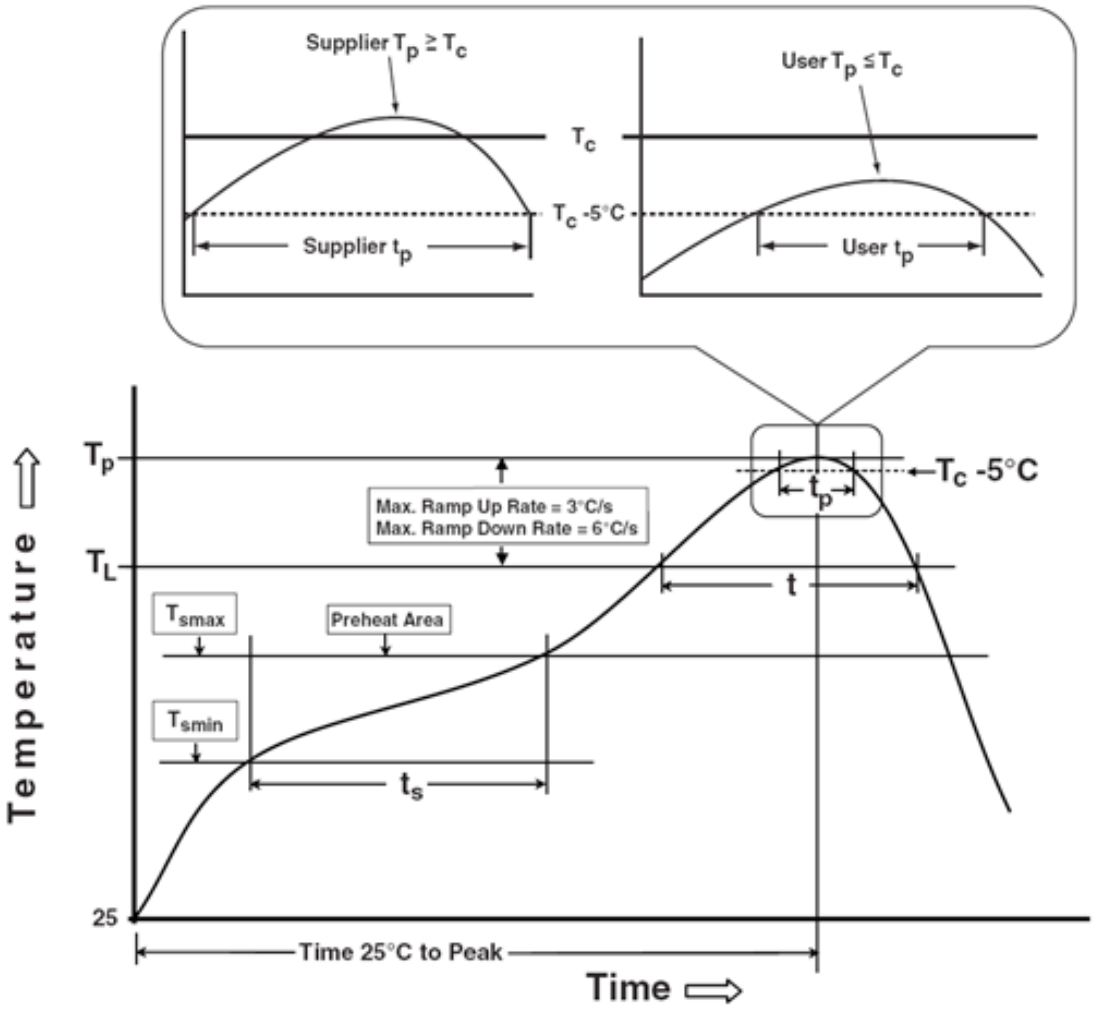
TQFN3x3-16



WLCSP1.42x1.42



Classification Profile



Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat & Soak Temperature min (T_{smin}) Temperature max (T_{smax}) Time (T_{smin} to T_{smax}) (t_s)	100 °C 150 °C 60-120 seconds	150 °C 200 °C 60-120 seconds
Average ramp-up rate (T_{smax} to T_P)	3 °C/second max.	3°C/second max.
Liquidous temperature (T_L) Time at liquidous (t_L)	183 °C 60-150 seconds	217 °C 60-150 seconds
Peak package body Temperature (T_p)*	See Classification Temp in table 1	See Classification Temp in table 2
Time (t_P)** within 5°C of the specified classification temperature (T_c)	20** seconds	30** seconds
Average ramp-down rate (T_p to T_{smax})	6 °C/second max.	6 °C/second max.
Time 25°C to peak temperature	6 minutes max.	8 minutes max.
* Tolerance for peak profile Temperature (T_p) is defined as a supplier minimum and a user maximum. ** Tolerance for time at peak profile temperature (t_p) is defined as a supplier minimum and a user maximum.		

Table 1. SnPb Eutectic Process – Classification Temperatures (Tc)

Package Thickness	Volume mm^3 <350	Volume mm^3 ≥350
<2.5 mm	235 °C	220 °C
≥2.5 mm	220 °C	220 °C

Table 2. Pb-free Process – Classification Temperatures (Tc)

Package Thickness	Volume mm^3 <350	Volume mm^3 350-2000	Volume mm^3 >2000
<1.6 mm	260 °C	260 °C	260 °C
1.6 mm – 2.5 mm	260 °C	250 °C	245 °C
≥2.5 mm	250 °C	245 °C	245 °C

Reliability Test Program

Test item	Method	Description
SOLDERABILITY	JESD-22, B102	5 Sec, 245°C
HOLT	JESD-22, A108	1000 Hrs, Bias @ T_j=125°C
PCT	JESD-22, A102	168 Hrs, 100%RH, 2atm, 121°C
TCT	JESD-22, A104	500 Cycles, -65°C~150°C
HBM	MIL-STD-883-3015.7	VHBM ≧ 2KV
MM	JESD-22, A115	VMM ≧ 200V
Latch-Up	JESD 78	10ms, 1_{tr} ≧ 100mA

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