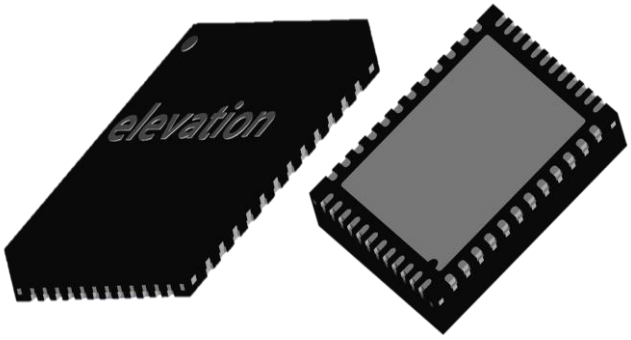
EV3361Q0

60V 1-Ch Constant Current Driver for Automotive LED

Description

The EV3361Q0 is 60V 1-ch constant current driver for automotive LED and general LED applications. It has wide input voltage up to 60V.
EV3361Q0 can control LED brightness through PWM with series/ parallel IC connection by SYNC_OUT pin.
To control PWM frequency and duty, EV3361Q0 provide adjustment function for charge/discharge current on each PWM_CHG &PWM_DIS pins and external capacitor value on CRT pin.
EV3361Q0 provides high reliability with protections which are output open & short detection, over voltage mute and over temperature functions integrated.



QFN48 (Body: 7 x 7 x 0.75 mm)

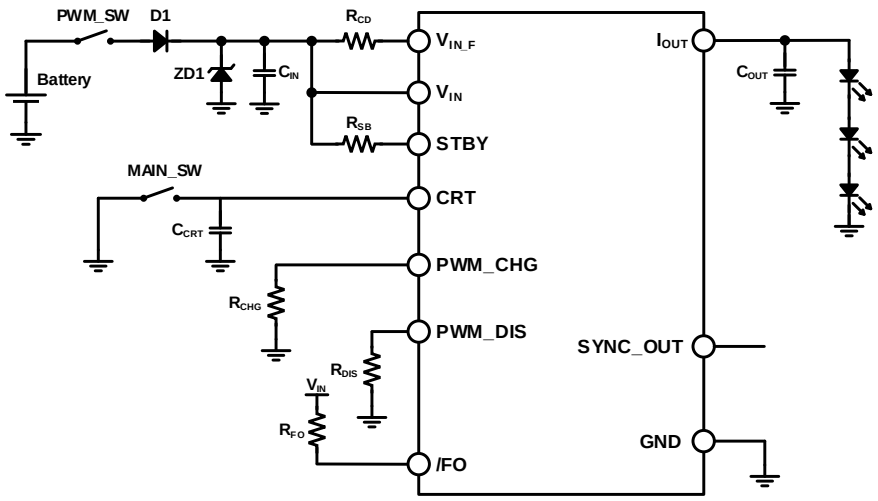
Features

- Maximum voltage +60V
- Wide input voltage operation 4.5V – 42V
- Maximum output current 300mA
- Output current accuracy ±5%
- PWM dimming output function for synchronous
- STBY function for standby power consumption
- Over voltage mute
- Redundance block for full turn-on mode
- Dual /FO functionality (Fault-out and Enable)
  - Output open protection
  - Output short protection
  - Thermal shutdown circuit (TSD)
  - Enable for output shutdown
- AEC-Q100 Qualified (Grade1)

Applications

- On-board Exterior Lamp
  (Rear Lamp, Turn Lamp, DRL/Position Lamp, Fog Lamp, etc.)
- On-board Interior Lamp
  (Air Conditioner Lamp, Interior Lamp, Cluster Light, etc.)

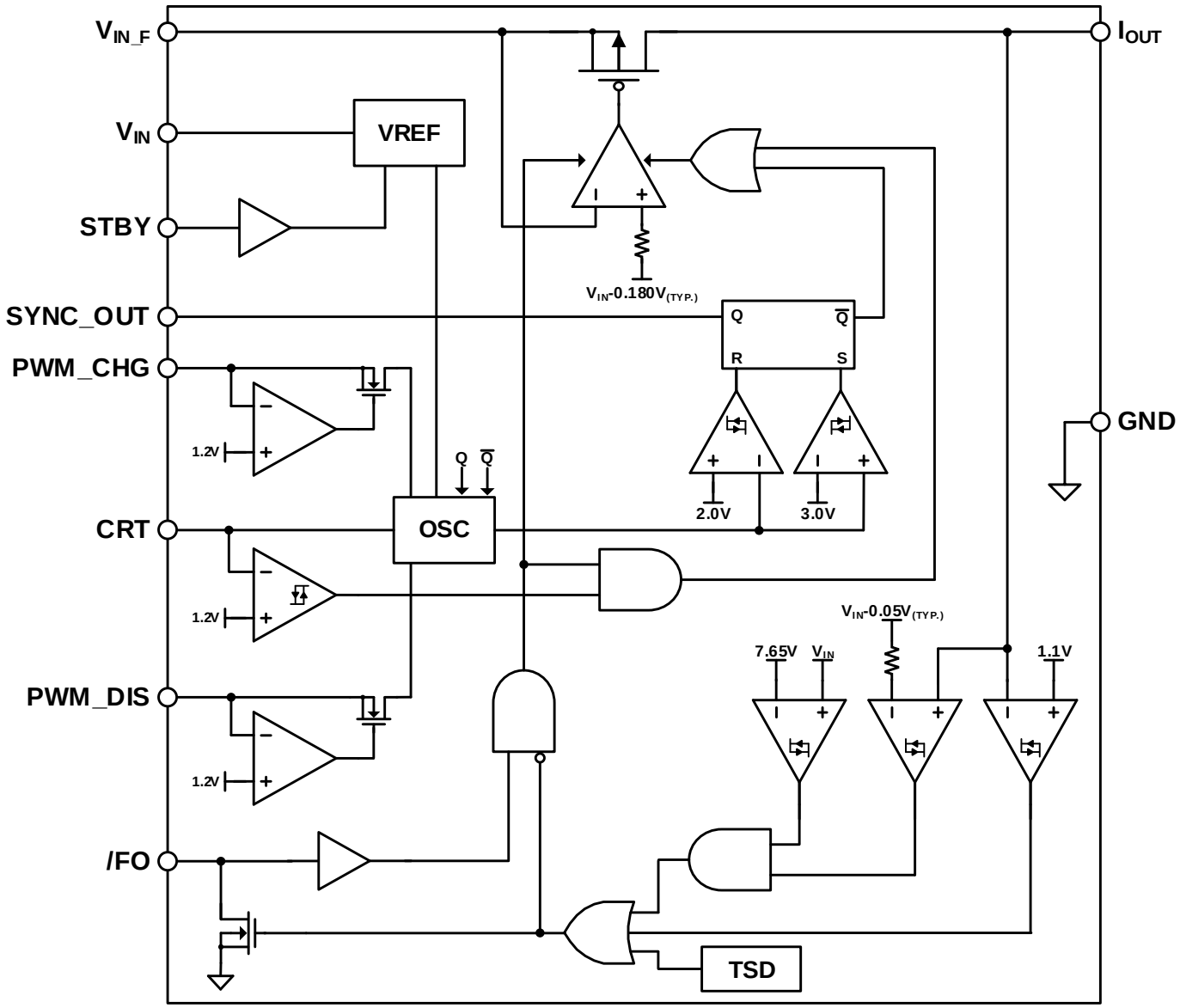
Simplified Application Diagram



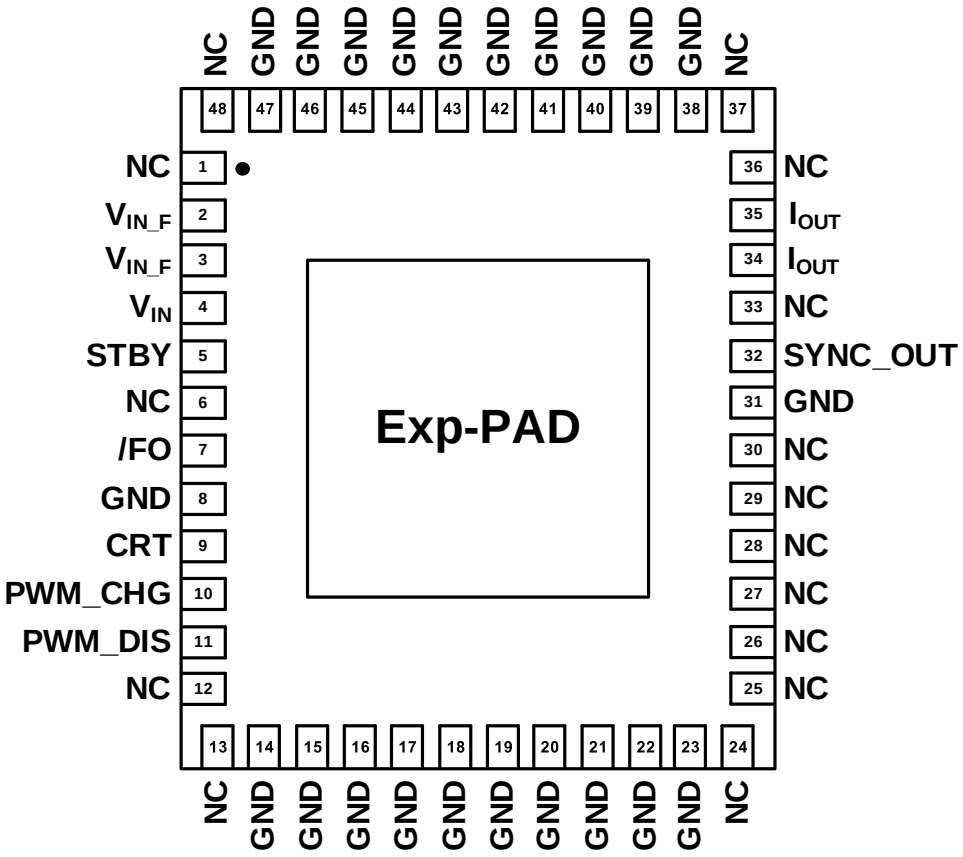
Ordering Information

Part Number	Operating Temperature Range	Package	Packing Method
EV3361Q0	-40°C to +125°C	QFN48	Tape & Reel

Internal Block Diagram



Pin Configuration and Description



Pin Name	Pin Description
V_{IN_F}	Output current detection
V_{IN}	Power supply Input
STBY	Standby input
/FO	Indicates Output-short and Output-open, TSD (negative logic, open-drain output)
GND	Common supply ground
CRT	PWM dimming timer setting
PWM_CHG	Charge current setting
PWM_DIS	Discharge current setting
SYNC_OUT	PWM dimming output
I_{OUT}	LED current output
NC	Not connected
Exp-PAD	Exposed pad, must be connected to GND

■ Absolute Maximum Ratings (T_A=25℃, unless otherwise specified)

Symbol	Parameter	Min.	Max.	Unit
V_{IN}	Power supply Voltage	- 0.3	60	V
V_{IN_F}	V_{IN_F} input voltage	-0.3	V_{IN}+0.3	
STBY	STBY input voltage	-0.3	V_{IN}+0.3	
/FO	/FO input voltage	-0.3	V_{IN}+0.3	
CRT	CRT input voltage	-0.3	5.5	
PWM_CHG	PWM_CHG output voltage	-0.3	5.5	
PWM_DIS	PWM_DIS output voltage	-0.3	5.5	
SYNC_OUT	SYNC_OUT output voltage	-0.3	5.5	
I_{OUT}	I_{OUT} output voltage	-0.3	V_{IN}+0.3	
P_D	Power dissipation		TBD	W
$R_{\theta JA}$(1)	Thermal resistance, junction to ambient		TBD	℃/W
T_S	Storage temperature range	-55	150	℃
T_J	Junction temperature		150	℃
I_O	I_{OUT} output maximum current		300	mA
HBM(2)	Human body model	±2		kV
CDM(3)	Charged-device model	±500		V

Note:

(1) Mounted on 50 x 50 x 1.6mm PCB (FR-4 glass epoxy material, JESD51-7).
(2) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.
(3) AEC Q100-011

■ Recommended Operating Conditions

Symbol	Parameter	Min.	Max.	Unit
V_{IN}	Supply voltage	4.5	42	V
R_{CD}	Current detection resistor	0.6	3.6	Ω
C_{OUT}	Output capacitor	0.1		μF
F_{PWM}	CRT PWM frequency rage	100	5000	Hz
T_{MIN}	PWM minimum pulse width	20		μs
T_A	Operating ambient temperature	-40	125	℃

■ Electrical Characteristics

(T_A= -40℃ to 125℃, V_{IN}=13V, R_{CD}= 1.2Ω, R_{SB}=10kΩ, R_{FO}=10kΩ unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{VIN_OPER}	Operating V_{IN} supply current	V_{STBY}=5V		2.1	6.0	mA
I_{VIN_STBY}	Quiescent V_{IN} supply current	V_{STBY}=0V		20		μA
V_{VIN_POR}	V_{IN} threshold voltage for power on				4.5	V
T_{STBY}	STBY threshold voltage I_{OUT} delay time	V_{STBY}=1.65V, I_{OUT}=80% C_{OUT}=0.1uF		TBD		μs
T_{POR}	Power on V_{IN} to I_{OUT} delay time	V_{IN}=4.5V, I_{OUT}=80% C_{OUT}=0.1uF		TBD		μs
I_{OUT}	Output current accuracy		142.5	150	157.5	mA
V_{DR_OUT}	V_{IN_F} - I_{OUT} drop voltage	I_O=150mA		0.45	1.0	V
I_{OUT_OFF}	I_{OUT} OFF current	V_{IOUT}=2V, V_{CTR}=1.5V T_A=25℃			1	μA
$V_{IN\_F\_REF}$	V_{IN_F} voltage	$V_{IN\_F\_REF}$=V_{IN}-V_{IN_F}	0.171	0.180	0.189	V
V_{CRT_TH+}	V_{CRT} positive going threshold		1.8	2.0	2.2	
V_{CRT_TH-}	V_{CRT} negative going threshold		2.7	3.0	3.3	
V_{PWM_CHG}	PWM_CHG reference voltage		1.14	1.2	1.26	
V_{PWM_DIS}	PWM_DIS reference voltage		1.14	1.2	1.26	
$PWM_{\_REF\_MISMATCH}$	PWM_CHG- PWM_DIS mismatch	T_A=25℃	-12		12	mV
I_{PWM_CHG}	PWM_CHG bias current		12		300	μA
I_{PWM_DIS}	PWM_DIS bias current		6		80	
$/FO_{\_TH+}$	/FO input voltage high		4.0		V_{IN}+0.2	V
$/FO_{\_TH-}$	/FO input voltage low		GND-0.2		2.0	
V_{FO-}	V_{FO-} low voltage	I_{FO}=2mA			1.5	V
I_{FO+}	I_{FO-} high current	V_{FO}=13V		38	100	μA
V_{STBY_TH+}	STBY positive going threshold		1.3	1.65	2.0	V
V_{STBY_HYS}	STBY hysteresis			0.1		

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{STBY-}	STBY low input bias current	V_{STBY}=0V			1	μA
V_{IOUT_SHORT}	I_{OUT} short detection voltage		0.88	1.10	1.32	V
V_{IOUT_OPEN}	I_{OUT} open detection voltage		V_{IN}-0.15	V_{IN}-0.05	V_{IN}-0.02	V
$V_{IOUT\_OPEN\_RELEASE}$	I_{OUT} open detection release voltage		V_{IN}-0.3	V_{IN}-0.15	V_{IN}-0.06	
$I_{OUT\_SC\_FTL\_P}$	V_{IOUT} short /FO filter time	/FO=2.0V V_{IOUT}=1.1V	40	65	90	μs
V_{M_OPEN}	Disable open detection voltage	V_{IN} voltage	7.3	7.65	8	V
$SYNC\_OUT_{IO+}$	SYNC_OUT source current	V_{CRT}=3.4V, V_{SYNC_OUT}=1.5V	-	1.5	-	mA
$SYNC\_OUT_{IO-}$	SYNC_OUT sink current	V_{CRT}=0.9V, V_{SYNC_OUT}=3.0V	-	1.5	-	
$SYNC\_OUT_{ON}$	Turn-on propagation delay time	V_{CRT}=2.0V and V_{SYNC}=1.5V C_L=50pF			1	μs
$SYNC\_OUT_{OFF}$	Turn-off propagation delay time	V_{CRT}=3.0V and V_{SYNC}=3.0V C_L=50pF			1	
V_{IN_MUTE}	Over voltage mute	V_{IOUT}=6.0V	27	29	33	V
TSD	Thermal shutdown circuit			175		℃
TSD_{HYS}	Thermal shutdown circuit hysteresis			20		

Functional Description

A. Output Current Setting

LED current of I_{OUT} can be set as following equation to using current setting resistance R_{CD}.:

For example, If I_{OUT} output constant current is 150mA, R_{CD} resistance value is 1.2Ω

$$R_{CD} = \frac{V_{IN\_F\_REF}}{\text{Output crrrent}} = \frac{0.180V_{(Typ.)}}{150mA} = 1.2\Omega$$

B. PWM Dimming Operation and LED full turn-on operation

PWM Dimming for LED light control has two methods. One is applying PWM from the outside on the CRT terminal, and the other is using external components on the CRT pin.
As an LED dimming method using external components, frequency and duty can be set by generating a triangular waveform using a charging/discharging current of CRT pin connected external capacitor. In addition, multiple ICs may be synchronized and operated using SYNC_OUT pin.

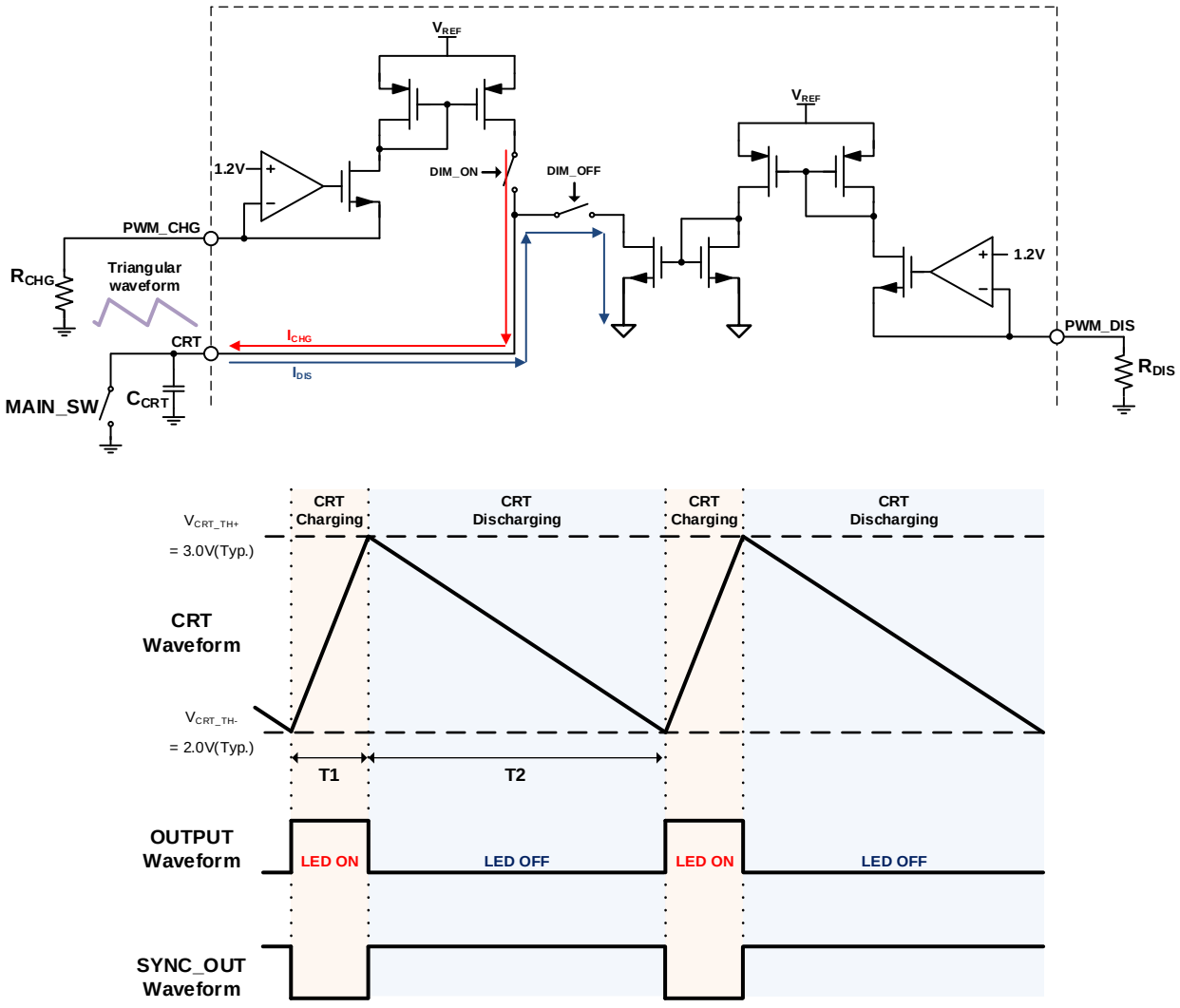


Figure 9. PWM dimming internal circuit and Waveforms

LED dimming operation frequency: 200Hz, Duty: 3.0%, external components obtained from the following equations:
(Turn-on time: 150μs, Turn-off time: 4850μs, R_{CHG}=5.49kΩ, V_{CRT_TH+}=3.0V(TYP.), V_{CRT_TH-}=2.0V(TYP.))

Capacitor of CRT charging current I_{CHG} can be obtained from the following equations:

$$I_{CHG} = \frac{V_{CHG\_ref}}{R_{CHG}} = \frac{1.2V}{5.49k\Omega} \fallingdotseq 219\mu A$$

C_{CRT} capacitor value can be obtained from the following equations:

$$C_{CRT} = \frac{I_{CRT\_SO} \times T_1}{\Delta V_{CRT}} = \frac{219\mu A \times 150\mu S}{\left(3.0V_{(Typ.)} - 2.0V_{(Typ.)}\right)} \fallingdotseq 33nF$$

Capacitor of CRT discharging current I_{DIS} can be obtained from the following equations:

$$I_{DIS} = \frac{\Delta V_{CRT} \times C_{CRT}}{T_2} = \frac{\left(3.0V_{(Typ.)} - 2.0V_{(Typ.)}\right) \times 33 \times 10^{-9}}{4850 \times 10^{-6}} \fallingdotseq 6.8\mu A$$

R_{DIS} discharging resistor can be obtained from the following equations:

$$R_{DIS} = \frac{V_{DIS\_ref}}{I_{DIS}} = \frac{1.2V}{6.8\mu A} \fallingdotseq 176k\Omega$$

The standard component value connected pulse time: Frequency 200.4z (T1=151μs, T2=4840μs) duty: 3.0%.
(R_{CHG}, R_{DIS} and C_{CRT} are standard value, T1, T2 are the result of reflecting this value.)
When the CRT pin connected to GND, the LED operates as Full turn-on operation. Also, immediately SYNC_OUT is low operation.

C. External PWM or Series/Parallel PWM Dimming Operation

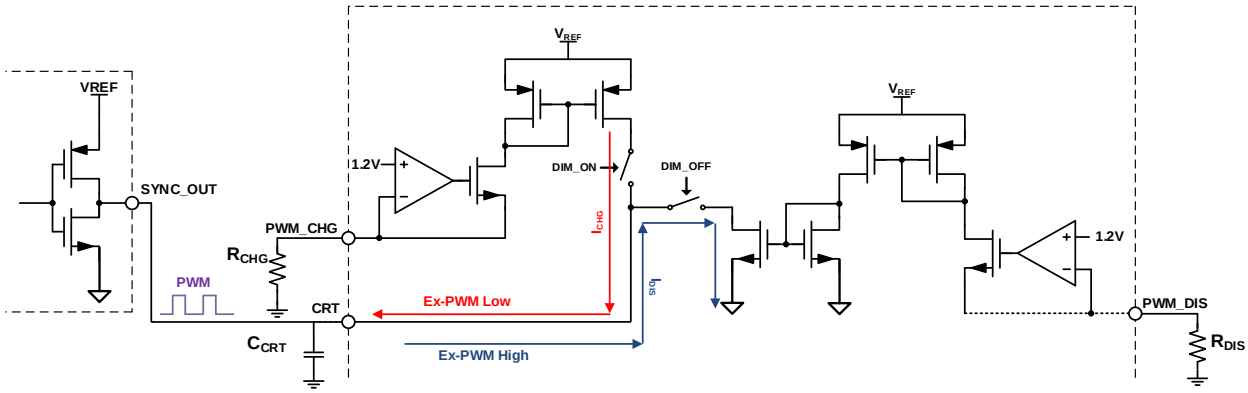


Figure 10. External PWM or Series/Parallel PWM Dimming Operation

For synchronizing ICs in series/parallel operation, using external PWM or connecting master's SYNC_OUT pin. Also SYNC_OUT is independent about /FO event for other slave ICs operation. If external components connect to R_{DIS}, R_{CHG} and C_{CRT} on the slave IC side, then it has a problem with the description below.
External PWM pulse is "LOW", I_{CHG} charging current is issued like red line (Figure 10). The current flows from internal charging current to SYNC_OUT. (SYNC_OUT sink current = Charging current * parallel operation ICs).
External PWM pulse is "HIGH", I_{DIS} source current of external driver increased like blue line (Figure 10). The current flows from external IC output or SYNC_OUT to internal.
(SYNC_OUT source current = Discharging current parallel * parallel operation ICs).
If use external PWM or SYNC_OUT, don't connect any external components on slave IC side.

D. Redundance block for LED full turn-on

This IC contains redundance block to turn-on all LEDs. The redundance block makes the brake lights work for safety even in abnormal situations. If the LED full turn-on path becomes abnormal, the LED full turn-on can be controlled through another path. When CRT is connected to GND, redundance block and OSC block operate to turn-on all LEDs. But OSC block and RS flip-flop become abnormal and /FO is “High”, only redundance block of the red line (Figure 11) operates to LED full turn-on.

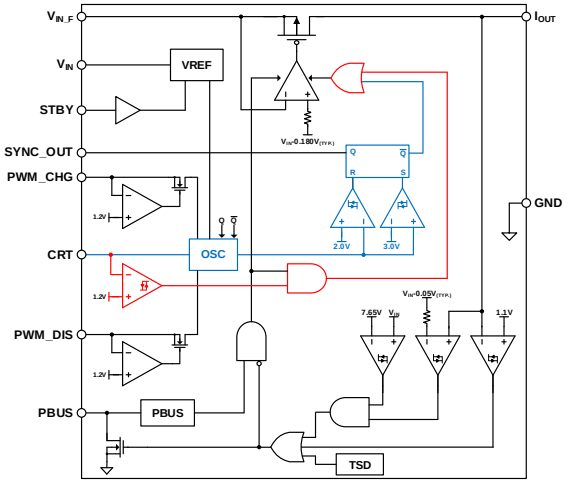


Figure 11. Redundance path for LED full turn-on operation

E. SYNC_OUT Series/Parallel Operation and /FO Operation

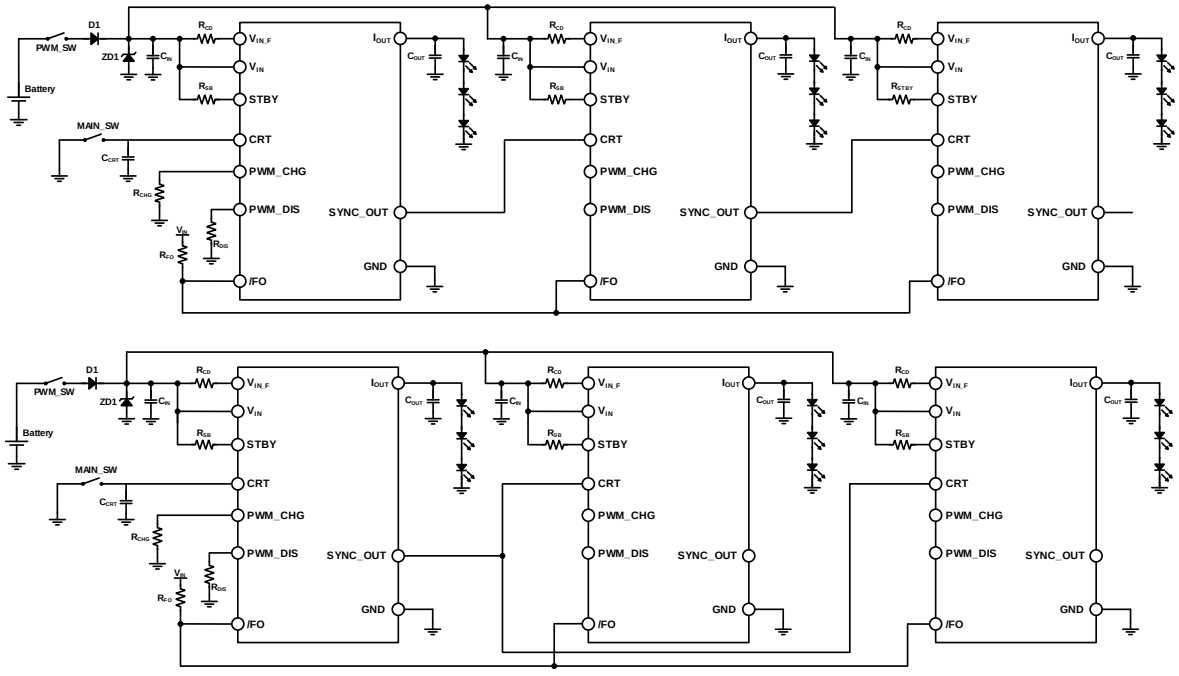


Figure 12. Series/Parallel PWM Dimming Operation

Figure 12 is an example of series/parallel PWM dimming operation for synchronous LED lamp. The PWM signal generated by the master IC is output through SYNC_OUT and it is connected to the slave IC’s CRT pin. Also, /FO is connected in parallel, both master and slave are turned off immediately in-case of abnormal operation.

F. LED Setting and Thermal design

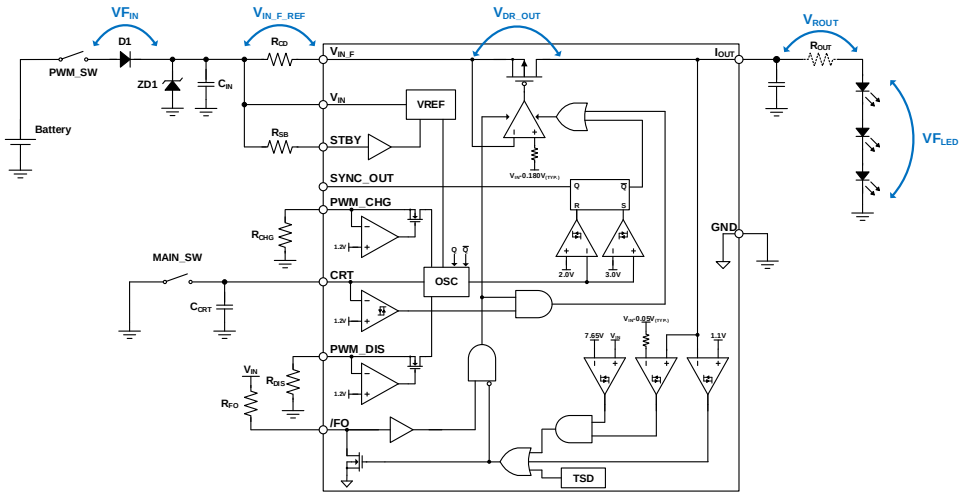


Figure 13. LED setting range and Thermal resistor circuit

The number of LED connections N should meet the following conditions:

$$\mathrm{VF_{LED}} \times \mathrm{N} \leq +\mathrm{Battery} - \mathrm{VF_{IN}} - \mathrm{V_{IN\_F\_REF}} - \mathrm{V_{DR\_OUT}}$$

If there are few LED lamps, insert resistance between I_{OUT} and LED to reduce V_{RD_OUT} voltage for IC thermal damage:

$$\mathrm{VF_{LED}} \times \mathrm{N} \leq +\mathrm{Battery} - \mathrm{VF_{IN}} - \mathrm{V_{IN\_F\_REF}} - \mathrm{V_{DR\_OUT}} - \mathrm{V_{R\_OUT}}$$

Example of thermal resistor value between I_{OUT} and LED:
(VF_{IN} Diode drop Voltage: 0.4V, Battery voltage: 9V~16V, LED series voltage: 5.7V, V_{DR_OUT}≤0V, I_{OUT}=150mA)

$$\mathrm{V_{DROUT}} \leq +\mathrm{Battery} - \mathrm{VF_{IN}} - \mathrm{V_{DR_{OUT}}} - \mathrm{VF_{LED}} = 9.0\mathrm{V} - 0.4\mathrm{V} - 0.189\mathrm{V_{(Max)}} - 7\mathrm{V} = 2.71\mathrm{V}$$

$$\mathrm{R_{OUT}} \leq \frac{\mathrm{V_{DROUT}}}{\mathrm{I_{OUT}}} = \frac{2.71\mathrm{V}}{150\mathrm{mA}} = 18\Omega$$

Power MOSFET V_{DR_OUT} and Thermal resistor R_{OUT} Power dissipation:

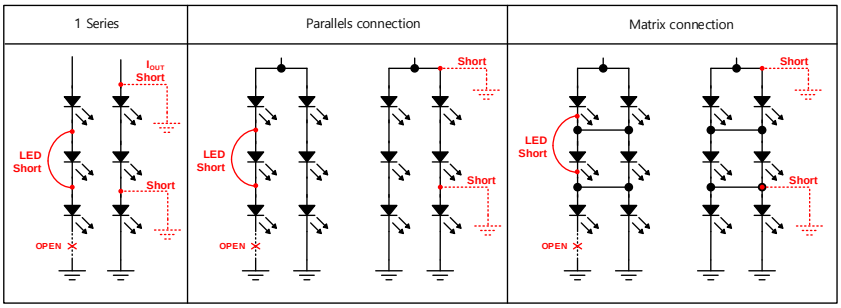
$$\mathrm{V_{DROUT}} = +\mathrm{Battery} - \mathrm{VF_{IN}} - \mathrm{V_{R_{OUT}}} - \mathrm{VF_{LED}} - \mathrm{V_{R_{OUT}}} = 16.0\mathrm{V} - 0.4\mathrm{V} - 0.189\mathrm{V_{(Max)}} - 5.7\mathrm{V} - (18\Omega \times 150\mathrm{mA}) = 7.0\mathrm{V}$$

$$\mathrm{P_D} = \mathrm{V_{DROUT}} \times \mathrm{I_{OUT}} + \mathrm{IC\ operation\ power} = 7.0\mathrm{V} \times 150\mathrm{mA} + 16\mathrm{V} \times 6.0\mathrm{mA(I_{VIN\_OPER\_MAX})} = 1.15\mathrm{W}$$

$$\mathrm{P_R} = \mathrm{R_{OUT}} \times \mathrm{I_{OUT}}^2 = 18.0\Omega \times 150^2\mathrm{mA} = 0.41\mathrm{W}$$

G. Connection LED and LED Open/Short Protection

LED connected to I_{OUT} pin. Note that protective detection may or may not be possible depending on the connection patterns.



Connection pattern	LED OPEN detection	I_{OUT} Short detection	LED Short detection	Short detection
1 Series connection	Detection	Detection	Non- Detection	Non- Detection
Parallels connection	Non- Detection	Detection	Non- Detection	Non- Detection
Matrix connection	Non- Detection	Detection	Non- Detection	Non- Detection

Figure14. LED Connection patterns and protection

H. Over Voltage Mute

If $29V_{(Typ.)} \leq V_{IN}$, Overvoltage Mute is activated to restrict output current to suppress heat generated from IC.
I_{OUT} attenuates by 3.2%/$V_{(Typ.)}$.

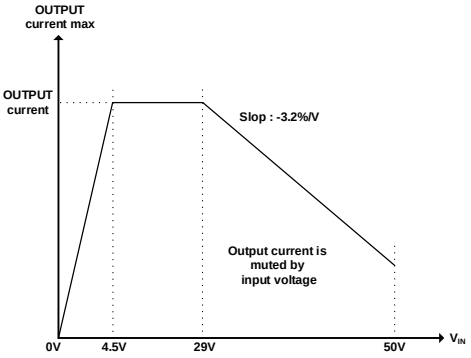


Figure15. Input over voltage mute

I. /FO function

I. Output open protection

When V_{IN} Voltage is over $7.65V_{(Typ.)}$ and the I_{OUT} pin connected to the LED becomes open, I_{OUT} pin occurred high voltage is issued on I_{OUT} pin. By comparing the V_{IOUT_OPEN} (V_{IN}-$0.05_{(TYP.)}$) inside the OP Amp and the output voltage, /FO is immediately to be “LOW” and IOUT become Turned off status. Output voltage touch on $V_{OUT\_OPEN\_RELEASE}$ voltage (V_{IN}-$0.15_{(TYP.)}$), /FO is to be “HIGH” and auto recovery.
In the initial state, V_{IN} Voltage rising is slow and V_{IN} voltage is under LED turn-on voltage, output open protection operated also /FO is “Low”. For initial state abnormal operation protection, adding open protection disable circuit.

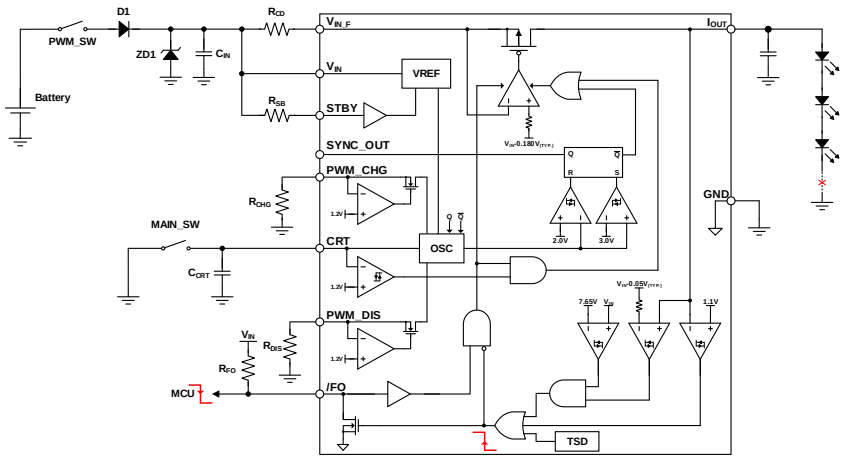


Figure 16. Output open protection

II. Output short protection

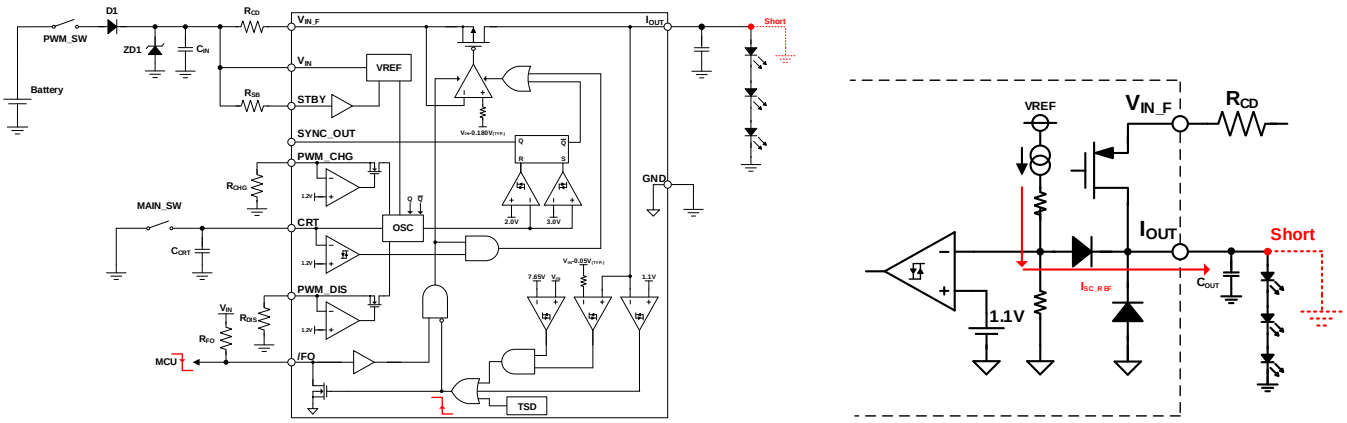


Figure 17. I_{OUT} short detection and internal circuit

If I_{OUT} current with GND short, internal I_{SC_REF} current flows by I_{OUT}. Also /FO is operation from High to Low during LED turn-on is operation.
Full urn-on operation, I_{OUT} Open & Short circuit detection are active continuously.
In PWM operation, LED Open & Short circuit detection is active only during the rising time of V_{CRT}.
When I_{OUT} is turn-off in PWM operation, the output will be high impedance. During this time noise can couple on to this pin and cause false detection of short condition. To prevent this, it is necessary to nearby connect a capacitor between I_{OUT} and GND.

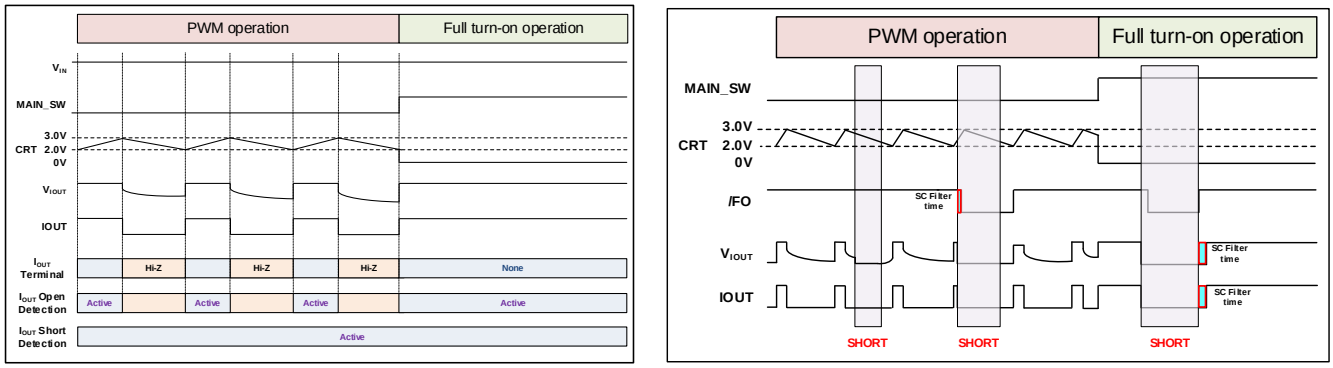


Figure 18. Timing of I_{OUT} Open & Short circuit detection

III. Over temperature protection.

EV3361Q0 has a built-in over temperature protection. This function prevents heat damage to the IC. If output short or abnormal operation, IC temperature will rise until the protection temperature (TSD=175℃(TYP.)). The TSD circuit works and turn-off the output pins and immediately /FO operation active to be Low. When the TSD falls below the TSD threshold (TSD_{HYS}=20℃(TYP.)) the circuits are automatically restored to normal operation.

IV. Fault reaction table

Table 1. is protection and /FO operation summary at abnormal operation.

Operation	/FO	I_{OUT}	Action
STBY	Hi-Z	Non-operation	STBY≥1.65V operation
UVLO	Hi-Z	Non-operation	V_{IN}≥4.5V operation
Over Voltage	Hi-Z	Operation	Operation
Output short	Low	Non-operation	Auto-recovery
Output open	Low	Non-operation	Auto-recovery
TSD	Low	Non-operation	Auto-recovery

Table1.Proection and /FO operation

J. Timing chart

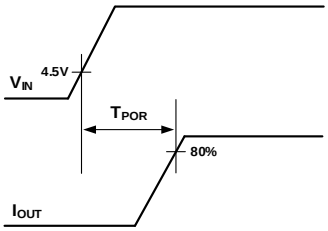


Figure 19. Power on V_{IN} to I_{OUT} delay time

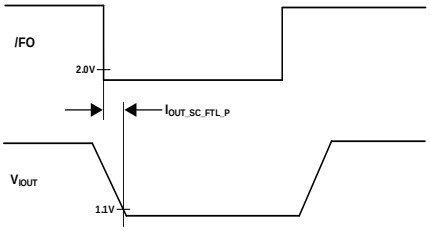


Figure 20. V_{IOUT} short /FO delay time

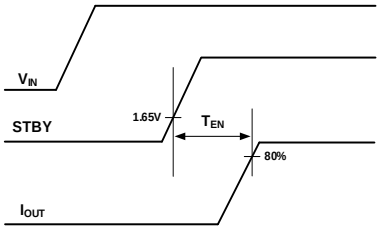


Figure 21. V_{STBY} and I_{OUT} delay time

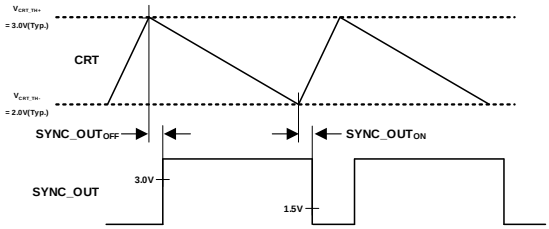


Figure 22. SYNC_OUT Turn-on propagation delay time

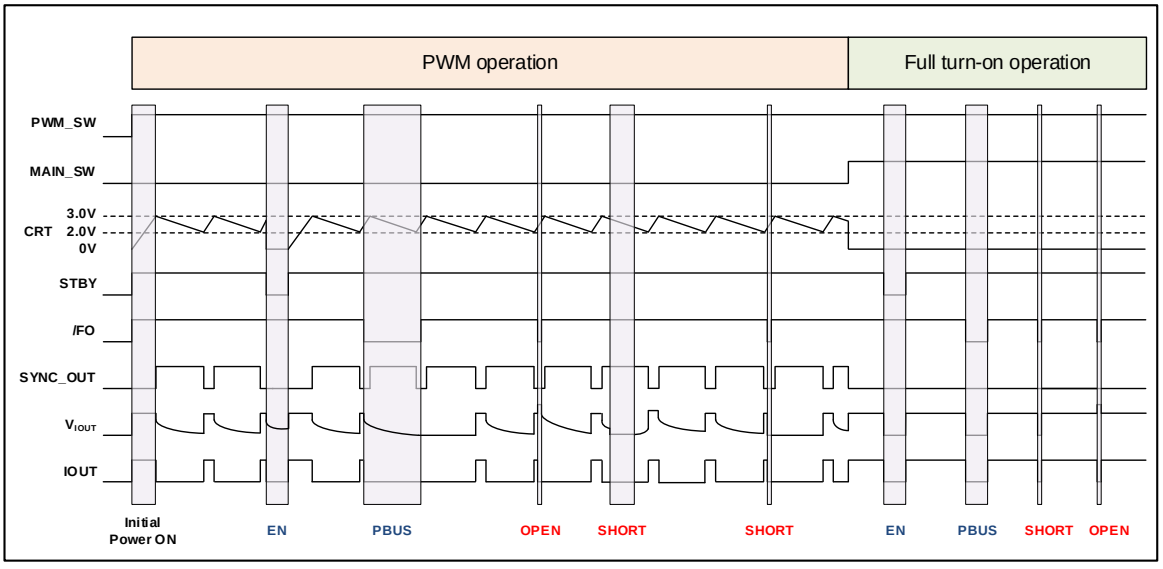


Figure23. PWM operation and Full turn-on operation timing chart

K. Recommended Application Circuit

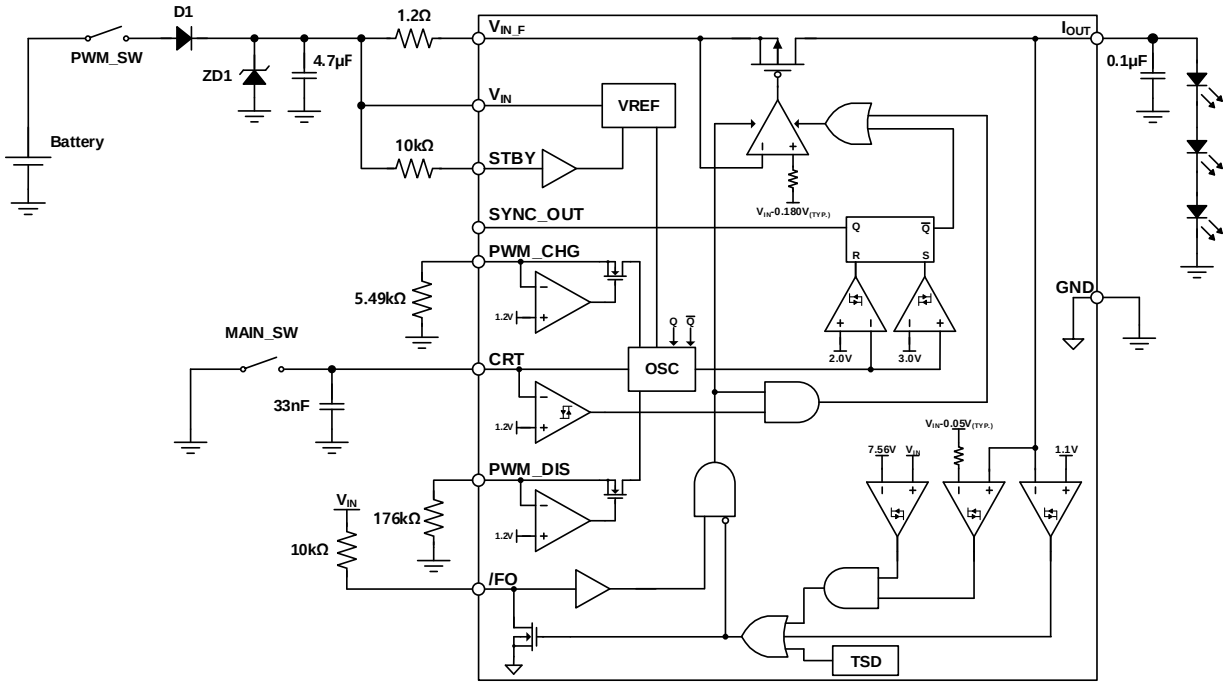
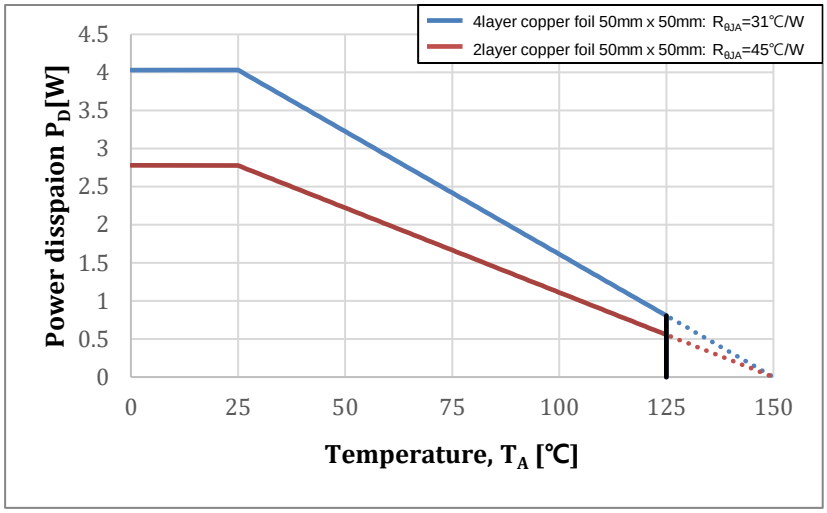


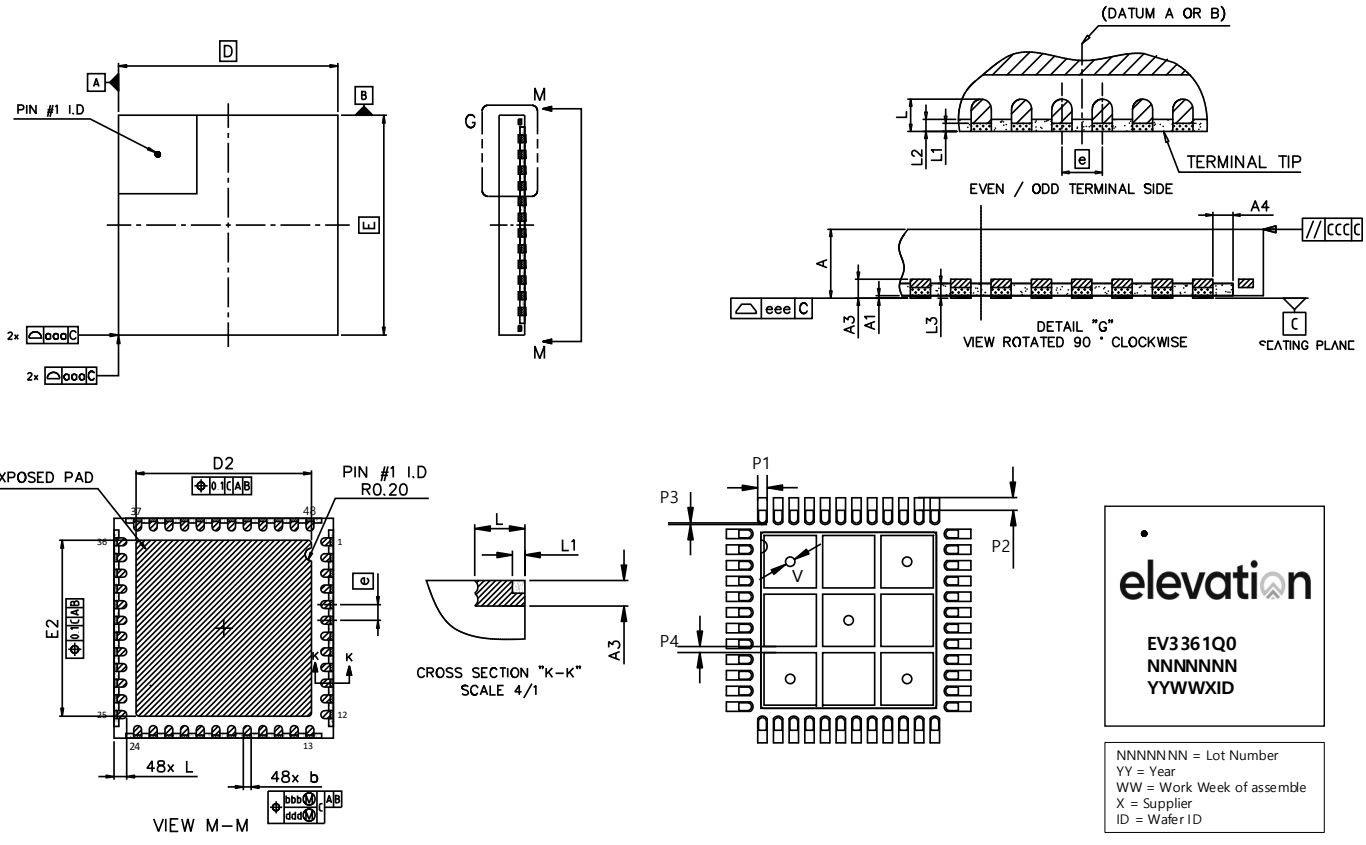
Figure24. Recommended application circuit

Operation and waveform

PWM_SW	MAIN_SW	Mode
OFF	OFF	OFF
ON	OFF	PWM Dimming Mode (FSW=200.4Hz, ON duty=3%)
ON	ON	Full turn-on Mode (ON duty=100%)

L. Thermal resistance


4layer copper foil 50mm x 50mm: $R_{\theta JA}$=31℃/W
2layer copper foil 50mm x 50mm: $R_{\theta JA}$=45℃/W
Power disspaion P_D[W]
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
25
50
75
100
125
150
Temperature, T_A [℃]


D
A
B
PIN #1 I.D
E1
2x
2x
M
G
M
(DATUM A OR B)
L
L2
L1
e
TERMINAL TIP
EVEN / ODD TERMINAL SIDE
A4
A
eee C
A3
A1
L3
DETAIL "G"
VIEW ROTATED 90 ° CLOCKWISE
C
SEATING PLANE
EXPOSED PAD
D2
PIN #1 I.D
R0.20
E2
e
K
48x L
48x b
VIEW M–M
L
L1
A3
CROSS SECTION "K–K"
SCALE 4/1
P1
P3
P2
P4
V
elevation
EV3361Q0
NNNNNNN
YYWWXID
NNNNNNN = Lot Number
YY = Year
WW = Work Week of assemble
X = Supplier
ID = Wafer ID

DIM	MIN	NOM	MAX
A	0.80	0.85	0.90
A1	0.00		0.05
A3		0.203 REF	
A4	0.00		0.25
b	0.20	0.25	0.30
D		7.00 BSC	
E		7.00 BSC	
D2	5.50	5.60	5.70
E2	5.50	5.60	5.70
e		0.500 BSC	
L	0.35	0.40	0.45
L1		0.100	0.150
L2			0.200
L3	0.102	0.127	0.152
P1		0.3	
P2		0.4	
P3		0.05	
P4		0.2	
V		0.3	

DIM	MIN	NOM	MAX
aaa		0.10	
bbb		0.07	
ccc		0.10	
ddd		0.05	
eee		0.08	

NOTES

CONFIRM TO ASME Y14.5M-1994.

2.0 ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.

EXPOSED HEAT SLUG AS WELL AS THE TERMINAL.

UNIT	DIMENSION AND TOLERANCE
Millimeter(mm)	
COMPANY	

TITLE: SAW QFN, 7X7MM, 48LD, 5.90X5.90PAD, PULL BACK LEAD (WETTABLE FLANK TYPE)

Important Notice

Elevation reserves the right to modify, improve, and terminate its products, services, documentations, etc. without advance notice. Customers are encouraged to contact Elevation sales representatives to get the latest product information.

Without proper legal authorization, Elevation products shall not be used for medical or military applications. Elevation does not assume any liability of personal or property damages of any kind due to such applications.