

TOSHIBA Bi-CMOS INTEGRATED CIRCUIT SILICON MONOLITHIC

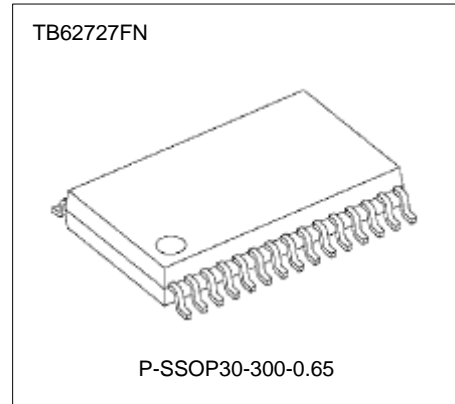
T B 6 2 7 2 7 F N

16-bit constant current LED module with built-in dot-current correction for each output

The TB62727FN is an LED-driver suitable for lighting single-color and full-color LED modules and panels. This device contains a built-in dot current-correction for each output as well as TSD (Thermal Shutdown Detection) and OOD (Output Open Detection).

Features

- *Output current capability and the number of outputs :
60 mA x 16 outputs
- *Constant current range : Iout = 2 to 50 mA
- *Application output voltage : Vout (on) =< 4.0V
- *For anode common LED
- *Input signal voltage level : TTL Level (Shmitt Triggered Input)
- *Power supply voltage range : VDD=4.5 to 5.5V
- *Maximum output terminal : voltage VOUT(off)=17V
- *Data transfer clock : fCLK=20 MHz (cascade connection)
- *Operation temperature range : Topr = -40 to 85 degrees
- *Package : P-SSOP30-300-0.65
- *Adjustment functions : (Input 128 times clock and serial-data.)
6-bit dot current correction :
This function corrects the current value of each output from 0% to 100% in 64 steps



*Current accuracy (dot-current correction not used)

Output voltage	Current accuracy		Output current
	between bits	between ICs	
=> 0.4V	+/- 4 %	+/- 15 %	2 to 5 mA
		+/- 12 %	5 to 50 mA

***Protection function circuits :**

1: Thermal Shutdown Detection (TSD)

This function monitors the rise in temperature of the junction.

Junction temperatures over 140 degrees - - - Monitor TSD terminal = "L".

2: Output terminal open detection function

This function detects output terminal open- - - Monitor ODD terminal = "L".

The TSD terminal and OOD terminal are open collector type.

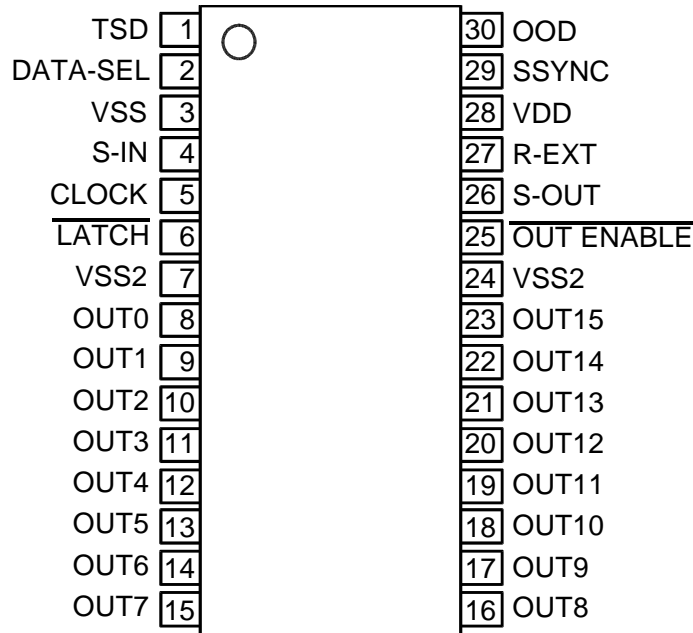
Warnings

Short-circuiting an output terminal to GND or to the power supply terminal may damage the device.

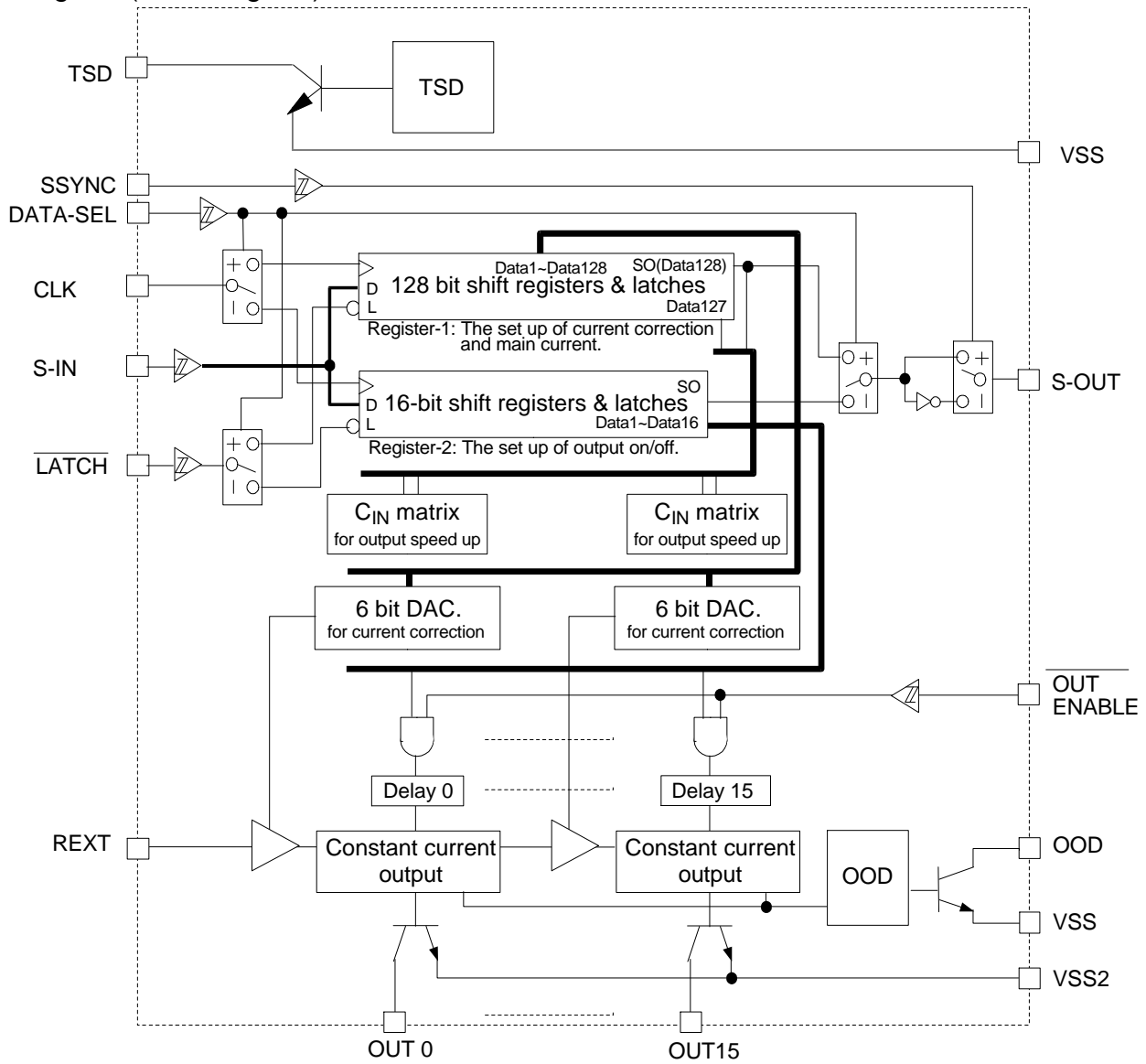
Please take the proper precautions when wiring the output terminals, power supply terminal and GND terminals (V_{SS} , V_{SS2}).

Pin Assignment (TOP VIEW)

Package Type : SSOP30-P-300-0.50 (0.50mm Pitch)



Block diagram (whole figure)



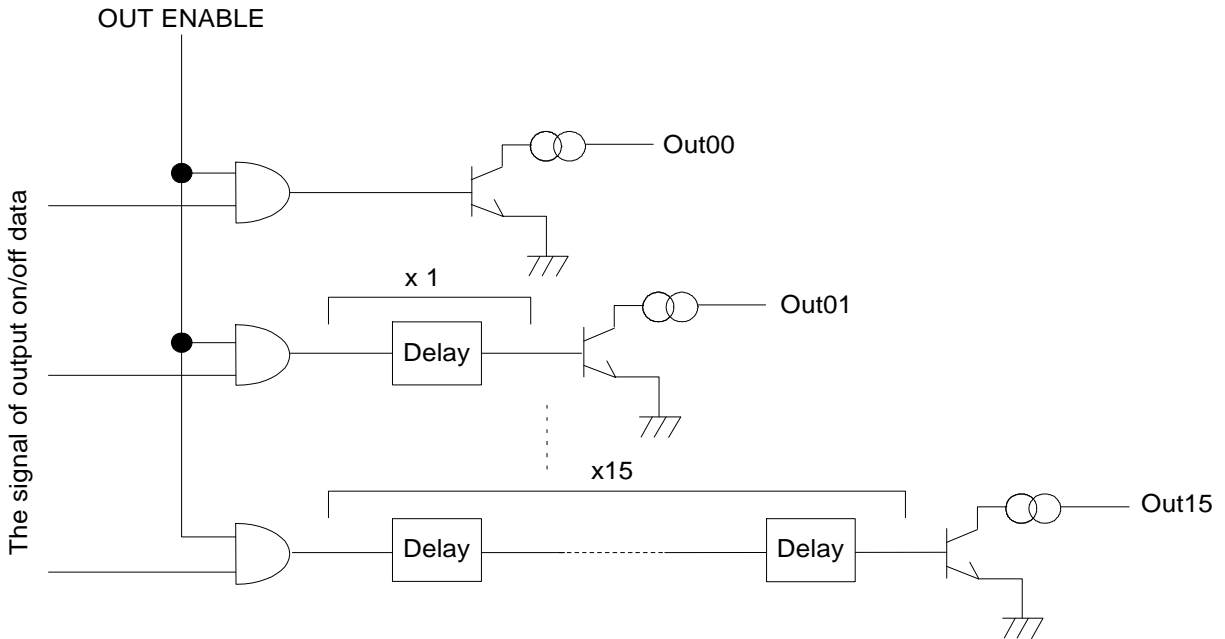
Action table 1 (OUT ENABLE)

OUT ENABLE	Action for outputs
H	Output off
L	Output on

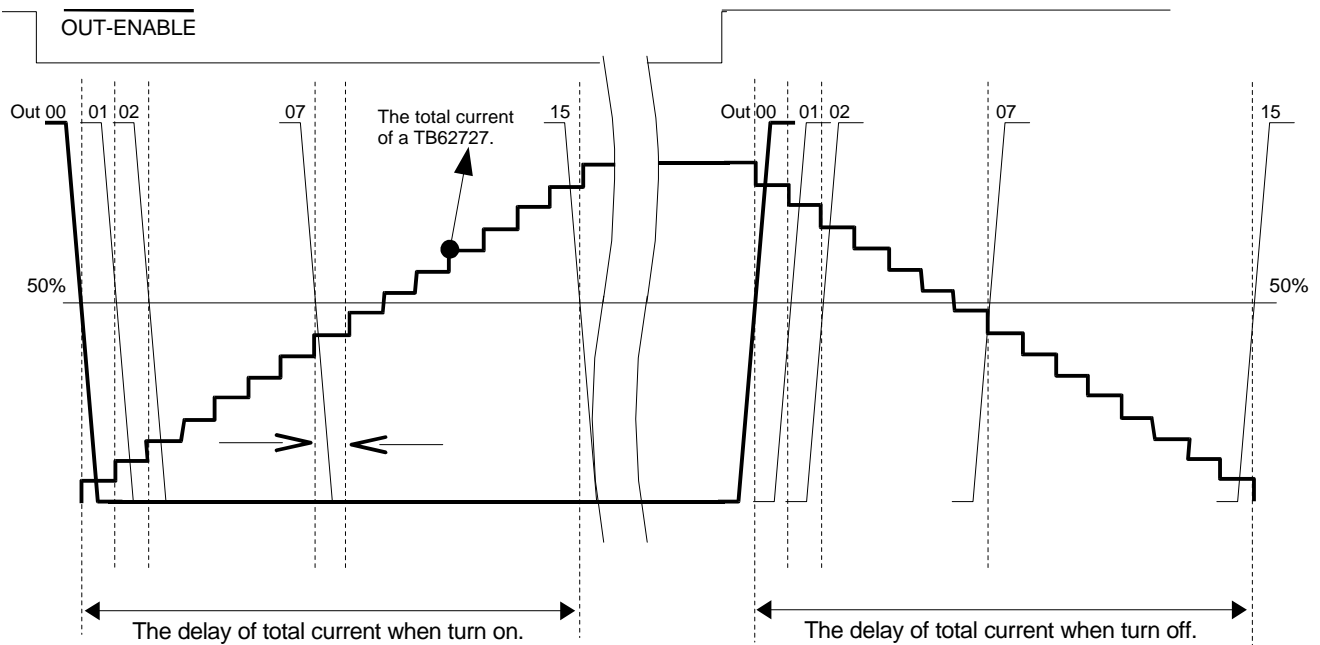
Action table 2 (SSYNC)

SSYNC	Action of S-OUT
H	Synchronizes for positive edge of CLOCK.
L	Inverted S-OUT

The connection of the delay to decrease switching noise : Delay 0 ~ Delay 15



The total current and each output waveform of TB62727



The delay circuit is used on the output to decrease the level of noise.

Action table 3 for DATA-SEL

DATA-SEL	Action of DATA-SEL (CLK and LATCH signal select a register.)
H	Select input for output current correction data
L	Select input for output turns on/off data

Action table 4 (Output current correction data) - - - Register - 1(REG1)

Serial data for each output when DATA-SEL equal to H level.

Data1~8	Data9~16	Data17~24	Data25~32	Data33~40	Data41~48	Data49~56	Data57~64
for OUT 0	for OUT 1	for OUT 2	for OUT 3	for OUT 4	for OUT 5	for OUT 6	for OUT 7

Data65~72	Data73~80	Data81~88	Data89~96	Data97~104	Data105~112	Data113~120	Data121~128
for OUT 8	for OUT 9	for OUT10	for OUT11	for OUT12	for OUT13	for OUT14	for OUT15

Setup of data of each output with 8-bit Data. - - - Example Data 1-8 for OUT00

Data 8	Data 7	Data 6	Data 5	Data 4	Data 3	Data 2	Data 1
Don't care	Don't care	x 32	x 16	x 8	x 4	x 2	x 1

Note 1 : When all data are L, each output current is almost 0.

Action table 5 (Output turns On & Off control) - - - Register-2(REG2)

Serial data for each output when DATA-SEL equal to L level

Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7	Data 8
for Out 0	for Out 1	for Out 2	for Out 3	for Out 4	for Out 5	for Out 6	for Out 7

Data 9	Data 10	Data 11	Data 12	Data 13	Data 14	Data 15	Data 16
for Out 8	for Out 9	for Out10	for Out11	for Out12	for Out13	for Out14	for Out15

Note 2 : When data is H, each output is on. and when data is L, each output is off.

Note 3 : The data must be H's to obtain output current.

Action table 6 - - - Register-1(REG1)

Main output current is set to the IC when DATA-SEL equal to H level.

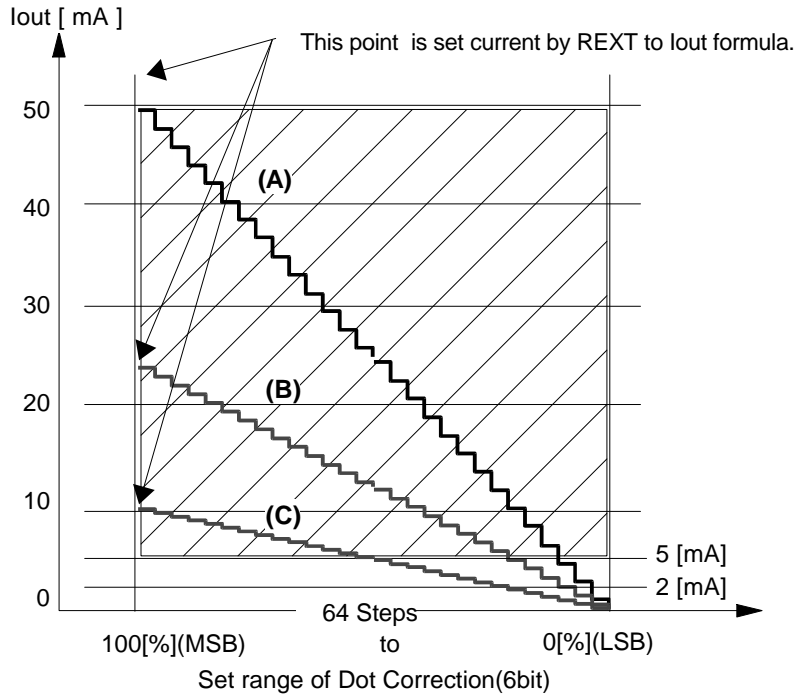
Data 1~126	Data 127	Data 128	Output current standard of set value	The effect condition of the speed-up
Don't care	L	L	2.5 mA (Initial)	Low
Don't care	L	H	5 mA	Middle
Don't care	H	L	15 mA	High
Don't care	H	H	25 mA	More high

Note 4 : This LED current set up only uses 2-bits on the MSB side of OUT15's data.

The rise time (tr) of the current waveform decreases when the effect condition of the speed up is set high or greater.

Note 5 : When data set up LED current to TB62727FN, the output waveform becomes stable.

Constant current adjustment range (image)
 GRAPH: Current adjustment based on 100%



Note 6 :

- * Dot correction function is the current adjustment function of each output.
- * The current value set by R_{EXT} resistance is set in the standard (Equal to Data=MSB and 100%).
- * The fineness of current value set is 1LSB; about equal to 1.58 %.
- * Wide set range (100-0%), with presumed brightness dispersion of LED +/- 20 %.
- * We recommend dot correction is set in the center of the range.
 And, do +/- 50% range of the re-correction after choosing current with REXT.
- * Line A shows the case that 50mA was applied to the standard current.
- * Line B shows the case that 25mA and Line C shows the case that 10mA.
- * Set range that it is recommended is current value inside the slant line area including the dot correction.
- * Dot correction accuracy is not good below 5mA.

Action table 7 - - - Dot current correction rate of the Serial-data of Register-1. (typ.)

Data	LLLLLL	LLLLLH	Ratio of a LSB	HHHHHL	HHHHHH	HLLLLL
Ratio of correction	0% (Output off)	1.58%	nearly equal to 1.58 %	98.42%	100%	Initial position (when supply in)

Note 7 : This value is typical values.
 The actual values contains the error of lower than +/- 1LSB.
 The initial values are about 50%.

Terminal function explanation table

No.	Terminal name	I/O	Internal-R	Function explanation
1	TSD	O	External	This is TSD monitor terminal and open collector output. TSD circuit detects unusual temperature when connected to pull-up resistance.
2	DATA-SEL	I	Pull-Down	Serial data selection signal input terminal. See Action Table 3 and 4.
3	VSS	P	-	Logic ground terminals. Please, must use all.
4	S-IN	I	-	Serial data input terminal. Data is transfer by rising edge of CLK.
5	CLK	I	-	Serial data transfer clock input terminal.
6	LATCH	I	Pull-Down	Serial data latch signal input terminal. Data is held by rising edge.
7, 24	VSS2	P	-	Ground terminals.
8~23	OUT0 to OUT15	O	-	LED drive output terminals. Connect cathode of LED.
25	OUT ENABLE	I	Pull-Up	Control signal input terminal of output OUT0 ~ OUT15. See Action Table 1.
26	S-OUT	O	-	Serial data output terminal. Output data trigger are select with SSYNC signal.
27	REXT	P	-	Connection terminal of the standard current set resistance.
28	VDD	P	-	Logic power supply terminals.
29	SSYNC	I	Pull-Up	Serial data output polarity set terminal. See Action Table 2.
30	OOD	O	External	This is OOD monitor terminal and open collector output. OOD is output open detected when connected to pull-up resistance.

Note 8 (Terminal attribute) : P : Power supply/ground/others, I : Input terminal, O : Output terminal.

Note 9 : We recommend the use of a pull up/down resistor on open terminal.
There is a risk of faulty operation due to noise if the terminal is open.

How to use the TB62727FN LED Driver

Operating outline to use Output On/Off control mainly for Uni-Color and Tri-Color.

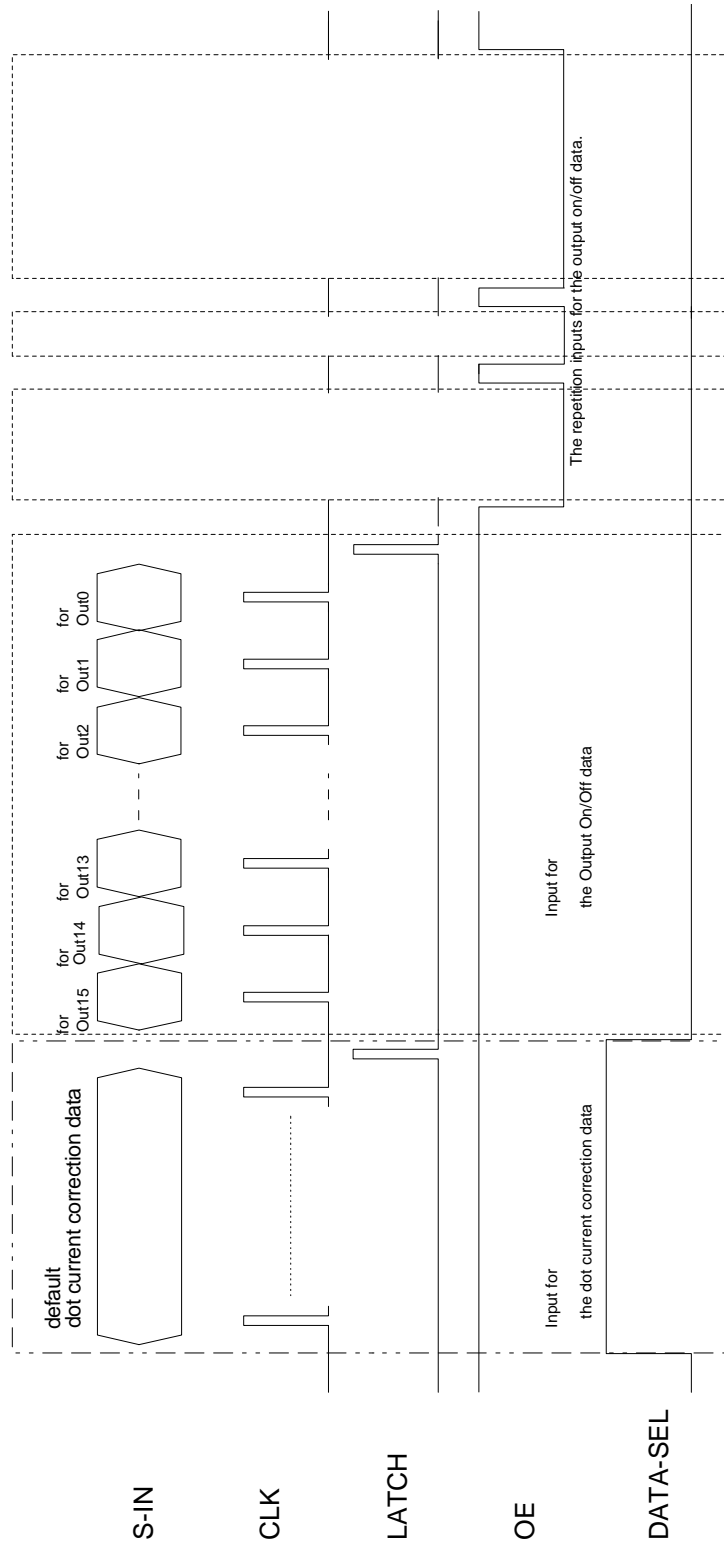
Step 1 - Prepare the default dot-current-correction data.

Step 2 - First, a DATA-SEL terminal is made Lo, and Hi is input with the CLK signal from the S-IN terminal, and then data are held at the LATCH signal. Output can be turned on with this by setting the OUT-ENABLE signal.

Step 3 - Next, a DATA-SEL terminal is made Hi, and dot compensation data for each output are input from the S-IN terminal, and then data are held at the LATCH signal. The current value of the output is established with this, too.

Step 4 - After that, input to the PWM pulse from OE terminal.

Step 5 - After that, replay to Step 2 and Step 4.



Note 10 : The default data is changed when the brightness is changed.

Note 11 : OE means OUT-ENABLE.

How to use the TB62727FN LED Driver

Operating outline to use output current correction control mainly for full-color.

Step 1 - Prepare the default output On-data for outputs.

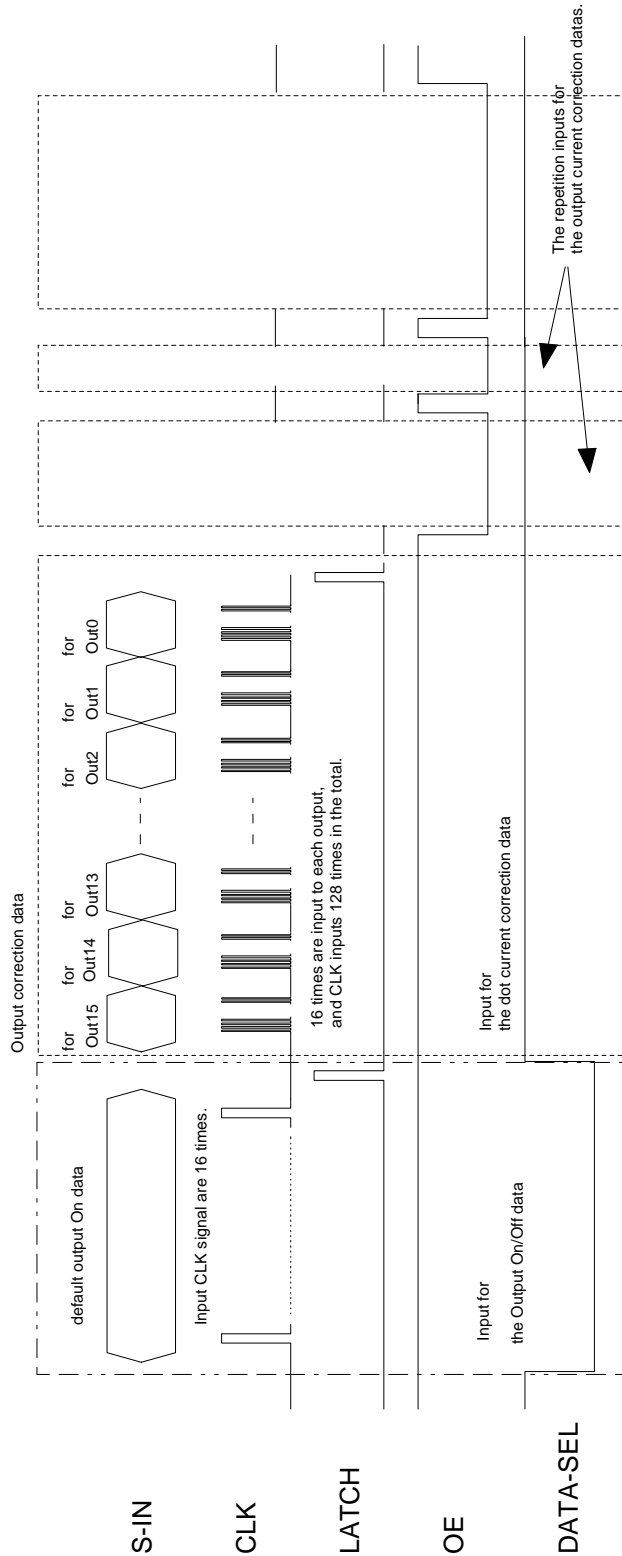
Step 2 - First, the DATA-SEL terminal is made Hi, and the dot compensation data of the default are input with the CLK signal from the S-IN terminal, and then data is held at the LATCH signal.

All the output was set up in the current value which was the same with this. (The errors are between the bits.)

Step 3 - Next, the DATA-SEL terminal is made Lo, and data for output on/off are input from the S-IN terminal and then data are held at the LATCH signal. Output can be turned on with this at the OUT-ENABLE signal Lo.

Step 4 - After that, input to the PWM pulse from OE terminal.

Step 5 - After that, replay to Step 2 and Step 4.

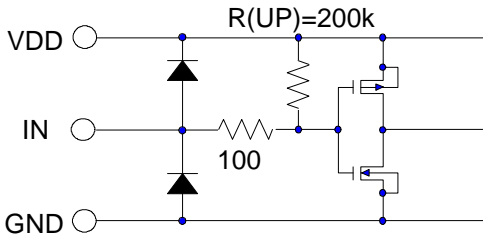


Note 12 : OE means OUT-ENABLE.

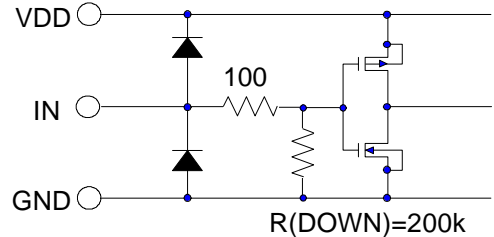
Note 13 : The default data is changed when the brightness is changed.

Equivalent input and output schematics

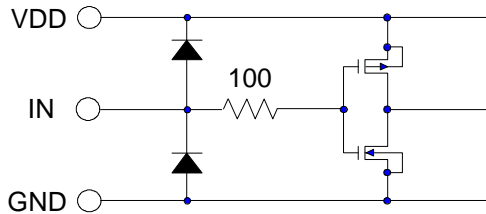
1. Input terminal with the pull up resistor
/OUT-ENABLE, SSYNC



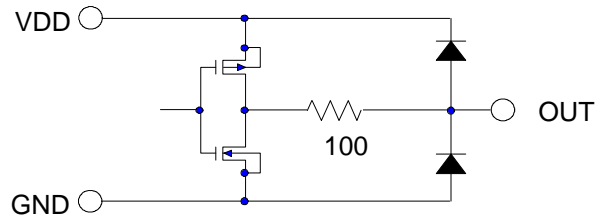
2. Input terminal with the pull down resistor
/LATCH, DATA-SEL



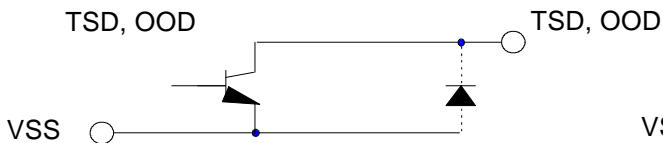
3. Input terminal
CLK, S-IN



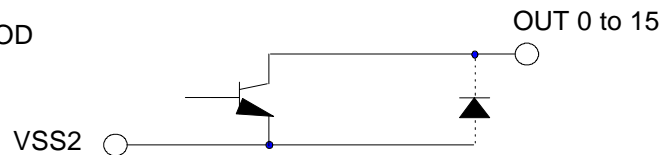
4. Output Terminal
S-OUT



5. Protection circuit monitor terminal
TSD, OOD



6. Constant current output terminal



Absolute maximum ratings

DC characteristic	Symbol	Rating	Unit	Notes
Supply voltage	V_{DD}	-0.3 to 6	V	
Constant current output voltage	V_O	-0.3 to 17		
Output current	I_{OUT}	+ 60	mA/bit	
Logic output voltage	V_{OUT}	-0.3 to VDD	V	
Logic input voltage	V_{IN}	-0.3 to VDD+0.3		
VSS2 current in total	I_{VSS2}	960	mA	All other Max Ratings are based on Max VSS2 current. If I_{VSS2} is less than I_{VSS2} Max, all other ratings may change
Power dissipation	P_d	1.25	W	On PCB. No wind.
		110 *		
Saturation heat resistance of package	$R_{th(j-a)}$	90 **	degree/ W	On PCB. Wind upper 1.0m/sec. This is reference value.
	$R_{th(j-c)}$	40** max		This is reference value.
Operating temperature	T_{opr}	-40 to 85	degree	
Storage temperature	T_{stg}	-55 to 150		

Note 14 :

* Subtract 9.0 mW/degree from the maximum rating value about 1° if operation temperature exceeds 25° when on PCB with dimension: 50 x 50 x 1.6mm Cu40%.

Note 15 :

** This is reference value.

The actual value varies greatly depending on the mounting condition.

We recommend measuring to obtain accurate results.

Recommended operating condition ($V_{DD}=4.5\sim 5.5V$, $T_{opr} = -40\sim 85$ degree, unless otherwise noted.)

DC characteristic	Symbol	Condition & terminal	Min	Typ	Max	Unit
Supply voltage	V_{DD}		4.5	5.0	5.5	V
High level input voltage	V_{IH}	CLOCK, S-IN, LATCH /OUT-ENABLE, SSYNC, DATA-SEL	2	VDD	VDD+0.3	
Low level input voltage	V_{IL}		VSS-0.3	VSS	0.8	
High level output current	I_{OH}	S-OUT			-1	mA
Low level output current	I_{OL}	S-OUT, TSD, ODD			+1	
Constant current output	I_{OUT}	OUT0 to OUT15	+5		+50	mA/bit
Output voltage	V_O	OUT0 to OUT15 off.			+17	V
	V_{OH}	TSD, ODD			+5	
Operating temperature	T_{opr}		-40		+85	degree

AC characteristics	Symbol	Condition & terminal	Min	Typ	Max	Unit
Clock frequency	f_{CLK}	cascade connected, CLK			20	MHz
Minimum pulse width	t_{wH1}/t_{wL1}	/OUT-ENABLE	250			ns
	t_{wH2}/t_{wL2}	/LATCH	25			
	t_{wH3}/t_{wL3}	CLOCK	20**			
	t_{wH4}/t_{wL4}	DATA-SEL	25			
Setup time	t_{setup1}	S-IN to CLOCK	20**			
	t_{setup2}	CLOCK to /LATCH	20**			
Hold time	t_{hold1}	S-IN to CLOCK	2			
	t_{hold2}	CLOCK to /LATCH	5			
Blank time	t_{blank}	DATA-SEL to CLOCK	20**			

Note 16 : ** The value is fixed by the ability of device tester.

Electrical characteristics 1

(Typ:V_{DD}=5V, T_{opr}=25degree, Min/Max:V_{DD}=4.5~5.5V, T_{opr}=-40~85 degree)

Parameter	Symbol	Test condition & terminal	Min	Typ	Max	Unit
High level output voltage	V _{OH}	I _{OH} =-1mA, S-OUT	V _{DD} -0.4			V
Low level output voltage	V _{OL}	I _{OL} =1mA, S-OUT			0.4	
		I _{OL} =+1.0mA, TSD,OOD			0.4	
Input current	I _i	All terminals without pull up/pull down resistor.			+/-1	uA
Supply current	I _{dd(off)}	CLOCK="L", S-IN="L", OUT-ENABLE="L", Set condition *0a		1.3	3	mA
	I _{dd(on)1}	CLOCK=20 MHz, S-IN=1/2 CLOCK Set condition *1a		5.5	9	
		T _{opr} =-40degree, Other condition is same above.			13	
	I _{dd(on)2}	CLOCK=20 MHz, S-IN=1/2 CLOCK Set condition *2a		6	10	
		T _{opr} =-40degree, Other condition is same above.			15	
	I _{dd(on)3}	CLOCK=20 MHz, S-IN=1/2 CLOCK Set condition *3a		9	14	
T _{opr} =-40degree, Other condition is same above.				18		
I _{dd(on)4}	CLOCK=20 MHz, S-IN=1/2 CLOCK Set condition *4a		12	18		
	T _{opr} =-40degree, Other condition is same above.			25		

Electrical characteristics current set condition

(T_{opr}=25 degree, V_{OUT}=0.4V unless otherwise noted)

No.	Set condition	Dot correction data	It is equivalent to I _{OUT} .
*0a	Output all off, V _{OUT} =Open, R _{EXT} = Open	"XXLLLLLL"	I _{OUT} =0 mA
*1a	OUT-ENABLE="L", All output on, V _{OUT} =Open, R _{EXT} = 7.4k ohm	"XXHLLLLL" (This is initial value.)	I _{OUT} =2.55 +/-15% mA
			I _{OUT} =5.1 +/-12% mA
*2a	OUT-ENABLE="L", All output on, V _{OUT} =Open, R _{EXT} = 3.6k ohm		I _{OUT} =15 +/-12% mA
*3a	OUT-ENABLE="L", All output on, V _{OUT} =Open, R _{EXT} = 1.2k ohm		I _{OUT} =24 +/-12% mA
*4a	OUT-ENABLE="L", All output on, V _{OUT} =Open, R _{EXT} = 740 ohm		I _{OUT} =24 +/-12% mA
*5a	R _{EXT} = 740 ohm	"XXLLLLLL"	I _{OUT} =46 +/-12% mA

Electrical characteristics 2

(Typ: $V_{DD}=5V$, $T_{opr}=25\text{degree}$, Min/Max: $V_{DD}=4.5\sim 5.5V$, $T_{opr}=-40\sim 85\text{ degree}$)

Parameter	Symbol	Test condition	Min	Typ	Max	Unit
Constant Current Output (within current Accuracy between bits)	I_{o1}	Set condition *1b	2.17	2.55	2.93	mA/bit
	I_{o2}	Set condition *2b	4.49	5.1	5.71	
	I_{o3}	Set condition *3b	13.2	15	16.8	
	I_{o4}	Set condition *4b	21.12	24	26.88	
	I_{o5}	Set condition *5b	40.48	46	51.52	
Constant current output depends on temperature	$\%T_{OPR}$	Set condition *4b. $V_{OUT}=1V$, T_{opr} is changed from -40~85 degree.		+50	+80	mA/ degree
Leakage current of the constant current output	I_{OLK}	Set condition *0b, $V_{OUT}=17V$		0.05	0.1	mA/bit
Constant Current Accuracy between bits	dI_{OUT1}	Set condition *2b		+/-1.5	+/-4	%
	dI_{OUT2}	Set condition *3b		+/-1.5	+/-4	
	dI_{OUT3}	Set condition *4b		+/-1.5	+/-4	
Constant current output depends on output voltage	$\%V_{OUT}$	$V_{DD}=5.0V$, Set condition *4b, V_{OUT} is changed from 0.7~3V.		+/-5	+/-8	
Constant current output depends on supply voltage	$\%V_{DD}$	Set condition *4b, V_{DD} is changed from 4.5~5.5V		+/-1	+/-2	
thermal shutdown detection temperature	T_{sd}		140			degree
Output open detection voltage	V_{ood}	OOD		0.04 V_{DD}		V
Pull up/down resistor	R_{up} / R_{dw}		100k	200k	400k	ohm

Electrical characteristics current set condition

($T_{opr}=25\text{ degree}$, $V_{OUT}=0.4V$ unless otherwise noted)

No.	Set condition	Dot correction data	Set for output current (typ)
*0b	Output all off, $V_{OUT}=\text{Open}$, $R_{EXT}=\text{Open}$	"XXLLLLLL"	$I_{OUT}=0\text{ mA}$
*1b	OUT-ENABLE="L", All output on, $R_{EXT}= 7.4k\text{ ohm}$	"XXHLLLLL" (This is initial value.)	$I_{OUT}=2.55\text{ +/-}15\% \text{ mA}$
*2b	OUT-ENABLE="L", All output on, $R_{EXT}= 3.6k\text{ ohm}$		$I_{OUT}=5.1\text{ +/-}12\% \text{ mA}$
*3b	OUT-ENABLE="L", All output on, $R_{EXT}= 1.2k\text{ ohm}$		$I_{OUT}=15\text{ +/-}12\% \text{ mA}$
*4b	OUT-ENABLE="L", All output on, $R_{EXT}= 740\text{ ohm}$		$I_{OUT}=24\text{ +/-}12\% \text{ mA}$
*5a		"XXLLLLLL"	$I_{OUT}=46\text{ +/-}12\% \text{ mA}$

Switching characteristics

(Typ : $V_{DD}=5V$, $T_{opr}=25\text{degree}$, $C_L=50\text{pF}$, Min/Max : $V_{DD}=4.5$ to $5.5V$, $T_{opr}=-40$ to 85degree , $C_L=50\text{pF}$)

Refer to TEST CIRCUIT)

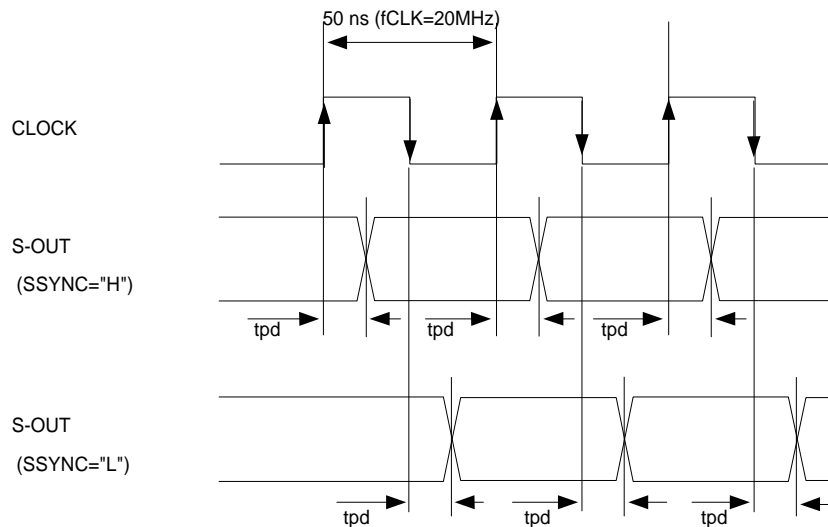
Characteristics	Symbol	Test condition	Min	Typ	Max	Unit	
Rise time	t_r	OUT 0 to OUT15	-	25	*75	ns	
Fall time	t_f	OUT 0 to OUT15	-	20	*60		
Propagation delay	t_{pHL1}	/OUT-ENABLE -> OUT 0	*20	40	*100		
	t_{pHL2}	/LATCH -> OUT0, /OUT-ENABLE="L"	*20	40	*100		
	t_{pHL}	TRD, OOD with pull up resistor, R(up)=10k ohm		180			
	t_{pLH1}	/OUT-ENABLE -> OUT 0	*20	40	*100		
	t_{pLH2}	/LATCH -> OUT0, /OUT-ENABLE="L"	*20	40	*100		
	t_{pLH}	TRD, OOD with pull up resistor, R(up)=10k ohm		370			
	t_{pd}	CLOCK -> S-OUT, See figure 1	SSYNC = "L"	7	12		18
		SSYNC = "H"	2	7	13		
Output skew by delay circuit	$t_{DLY(on)1}$	OUT0~OUT15 *		*15			
	$t_{DLY(off)1}$						
	$t_{DLY(on)2}$		**100	**225	**500		
	$t_{DLY(off)2}$						

Note 17 : This value may change depending on external circuitry.

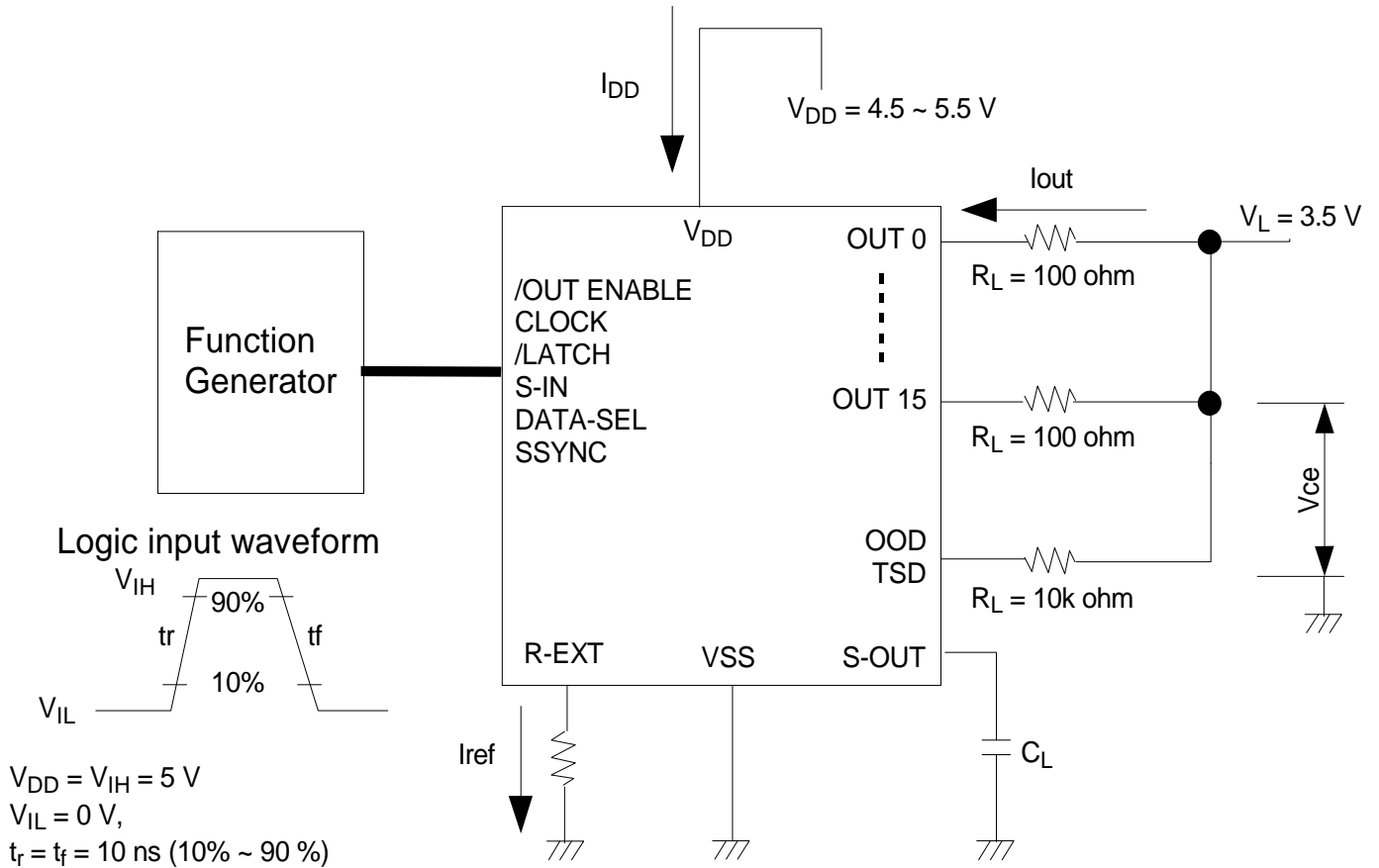
** The delay test is used to determine the difference in time of OUT0-OUT15.

* This is a guarantee value based on the circuits design.

Figure 1 : CLOCK to S-OUT Function



TEST CIRCUIT



Operating explanation and truth value table

Action table 8 - - - The transfer of the dot correction data :

Step	S-IN	CLK	LATCH	Operating and function
1	H or L	Positive edge	L	Input positive edge of CLK 128 times and transfer data to all the shift registers.
2		L	Positive edge	Input positive edge of LATCH once and make register hold data.

Figure 2-1 : Serial data transfer timing (for example of 1 device.)

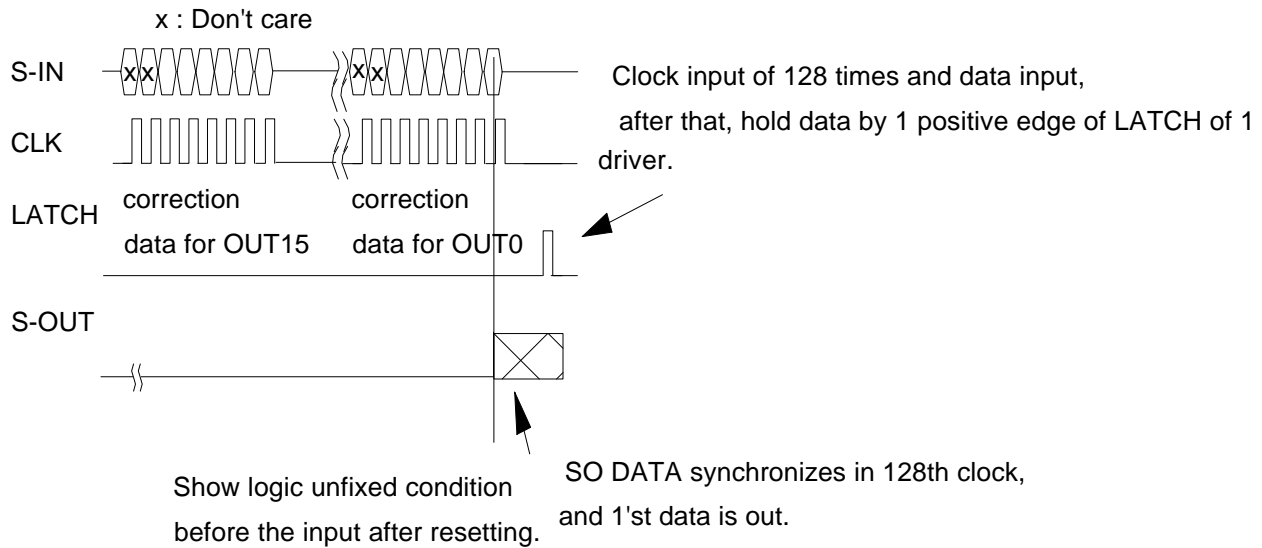
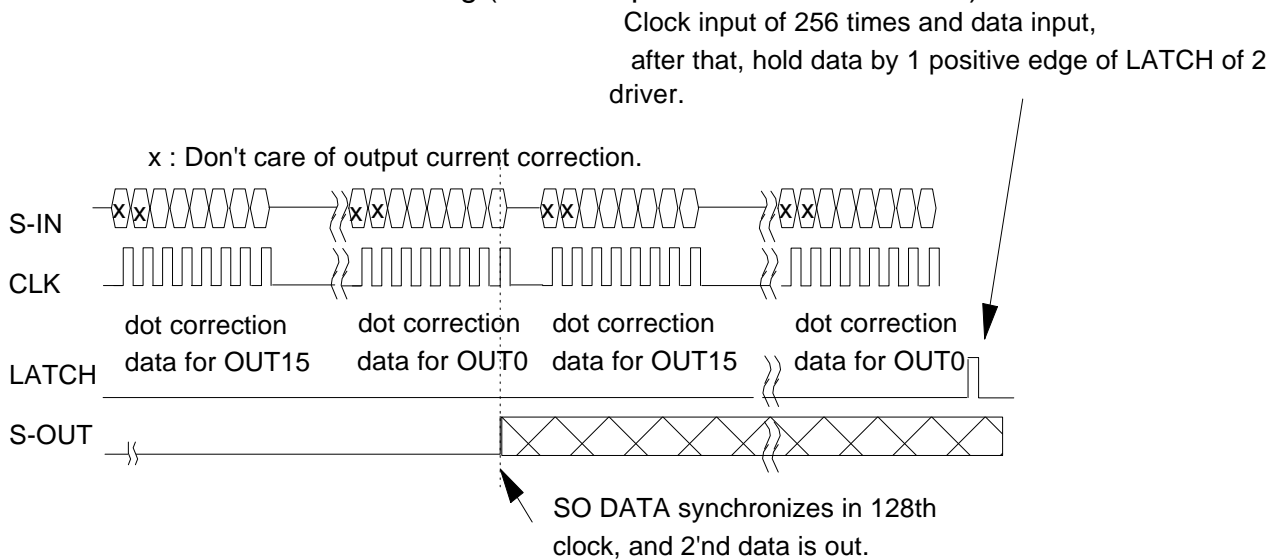


Figure 2-2 : Serial data transfer timing (for example of cascade connect.)



Operating explanation and truth value table

Action table 9 - - - Thermal detection function (It can be monitored with the TSD terminal.)

Perform temperature detection as described below.

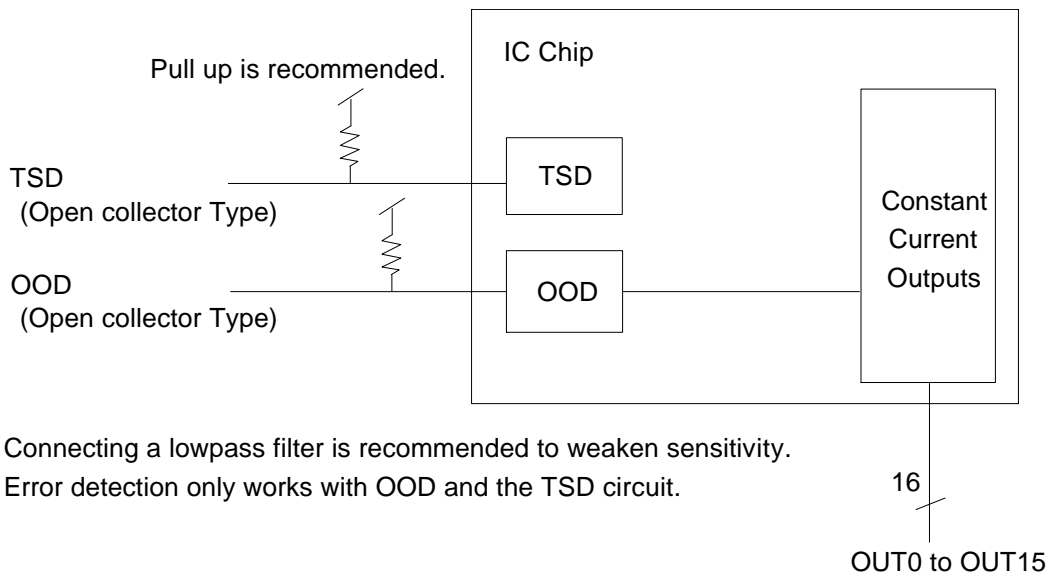
Junction Temp [degree]	TSD	OUT0 to OUT15	Function
-40 to 140	off	Normal operation	When temperature decreases, TSD is canceled automatically.
over 140	on		When chip temperature reaches the following range, the TSD terminal is on. Output is not turned off.

Action table 10 - - - Output open detection function (It can be monitored with the OOD terminal.)

Perform open output detection as described below.

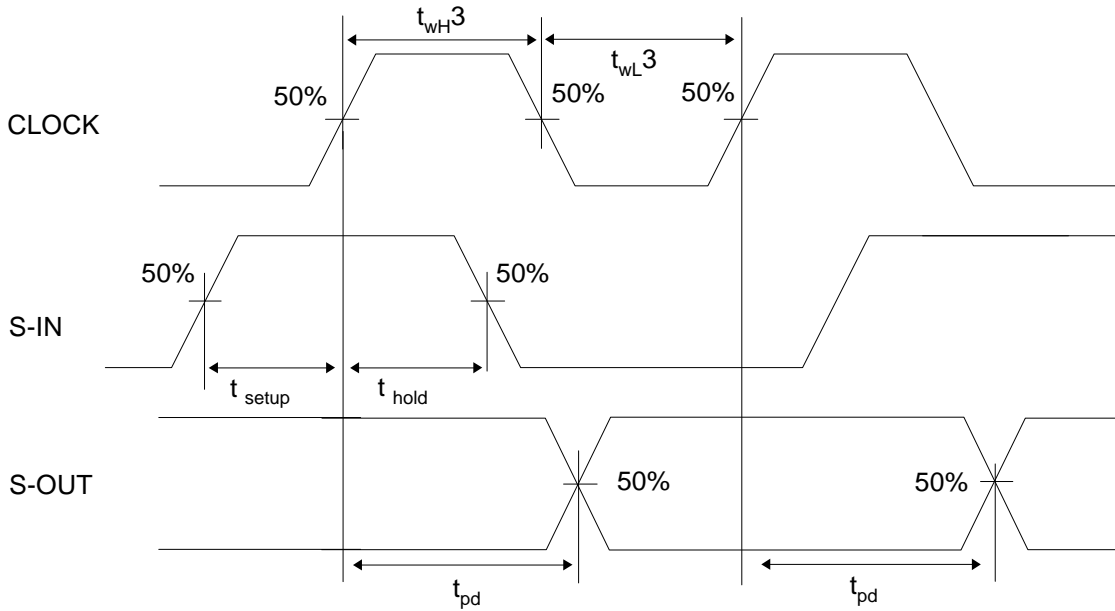
Output Voltage [V]	OOD	Function
$\geq VDD \times 0.04$	Off	
$\leq VDD \times 0.04$	On	Output opening is detected by the following voltage, the OOD terminal is on.

Figure 2 : The block diagram of the protection circuit 2

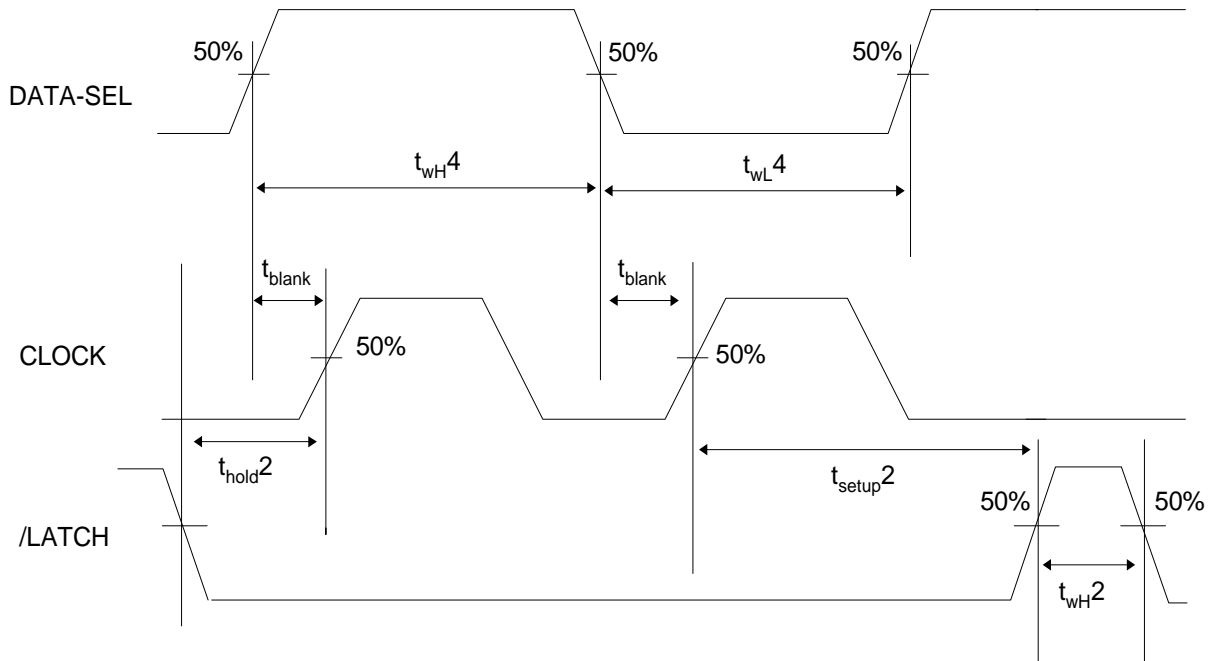


Logic input and output timing wave form (1)

1. CLOCK vs S-IN

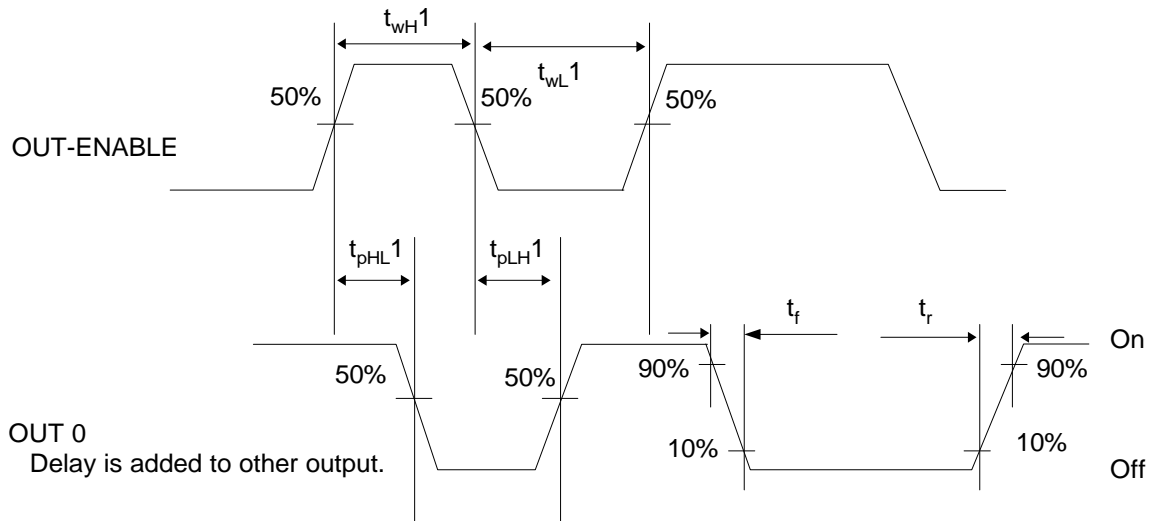


2. DATA-SEL vs CLOCK , CLOCK vs /LATCH

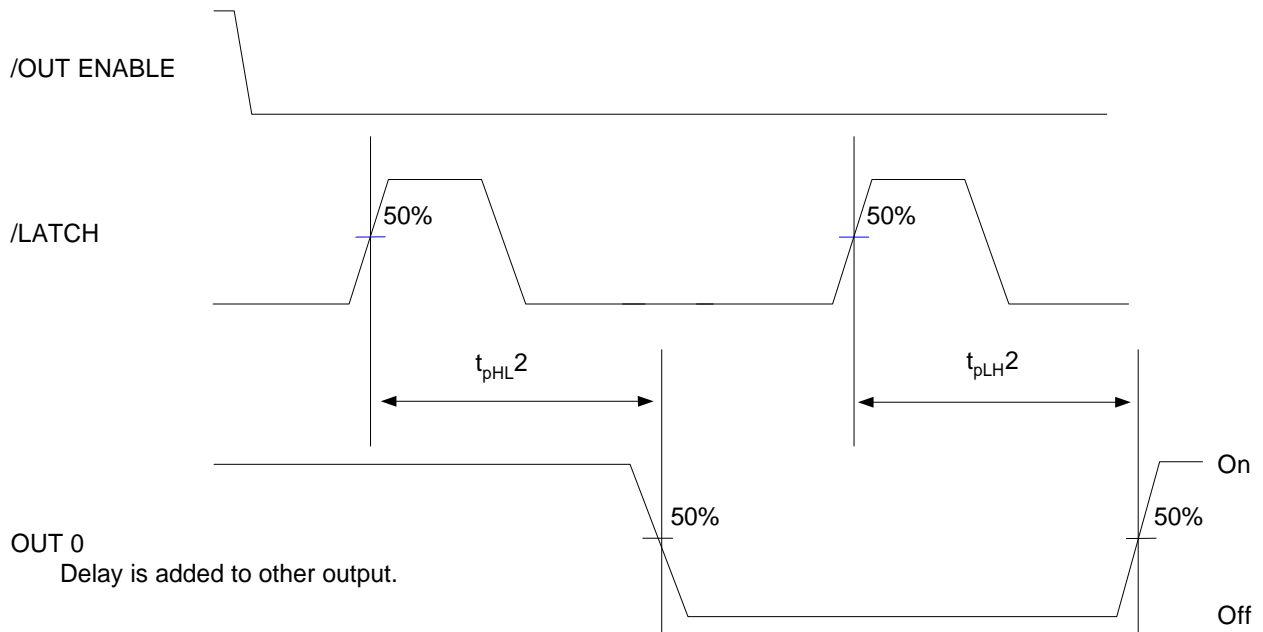


Logic input and output timing wave form (2)

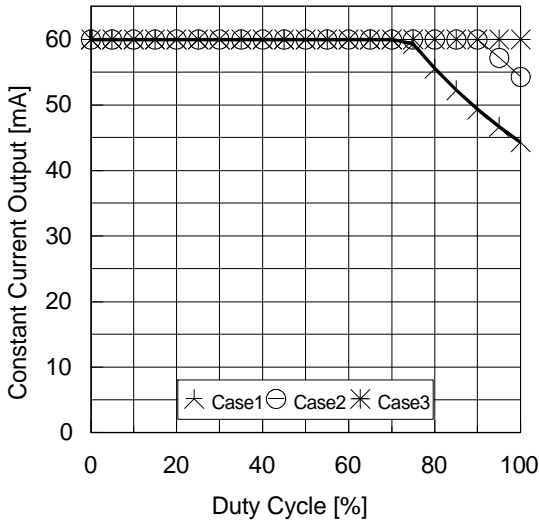
3. /OUT-ENABLE vs OUT0



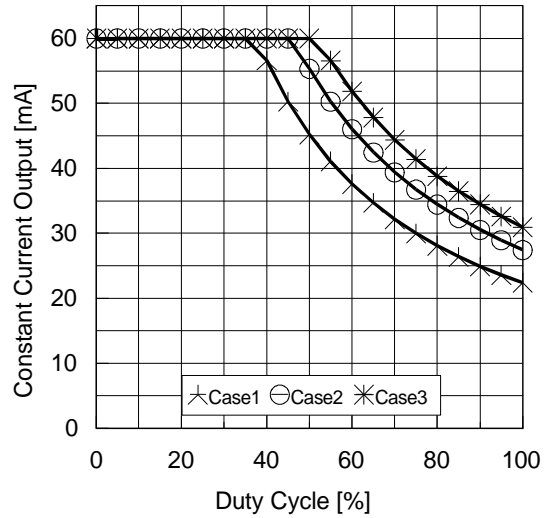
4. /LATCH vs OUT0



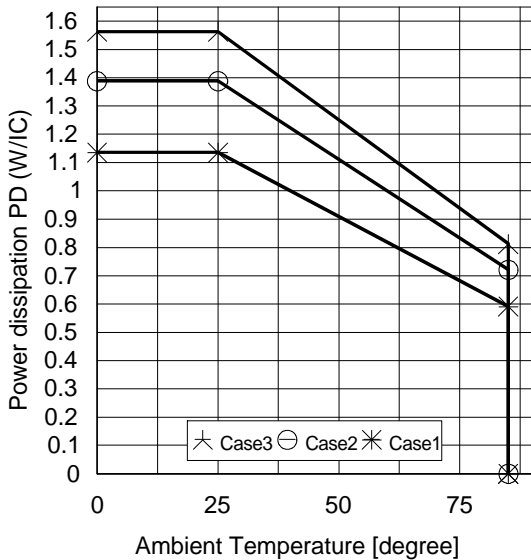
DUTY - IOUT On PCB
16bit activate, Vce=0.7V, Topr=25degree



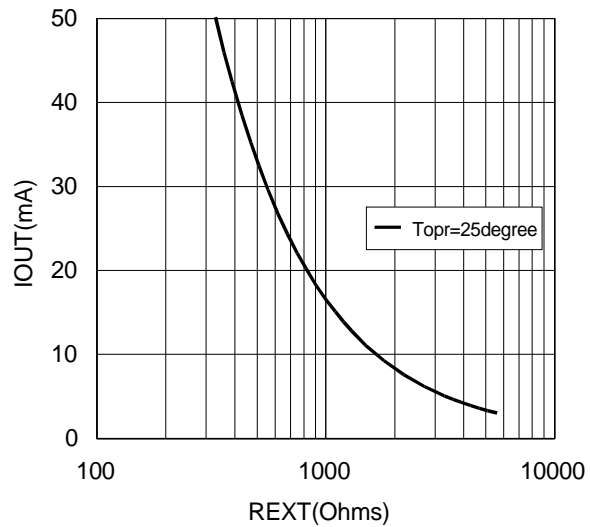
DUTY - IOUT On PCB
16bit activate, Vce=1.5V, Topr=25degree



Ta - Pd



REXT - IOUT
VCE=0.4V, Topr=25degree
When current correction is 32 of 63step.



NOTE :This is reference value.

- Case1: Velocity of the wind is 0m/s.
- Case2: Velocity of the wind is 1m/s.
- Case3: Velocity of the wind is 2m/s.

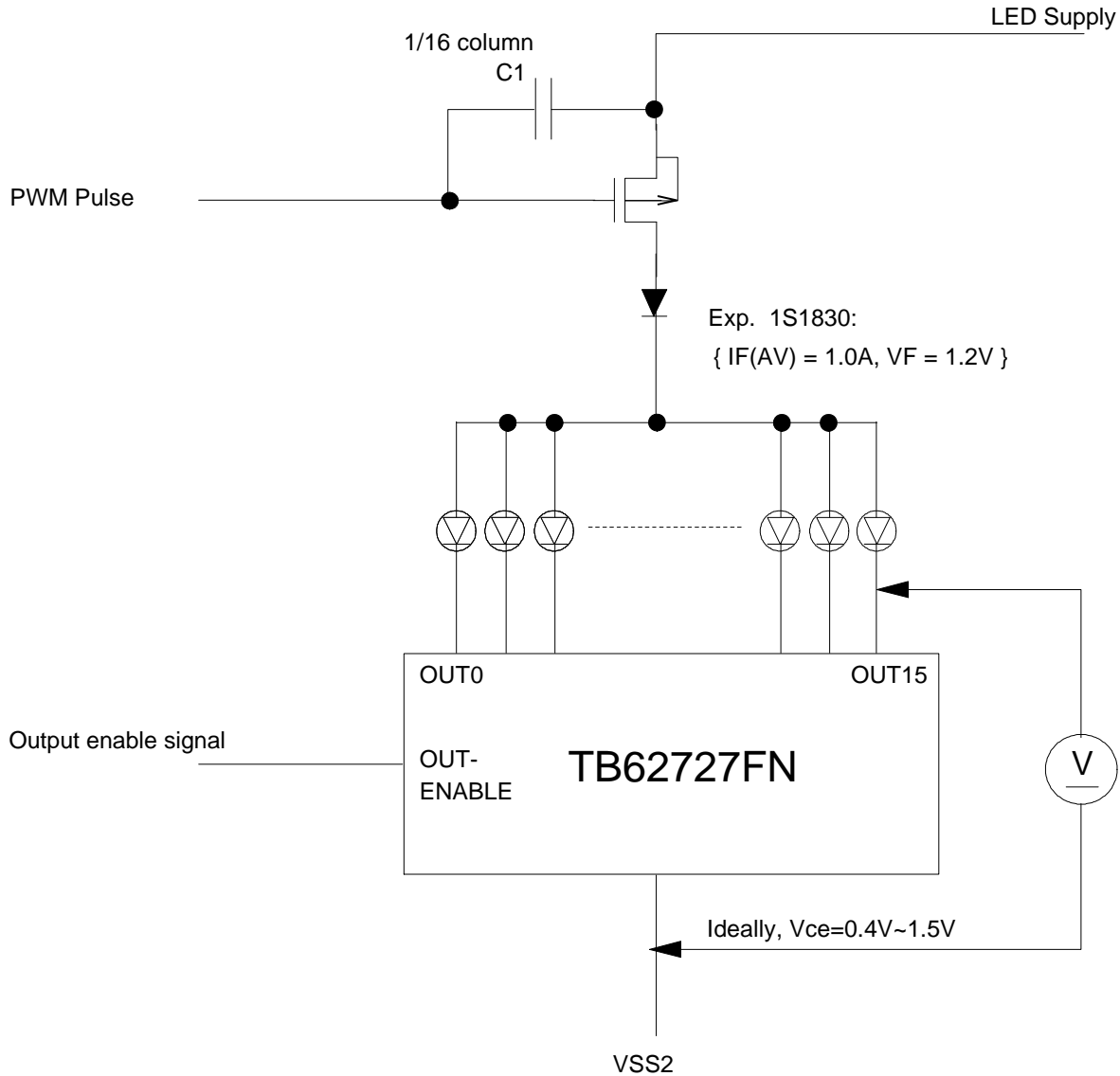
$$IOUT (mA) = 1000 * 0.46 * \text{Dot correction rate} * (1.15 / REXT)$$

APPENDIX - (A) : Decrease in Power Dissipation of the LED Driver.

This driver operates with $V_{CE} \geq 0.4V$.

If there is a change in V_F of the LED, V_{CE} may increase, thus increasing the Junction Temp. of the driver.

When using full color LEDs, we recommend connecting a diode on a common line of red LEDs.

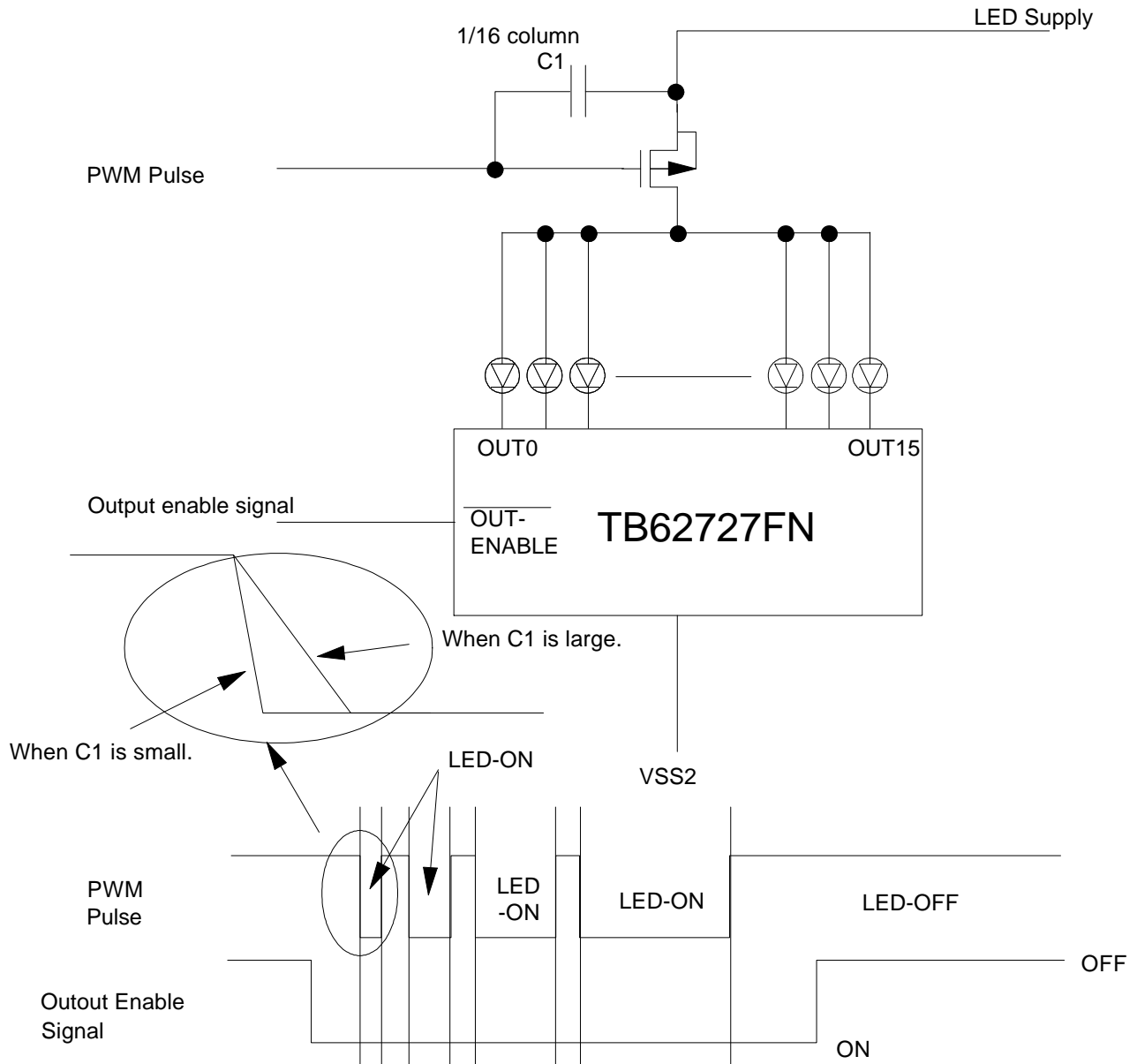


Emitting color of LED	V_F of LED	LED Supply	V_{DS} of FET	1S1830	V_{CE} of IC
Red	1.8 to 2.2V	3.3V / 5V	About 0.5V	1.2V	1.1~1.5V
Blue	3.5 to 4V	5V		-	0.5~1V
Green					

APPENDIX – (B) : High Speed Switching of the LED Outputs

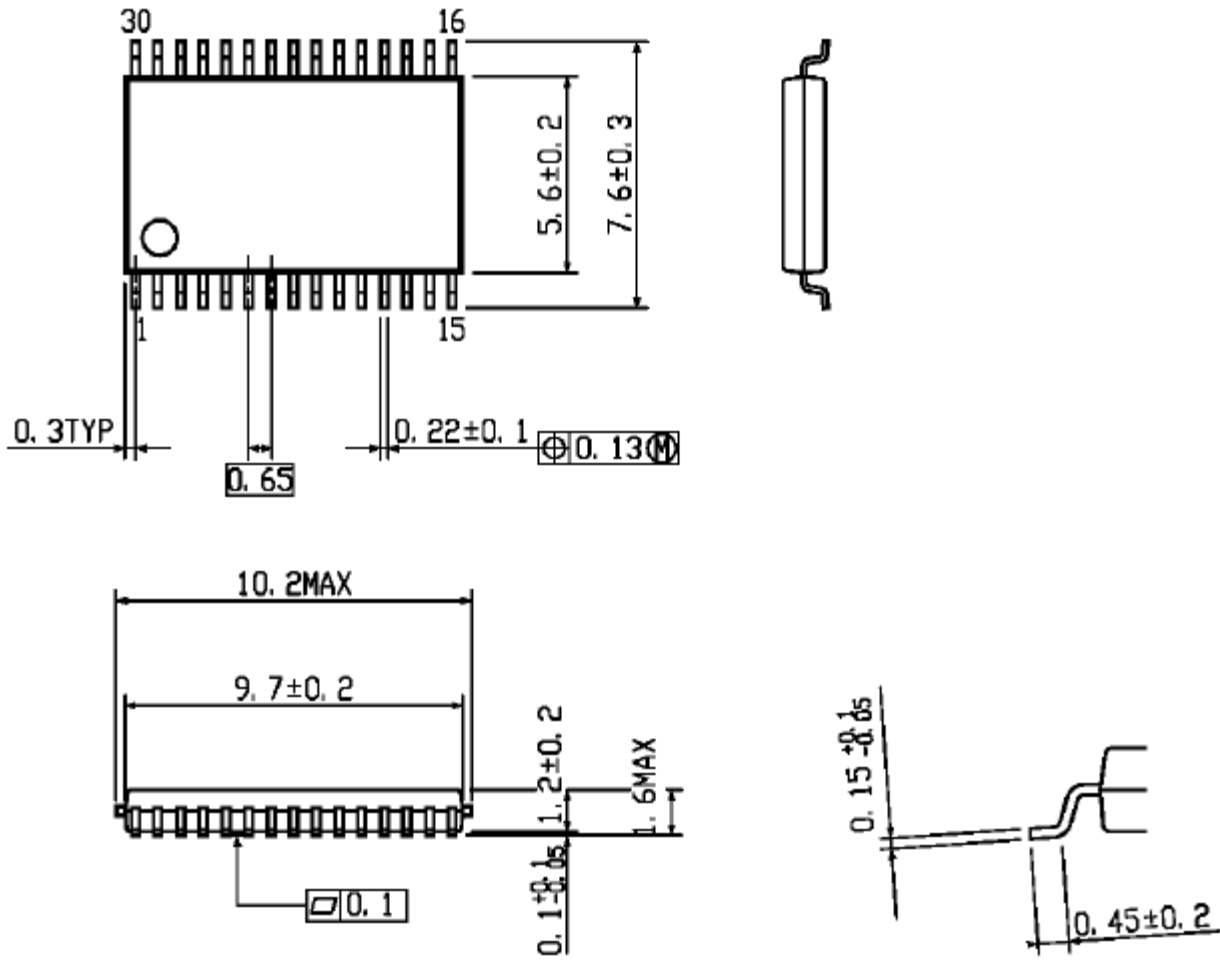
We recommend inputting the PWM pulse to PMOS of the column at OUT-ENABLE terminal. Because, the PMOS is possible High-speed operating.

When C1 is connected, rise time of the output wave form can be also be controlled.



** The input of the data and other control signals are omitted.

Unit : mm



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