STLD20CP1

Power management for white LED and camera flash

Features

- Inductor step-up to 17 V output for 2 to 4 white LEDs in series from 2.8 V to 6 V supply
- Charge pump 2X, 1X output for 1 power flash/torch WLED
- Control pins to select shutdown mode
- Single-wire pulse dimming control for white LED
- External resistor to set max current up to 300 mA in flash mode
- External resistor to set max current up to 100 mA in torch mode
- Logic input to select flash/strobe or movie/torch mode
- Soft start limits inrush current
- Internally limited inductor peak current
- Over-voltage and over-temperature protection.
- Package: QFN16 (3x3 mm)
- Temperature range: -40 °C to 85 °C



QFN16 (3x3 mm)

Description

The STLD20CP1 is a power management device for the supply of white LED TFT backlighting MAIN/SUB display and camera flash. It is a 1.3 MHz PWM step-up switching regulator and 2X and 1X charge pump. The current feedback control of the step-up provides excellent line transient response, making it particularly suitable for battery-powered applications. It is possible to select the value of the current flowing through the power white LED using two external resistors to choose the current value in torch mode or flash mode. Single-wire pulse dimming control and shutdown of the white LEDs for backlighting is obtained through two digital control pins: DM1 and DM2. The flash is driven by two logic pins: TF, to enable the flash function, and SEL to select torch or flash mode. Other features include over-voltage and over-temperature protection, and inductor current limitation. The high efficiency of the STLD20CP1 makes it suitable for hand-held instruments and particularly ideal in mobile phones. The STLD20CP1 is available in a small, thin low-profile QFN16 (3x3 mm) package.

Table 1. Device summary

Order code	Package	Packaging
STLD20CP1PQR	QFN16 (3x3 mm)	Tape and reel

Contents

1 **Diagram** 3

2 **Pin description** 4

3 **Maximum ratings** 5

4 **Truth tables** 6

5 **Electrical characteristics** 7

6 **Application information** 9

6.1 Step-up 9

6.2 Shutdown and brightness control 9

6.3 Peak inductor current limitation and soft start function 11

6.4 Charge pump 11

6.5 Current on power LED (flash) 11

6.6 Over-voltage and short-circuit protection 11

6.7 Start-up procedure 11

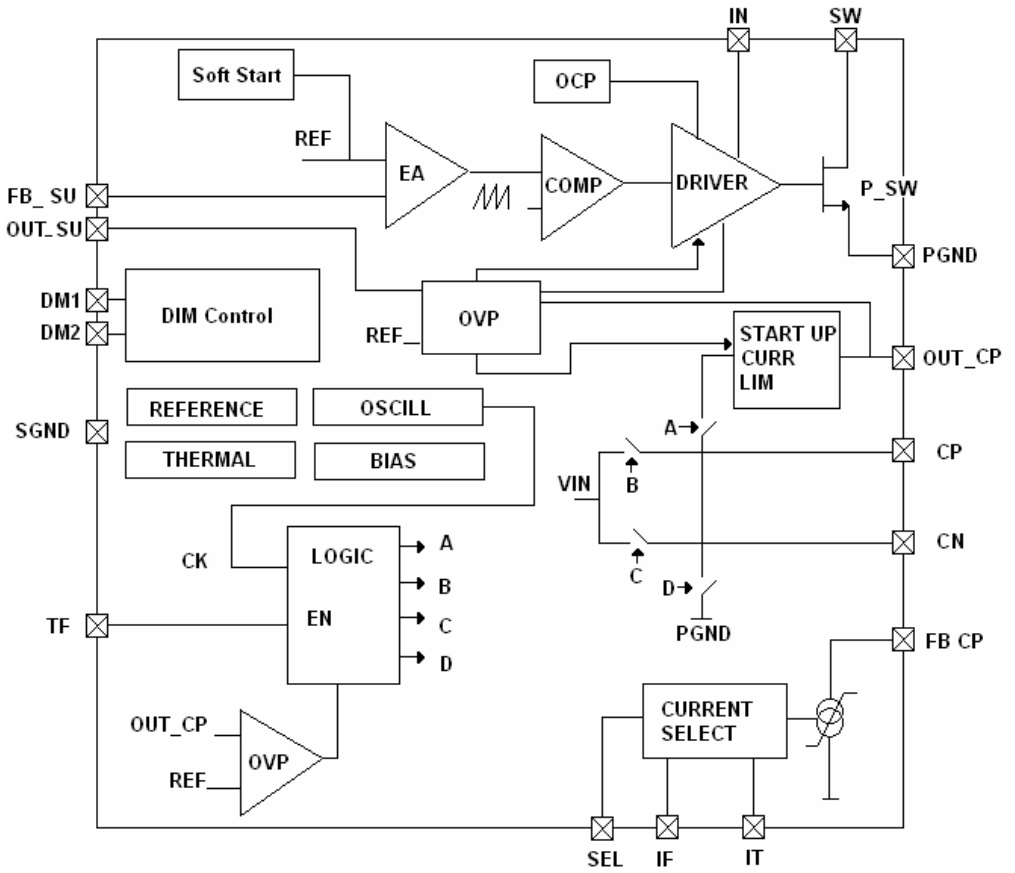
6.8 Thermal shutdown 12

7 **Package mechanical data** 14

8 **Revision history** 18

1 Diagram

Figure 1. Block diagram



2 Pin description

Figure 2. Pin configuration (top view)

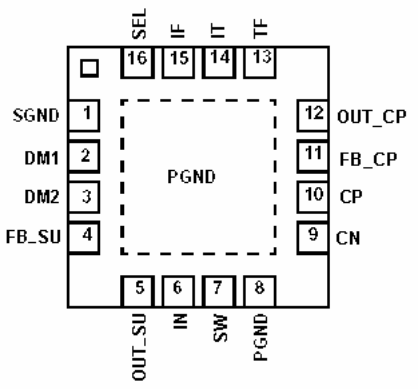


Table 2. Pin description

Symbol	Pin n°	Description
SGND	1	Signal ground
DM1	2	Logic input to control current through the white LEDs, and shutdown mode function on backlight
DM2	3	Logic input to control current through the white LEDs, and shutdown mode function on backlight
FB_SU	4	Feedback of step-up. Control current pin on backlight
OUT_SU	5	Sensing of the step-up output voltage in order to provide protection in case of the output voltage exceeds OVP threshold
IN	6	Supply voltage of the device
SW	7	Switch node. The internal N-channel drain is connected to this pin
PGND	8	Power ground
CN	9	Negative input for the external charge pump capacitor
CP	10	Positive input for the external charge pump capacitor
FB_CP	11	Feedback of charge pump. Control current pin on flash
OUT_CP	12	Out of the charge pump 2X, 1X
TF	13	Logic input to enable charge pump
IT	14	A resistor connected between this pin and IN sets the maximum value of current in torch mode (SEL=0)
IF	15	A resistor connected between this pin and IN sets the maximum value of current in flash mode (SEL=1)
SEL	16	Logic input to control flash mode. (see truth table charge pump)

3 Maximum ratings

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
IN	DC supply	From -0.3 to 7	V
SW	Switch node	From -0.3 to 20	V
OUT_SU	Output step-up	From -0.3 to 20	V
FB_SU	Feedback step-up	From -0.3 to 7	V
OUT_CP	Output charge pump	From -0.3 to 7	V
FB_CP	Feedback of charge pump	From -0.3 to 7	V
PGND	Power ground	From -0.3 to 0.3	V
IT	Torch current selection	From -0.3 to 7	V
IF	Flash current selection	From -0.3 to 7	V
CP	Pumping capacitor positive pin	From -0.3 to 7	V
CN	Pumping capacitor negative pin	From -0.3 to 7	V
TF	Charge pump enable	From -0.3 to 7	V
SEL	Logic input to control flash or torch mode	From -0.3 to 7	V
DM2	Logic input to control current of white LEDs	From -0.3 to 7	V
DM1	Logic input to control current of white LEDs	From -0.3 to 7	V
P_D	Power dissipation	Internally Limited	mW
T_{STG}	Storage temperature range	-65 to 150	°C
T_{OP}	Ambient operating temperature	-40 to 85	°C
V_{ESD}	ESD rating	3	KV

Note: Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied.

Table 4. Thermal data

Symbol	Parameter	Value	Unit
R_{thJA}	Thermal resistance junction-ambient	49.1	°C/W
R_{thJC}	Thermal resistance junction-case	4.216	°C/W

4 Truth tables

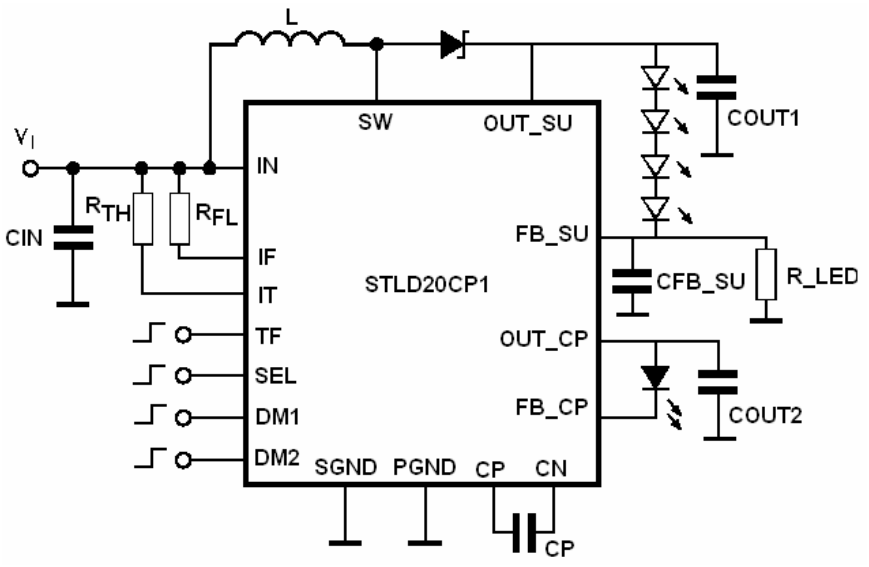
Table 5. Truth table selection mode step-up

DM1	DM2	Mode
0	0	Shutdown step-up
0	1	5% dimming
1	0	60% dimming
1	1	100% dimming

Table 6. Truth table selection mode charge pump

SEL	TF	Mode
X	0	Shutdown charge pump
0	1	Torch mode
1	1	Flash mode ON

Figure 3. Typical application circuit



5 Electrical characteristics

Table 7. Electrical characteristics for STLD20CP1 (T_J = -40 °C to 85 °C, V_I = 3.4 V, C_I = 2.2 µF, $C_{O1,2}$ = 2.2 µF, V_{O_SU} = 15 V, V_{O_CP} = 4 V, C_{CP} = 1 µF, C_{FB_SU} = 100 pF, L = 3.3 µH, DM1 = DM2 = 1.6 V, typ. values @ 25 °C, unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
Supply section						
V_I	Operating input voltage		2.8		6	V
V_{UVLO_H}	Under-voltage lockout HIGH				2.7	V
V_{UVLO_L}	Under-voltage lockout LOW		2.2			V
I_I	Supply current	I_{LED} = 50mA, TF = 0		700		µA
	Standby current	DM1= DM2 = TF = SEL = 0		1		µA
Dynamic performance						
ν	Efficiency step-up	I_{LED} = 20mA, V_I = 2.8V to 6.0V (1)	80			%
Backlight section, step-up						
V_OVP	Over-voltage protection		16.5			V
V_{FB_SU}	Feedback voltage		465	490	515	mV
I_{FB_SU}	Feedback leakage current	V_{FB_SU} = 1V		0.1	0.5	µA
f_{SW}	Frequency switching			1.3		MHz
Backlight section, step-up						
R_{DSON} P_SW	Step-up switch resistance	T_J = 25°C, I_{SW} = 100mA		0.8		Ω
I_{LK_SW}	P_SW leakage current	V_{SW} = 17V, DM1= DM2 = 0V		0.1	0.5	µA
I_{PK}	Peak inductor current			1,2		A
ΔV_{Ripple}	Output ripple step-up	I_{LED} = 50mA		30		mV_{pp}
$I_{LED\ MAX}$	Max LED current	V_{FB_SU}/R_LED, R_LED = 10Ω	50			mA
$I_{LED\ (LINE)}$	Static line regulation	V_I = 3.0V to 4.2V @ T_J = 25°C (1)	-5		5	%
F_B step	STEP feedback voltage	R_LED = 10Ω		10		mV
Digital control section						
$V\text{-}DM1_H$ $V\text{-}DM2_H$ $V\text{-}TF_H$ $V\text{-}SEL_H$	High voltage threshold	V_I = 2.8V to 6V	1.4			V
$I\text{-}DM1_H$	$I\text{-}DM1_H$ leakage current	$V\text{-}DM1_H$ = 6V		0.1	0.5	µA
$I\text{-}DM2_H$	$I\text{-}DM2_H$ leakage current	$V\text{-}DM2_H$ = 6V		0.1	0.5	µA
$I\text{-}TF_H$	$I\text{-}TF_H$ leakage current	$V\text{-}TF_H$ = 6V		0.1	0.5	µA
$I\text{-}SEL_H$	$I\text{-}SEL_H$ leakage current	$V\text{-}SEL_H$ = 6V		0.1	0.5	µA

Table 7. Electrical characteristics for STLD20CP1 (continued) (T_J = -40 °C to 85 °C, V_I = 3.4 V, C_I = 2.2 µF, $C_{O1,2}$ = 2.2 µF, V_{O_SU} = 15 V, V_{O_CP} = 4 V, C_{CP} = 1 µF, C_{FB_SU} = 100 pF, L = 3.3 µH, DM1 = DM2 = 1.6 V, typ. values @ 25 °C, unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V\text{-}DM1_L$ $V\text{-}DM2_L$ $V\text{-}TF_L$ $V\text{-}SEL_L$	Low voltage threshold	V_I = 2.8V to 6V			0.6	V
$I\text{-}DM1_L$	$I\text{-}DM1_L$ leakage current	$V\text{-}DM1_L$ = 0V		0.1	0.5	µA
$I\text{-}DM2_L$	$I\text{-}DM2_L$ leakage current	$V\text{-}DM2_L$ = 0V		0.1	0.5	µA
$I\text{-}TF_L$	$I\text{-}TF_L$ leakage current	$V\text{-}TF_L$ = 0V		0.1	0.5	µA
$I\text{-}SEL_L$	$I\text{-}SEL_L$ leakage current	$V\text{-}SEL_L$ = 0V		0.1	0.5	µA
Single-wire pulse dimming						
T_{LO}	Duration time of the low pulse		0.5		250	µs
T_{HI}	Duration time of the high pulse		0.5			µs
T_{SHDN}	Duration time to shut down the current			500		µs
Initial T_{HI}	Duration time required for the first pulse		50			µs
Flash section charge pump						
VIF	Voltage threshold	Flash mode		V_I-0.6		V
VIT	Voltage threshold	Torch mode		V_I-0.6		V
V_{FB_CP}	Feedback charge pump	I_Torch = 100mA		150		mV
V_{O_CP}	Over voltage charge pump				6	V
I_{O_CP} Max	Max current charge pump	Flash mode @ $V_I \geq$ 3V (1)			300	mA
		Torch mode @ $V_I \geq$ 3V (1)			130	
Flash section charge pump						
I_Flash	Accuracy current flash	V_I = 3.4V, R_{FL} = 1950Ω	-10		10	%
I_Flash (LINE)	Static line regulation current flash	$K*V_{IF}/R_{FL}$ = I_Flash, V_I = 3.0V to 4.2V @ T_J = 25°C	-10		10	%
I_Torch	Accuracy current torch	V_{IN} = 3.4V, R_{TH} = 7800Ω	-10		10	%
I_Torch (LINE)	Static line regulation current torch	$K*V_{IT}/R_{TH}$ = I_Torch, V_I = 3.0V to 4.2V @ T_J = 25°C	-10		10	%
Thermal shutdown						
T_{SD}	Thermal shutdown			180		°C
T_{HS}	Thermal shutdown hysteresis			20		°C

1. Guaranteed by design.

6 Application information

6.1 Step-up

The STLD20CP1 is a PWM controller working at a 1.3 MHz frequency, designed to function in discontinuous mode. The LED current regulation for the backlighting is achieved by connecting the FB_SU terminal at the top end of the external R_{LED} resistance.

$I_{LED} = V_{FB_SU}/R_{LED}$

6.2 Shutdown and brightness control

The shutdown and brightness control functions are achieved by using the digital control pins DM1 and DM2.

There are also other modes that can be used to perform dimming control on white LEDs.

The first is to use the truth table selection mode step-up that shows the behavior using a preselected digital dimming control.

The second is a PWM dimming control mode, which is implemented by keeping a DMx pin at a low or high value and the other DMx forcing a PWM digital signal up to 50 kHz with a minimum duty cycle 5%. A 5% duty cycle corresponds to the minimum current and a 100% duty cycle corresponds to full current. In cases where DM2 is a high value and DM1 is forced with a PWM digital (*Figure 4*), the dimming control varies from 5% to 100% of current. If DM2 is held low and the PWM signal is applied on DM1 (*Figure 5*), the dimming control varies from 0 up to 60% of current.

Figure 4. PWM dimming method from 5% to 100%

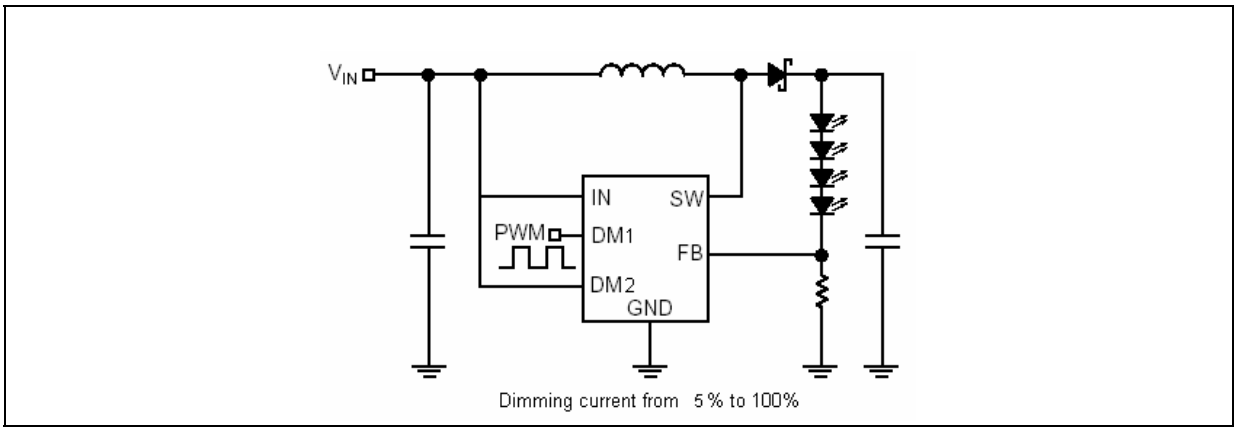
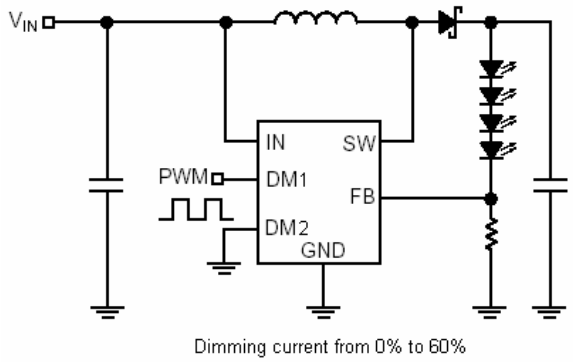


Figure 5. PWM dimming method from 0% to 60%



Likewise, by forcing DM1 low and applying a PWM signal on pin DM2, is it possible to achieve dimming from 0 to 5% (*Figure 6*), while putting DM1 high and the PWM signal on DM2, the device performs dimming from 60% to 100% (*Figure 7*).

Figure 6. PWM dimming method from 0% to 5%

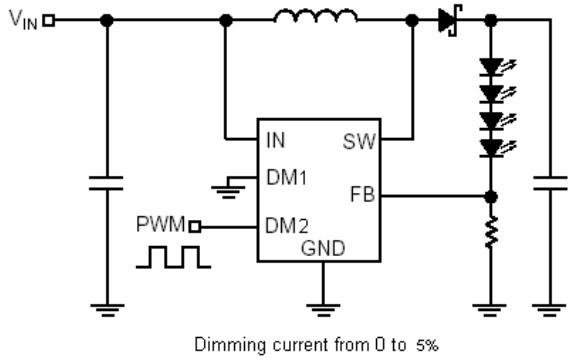
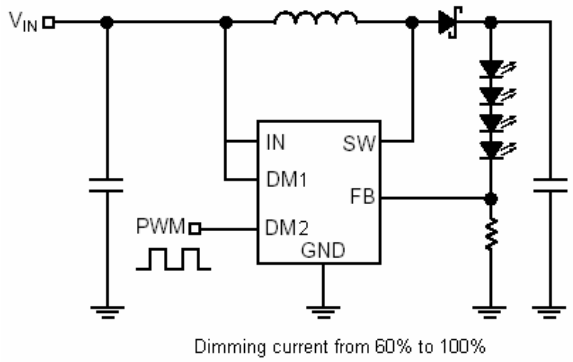


Figure 7. PWM dimming method from 60% to 100%



The third way is to utilize single-wire pulse dimming by connecting DM1 and DM2 together. This feature allows the selection of additional steps of LED current through a digital signal coming from the microprocessor, reducing the number of control traces on the PCB. When the DM1 and DM2 are simultaneously high, the high current value is selected on the LEDs, and each additional pulse reduces the LED current by 10%. After the tenth pulse, the LED

current reaches 5%. The eleventh pulse sets the LED current back to I_{LED} max. *Figure 8* shows a timing diagram for single-wire pulse dimming.

Analog dimming can be achieved by connecting a resistor network to the FB pin (*Figure 9*).

6.3 Peak inductor current limitation and soft start function

An integrated current sensor will sense the peak drain current of the switch P_SW in order to keep the inductor current below its saturation level. Since the peak drain current exceeds the fixed limit I_{PK} by the drain current reference, the comparator turns off the switch P_SW. During start up, this peak drain current limitation behaves inherently as a soft-start function.

6.4 Charge pump

The charge pump includes soft-start circuitry to limit inrush current at turn-on or when the device changes operation from x1 to x2. During the soft-start time, the output current is set to 10% of the maximum set by R_{TH} or R_{FL} (depending on the state of the SEL pin), until V_{FB_CP} reaches regulation. This function is implemented to avoid battery stress.

At start-up, the pin OUT_CP goes to V_{IN}, working in an x1 condition. Following this phase, if V_{FB_CP} >150 mV, the LED current is regulated and the device continues to operate in a 1x condition. Otherwise, if V_{FB_CP} <150 mV, the device changes to a 2x operating condition bringing V_{OUT_CP}>V_{IN}. allowing LED current regulation.

The device will change back to 1x mode when the input voltage rises above V_{OUT_CP} by approximately 50 mV.

6.5 Current on power LED (flash)

The current that level flowing through the power LED in both modes (torch and flash) can be selected using the following formula:

$I_{FLASH} = K\ (0.6/R_{FL})$, $I_{TORCH} = K\ (0.6/R_{TH})$

where K is a value of approximately 1220.

Figure 10 shows the relationship between the TF signal control and flash duration time for one camera shot, while *Figure 11* represents multiple shots.

6.6 Over-voltage and short-circuit protection

In case of open-circuit failure of the power LED, the output voltage is limited to about 5.5 V by gating the charge pump on/off.

If the power LED experiences a short-circuit or if the output charge pump is grounded, the charge pump is turned off.

6.7 Start-up procedure

Before inserting the driving preferences with the digital pins it is mandatory to turn on the device with correct supply voltage with all the digital pins set to GND.

6.8 Thermal shutdown

The device includes a thermal limit circuit that shuts down the IC at approximately +180 °C, and return to operation after the IC cools by approximately 20 °C.

Figure 8. Single-wire pulse dimming

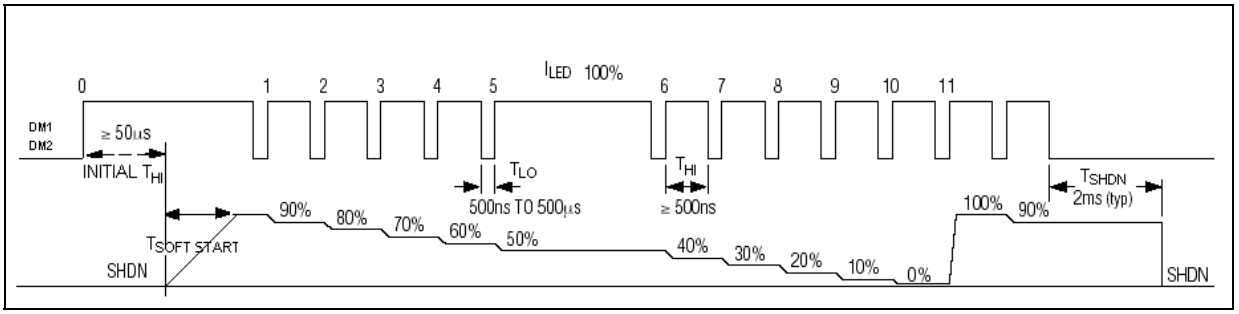


Figure 9. Analog continuous dimming

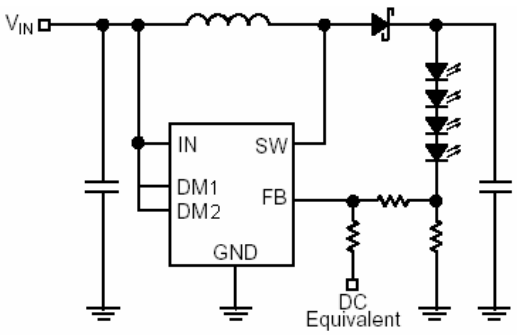


Figure 10. Single camera shot

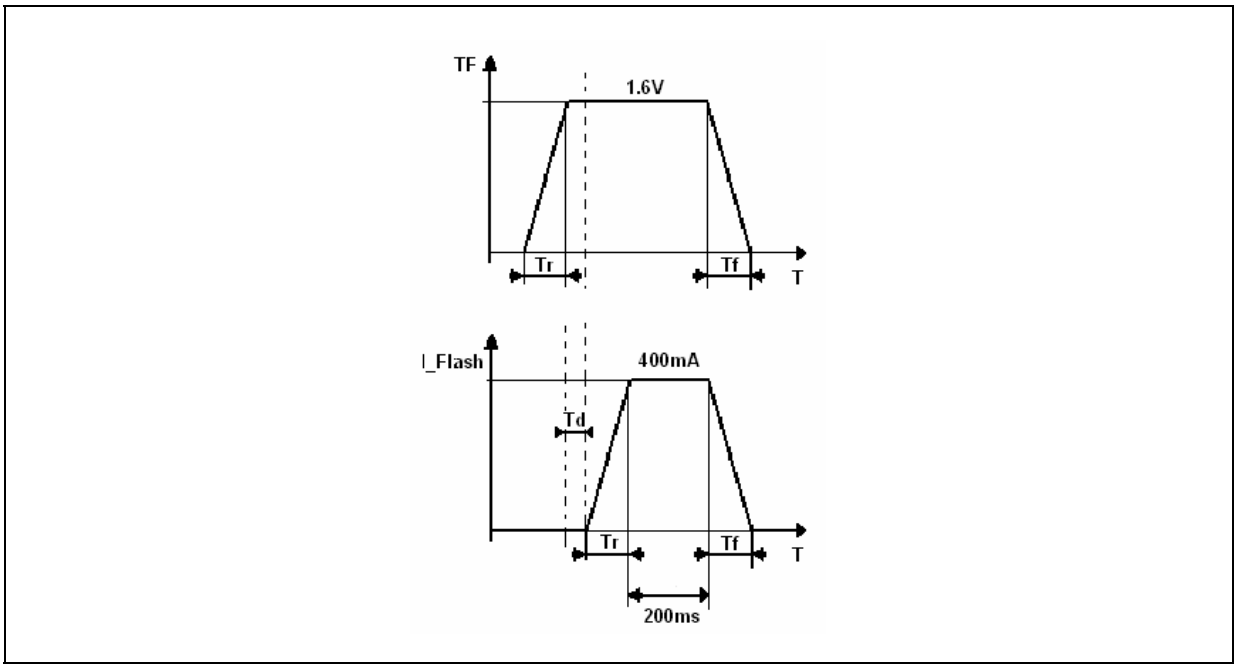
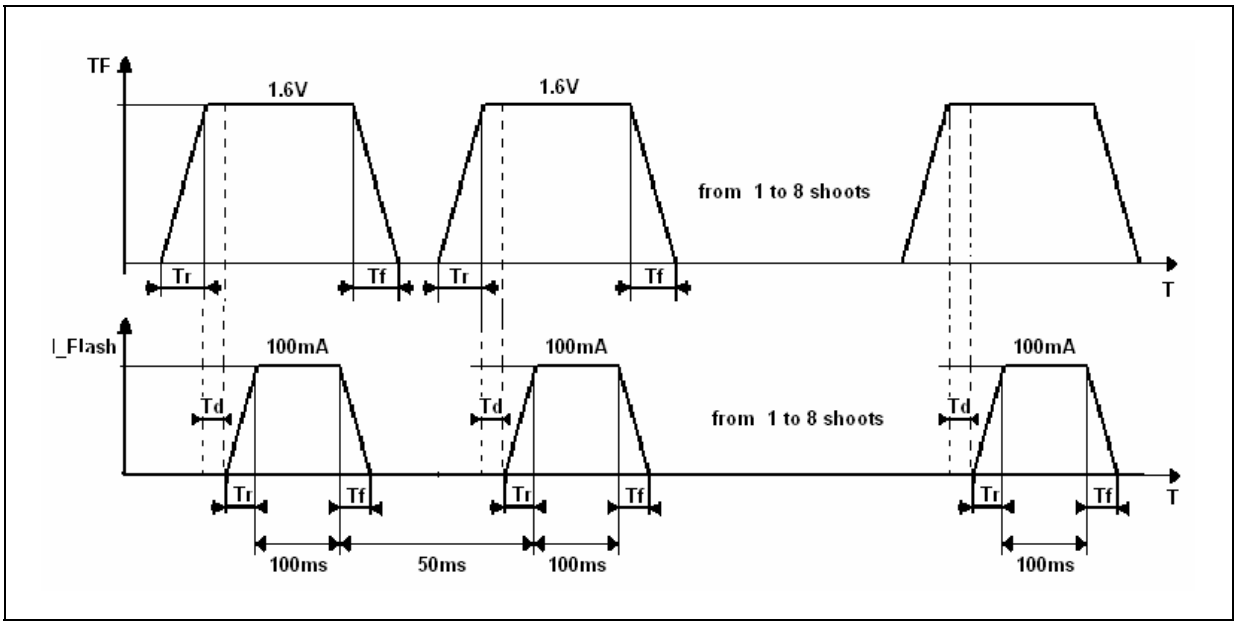


Figure 11. Multiple shots (graph is not to scale)

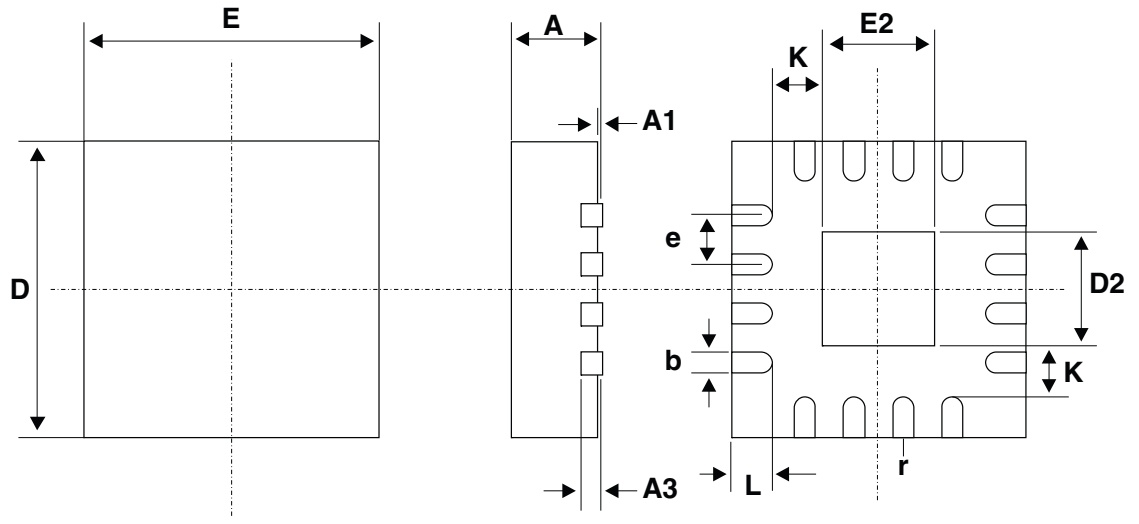


7 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: www.st.com

QFN16 (3x3 mm) mechanical data

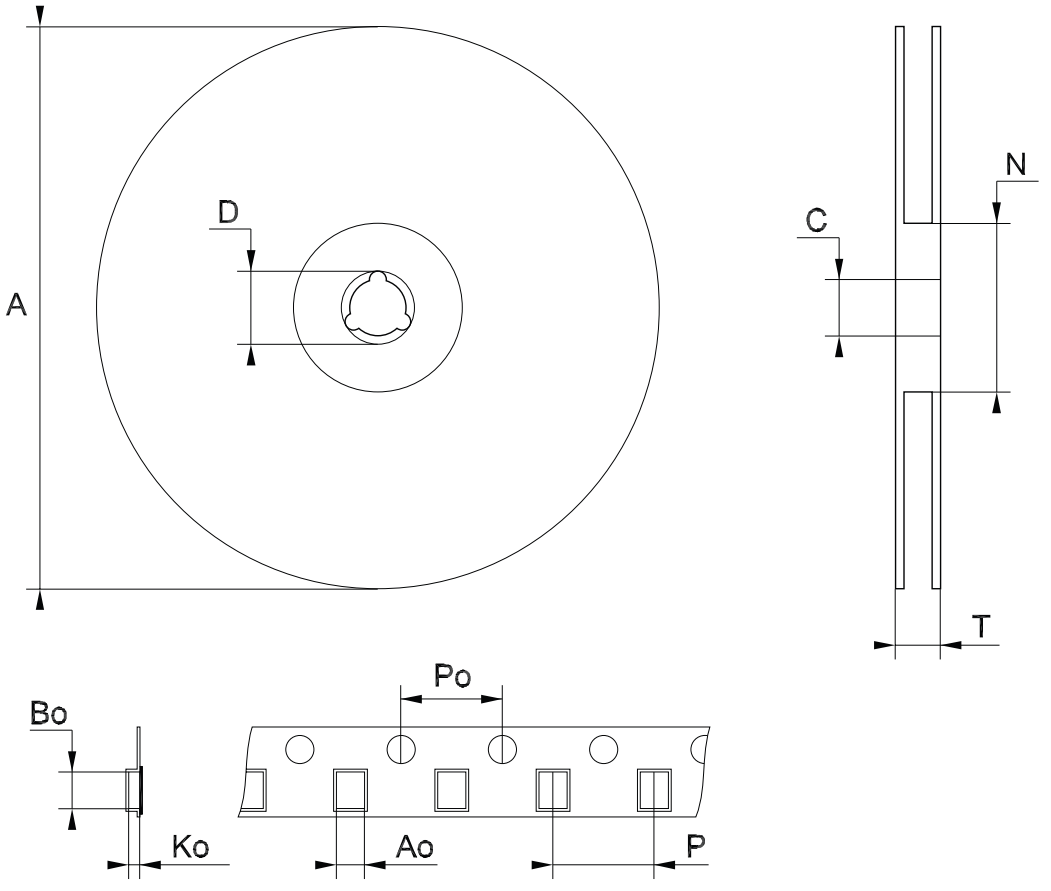
Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	0.80	0.90	1.00	0.032	0.035	0.039
A1		0.02	0.05		0.001	0.002
A3		0.20			0.008	
b	0.18	0.25	0.30	0.007	0.010	0.012
D		3.00			0.118	
D2	1.55	1.70	1.80	0.061	0.067	0.071
E		3.00			0.118	
E2	1.55	1.70	1.80	0.061	0.067	0.071
e		0.50			0.020	
K		0.20			0.008	
L	0.30	0.40	0.50	0.012	0.016	0.020
r	0.09			0.006		



This drawing is not to scale

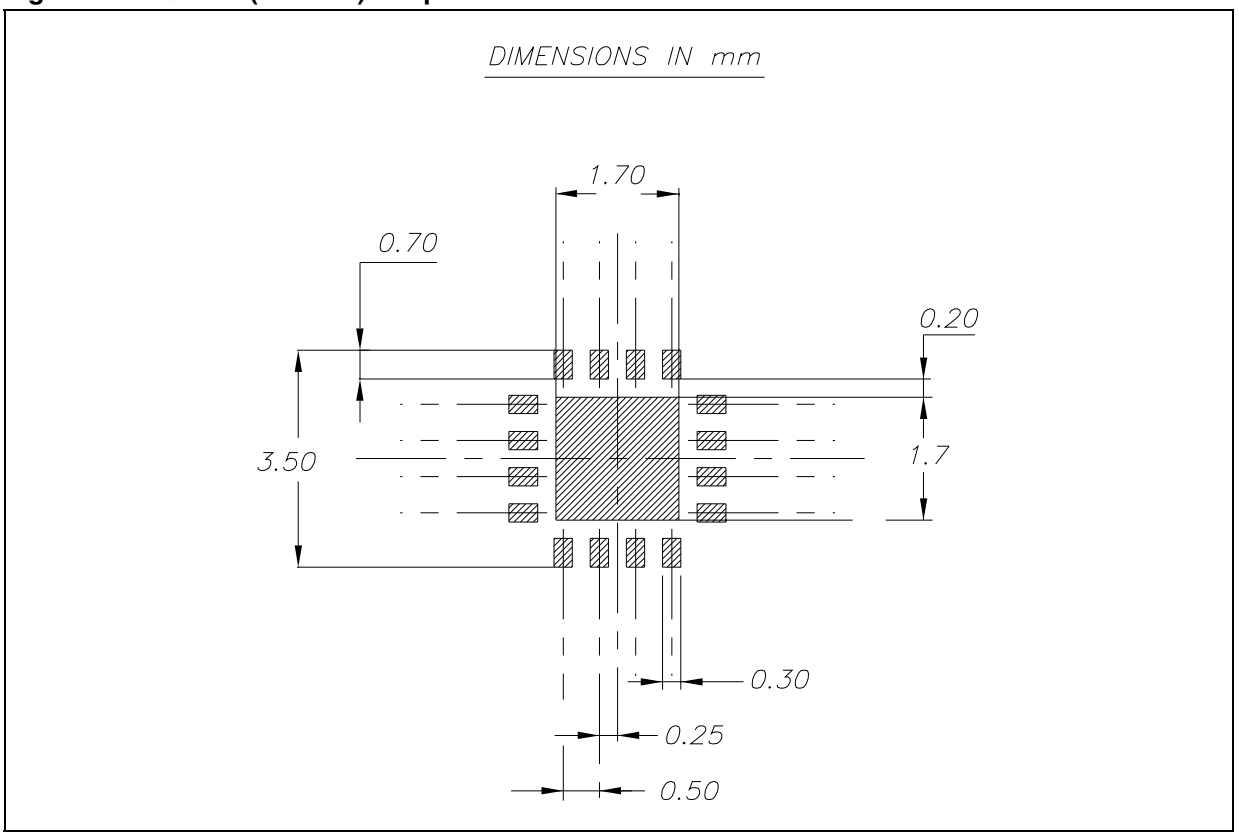
Tape & reel QFNxx/DFNxx (3x3) mechanical data

Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			180			7.087
C	12.8		13.2	0.504		0.519
D	20.2			0.795		
N	60			2.362		
T			14.4			0.567
Ao		3.3			0.130	
Bo		3.3			0.130	
Ko		1.1			0.043	
Po		4			0.157	
P		8			0.315	



Note: Drawing not in scale

Figure 12. QFN16 (3x3 mm) footprint recommended data



8 Revision history

Table 8. Document revision history

Date	Revision	Changes
14-Nov-2007	1	Initial release.
20-Nov-2007	2	Modified: *Table 1*.

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