DM133

Version : A.024
Issue Date : 2004/07/05
File Name : SP-DM133-A.024.doc
Total Pages : 20

16-Bit Constant Current LED Drivers

With LED Open/Short Detection

新竹市科學園區展業一路 9 號 7 樓之 1
SILICON TOUCH TECHNOLOGY INC.
9-7F-1, Prosperity Road I, Science Based Industrial Park,
Hsin-Chu, Taiwan 300, R.O.C.
Tel：886-3-5645656 Fax：886-3-5645626

DM133

16-Bit Constant Current LED Drivers

with LED Open/Short Detection

General Description

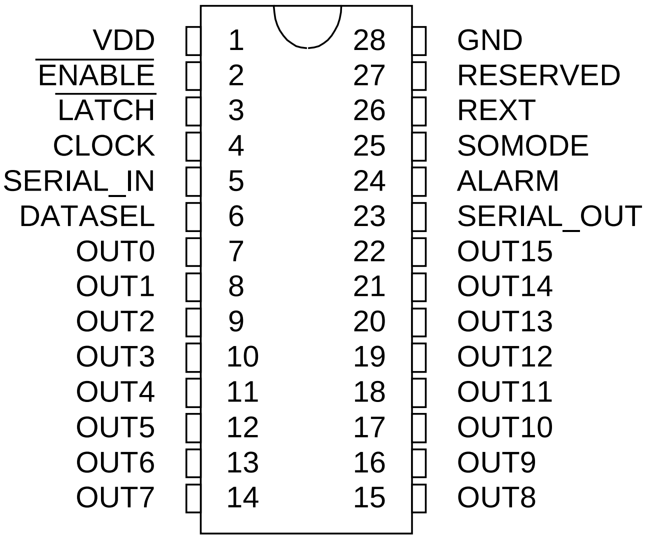
The DM133 is a constant current driver specifically designed for LED display applications. The device includes a 16-bit shift register, two latches, and constant current drivers on a single Silicon CMOS chip. Its built-in open/short detection and thermal alarm circuits help the user to detect the overheating of the IC and LED failures. Its user-friendly design allows the user to adjust the output current (5~60mA) by using an external resistor. The current also can be further tuned by 6-bit serial shift-in data.

Features

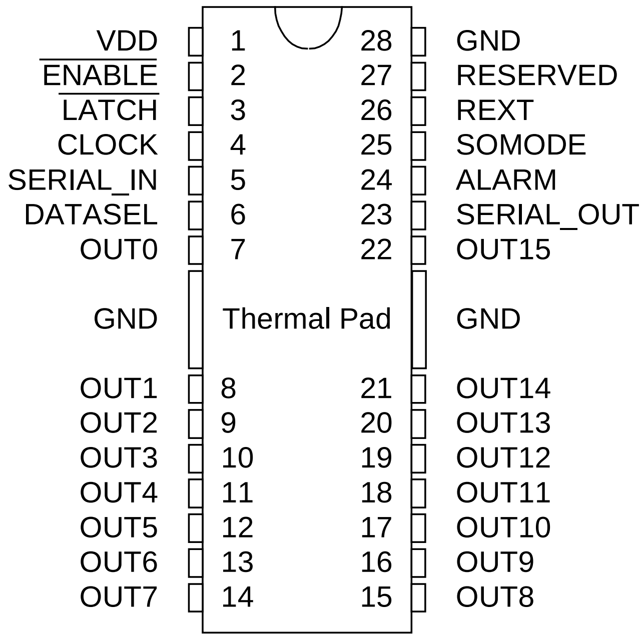
- Constant Current Output: Current with one resistor for 5mA to 60mA
- Maximum Clock Frequency: 25MHz (Max.)
- Power Supply Voltage: 3.3V to 5.0V
- CMOS Compatible Input/Output
- Package: HSOP28, SSOP28, QFN32
- Constant Current Matching:
  - 10mA ~ 60mA : Bit-to-Bit : ± 4.0% (Max)、Chip-to-Chip: ± 10.0% (Max)
  - 5mA ~ 10mA : Bit-to-Bit : ± 6.0% (Max)、Chip-to-Chip: ± 12.0% (Max)
- Maximum Output Voltage: 17V
- Thermal Alarm Function: Error signal output when junction temperature exceeds limit
- LED Open/Short Detection: Error signal output when LED is failed
- 6 bit Linear Global Current Adjustment

Pin Connection (Top view)

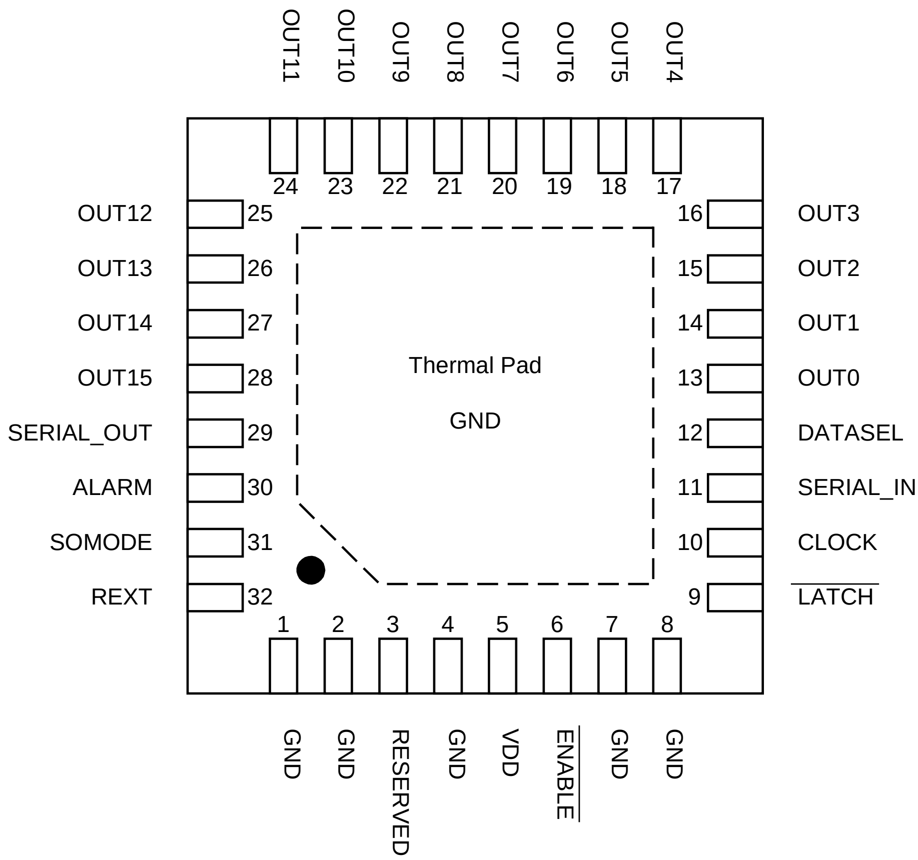
SSOP28



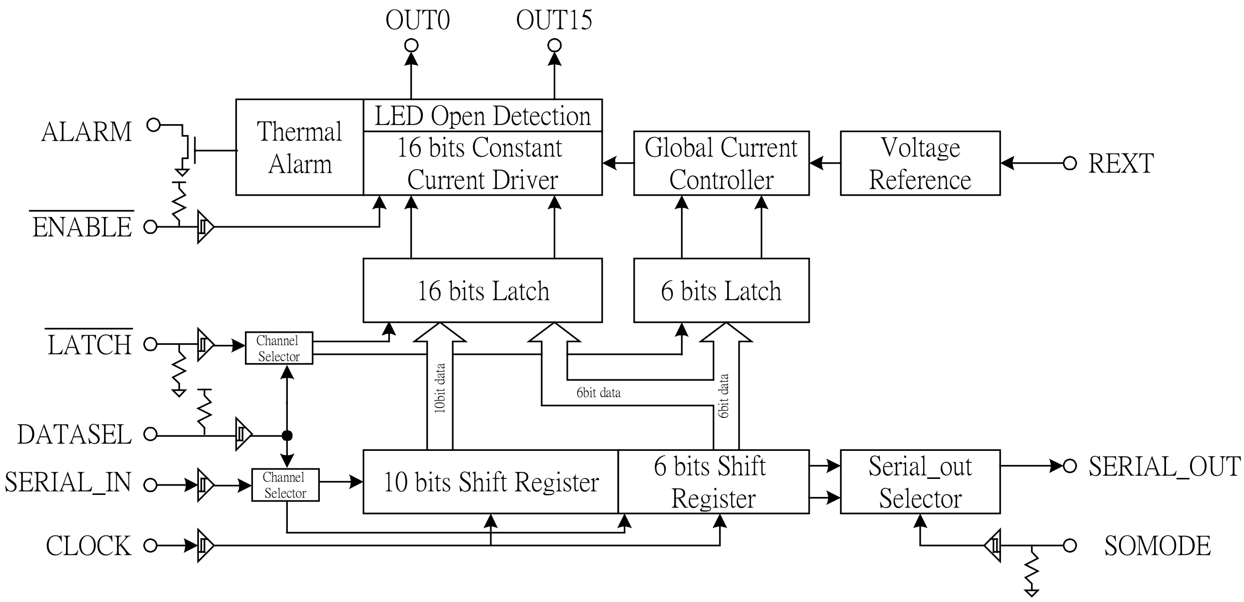
HSOP28



QFN32



Block Diagram

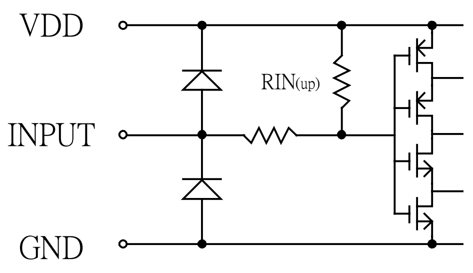


Pin Description

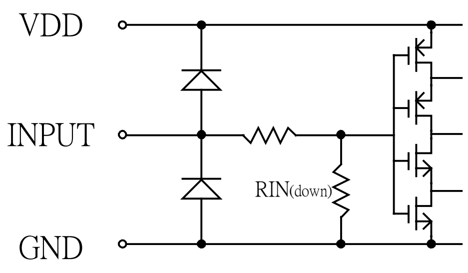
SDIP No.	PIN NAME	FUNCTION
1	V_{DD}	Supply voltage terminal.
2	$\overline{\text{ENABLE}}$	Input terminal of output enable (active low), all outputs are off when $\overline{\text{ENABLE}}$ is high.
3	$\overline{\text{LATCH}}$	Input terminal of data strobe. Data is latched when $\overline{\text{LATCH}}$ is low. And data on shift register goes through when $\overline{\text{LATCH}}$ is high.
4	CLOCK	Input terminal of a clock for shift register. Data is sampled at the rising edge of CLOCK.
5	SERIAL_IN	Input terminal of a data shift register.
6	DATASEL	Input terminal of a data path selection for output current on/off or global current adjustment
7~22	OUT0~15	Output terminals with constant current.
23	SERIAL-OUT	Output terminal of a data shift register.
24	ALARM	Output open drain terminal for an alarm function. It will go low as LED open/short or chip overheated.
25	SOMODE	Input terminal of a data output trigger mode selection
26	REXT	Input terminal of an external resistor. The current flows through the resistor from REXT to ground will be the reference base current of output sink current.
27	RESERVED	Terminal for testing, user should leave this pin open.
28	GND	Ground terminal

Equivalent Circuit of Inputs and Outputs

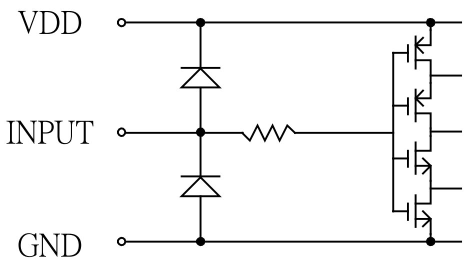
1. $\overline{\text{ENABLE}}$, DATASEL terminals



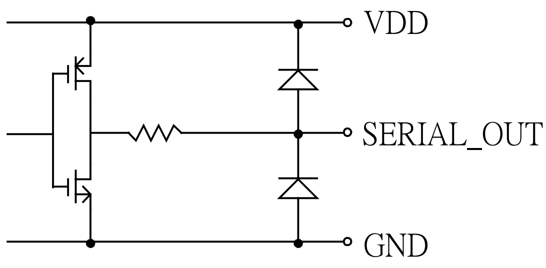
2. $\overline{\text{LATCH}}$, SOMODE terminals



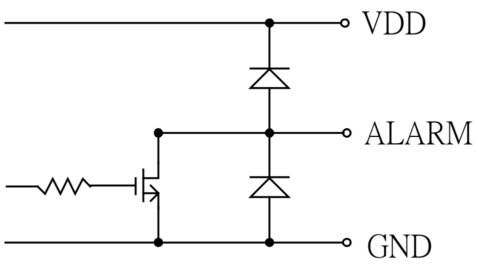
3. CLOCK, SERIAL-IN terminals



4. SERIAL-OUT terminal



5. ALARM terminal



Maximum Ratings (Tj$_{(max)}$ = 150°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Supply Voltage	VDD	-0.3 ~ 7.0	V
Input Voltage	VIN	-0.3 ~ VDD+0.3	V
Output Current	IOUT	70	mA
Output Voltage	VOUT	-0.3 ~ 17	V
Clock Frequency	fCLK	25	MHz
GND Terminal Current	IGND	1120	mA
Power Dissipation (4 layer PCB)	PD	2.11 (HSOP-28 : Ta=25°C)	W
		1.1 (SSOP-28: Ta=25°C)	W
		3.18 (QFN-32 : Ta=25°C)	W
Thermal Resistance	Rth(j-a)	59.1 (HSOP-28)	°C/W
		113.3 (SSOP-28)	°C/W
		39.3 (QFN-32)	°C/W
Operating Temperature	Topr	-40 ~ 85	°C
Storage Temperature	Tstg	-55 ~ 150	°C

Recommended Operating Condition

CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Supply Voltage	VDD	—	3.0	5.0	5.5	V
Output Voltage	VOUT	—	—	—	17	V
Output Current	IO	OUTn	5	—	60	mA
	IOH	SERIAL-OUT	—	—	1.0	
	IOL	SERIAL-OUT	—	—	-1.0	
Input Voltage	VIH	—	0.8VDD	—	VDD	V
	VIL	—	0.0	—	0.2VDD	
$\overline{\text{LATCH}}$ Pulse Width	tw LAT	VDD = 3.3 ~ 5.0 V	15	—	—	ns
CLOCK Pulse Width	tw CLK		15	—	—	ns
Set-up Time for DATA	tsetup(D)		10	—	—	ns
Hold Time for DATA	thold(D)		10	—	—	ns
Set-up Time for $\overline{\text{LATCH}}$	tsetup(L)		15	—	—	ns
Clock Frequency	fCLK	Single Chip operation	—	—	25	MHz
		Cascade operation (SOMODE='L') CL=13pF	—	—	25	
		Cascade operation (SOMODE='H') CL=13pF	—	—	15	

Electrical Characteristics (Typ:VDD = 5.0 V, Ta = 25°C unless otherwise noted)

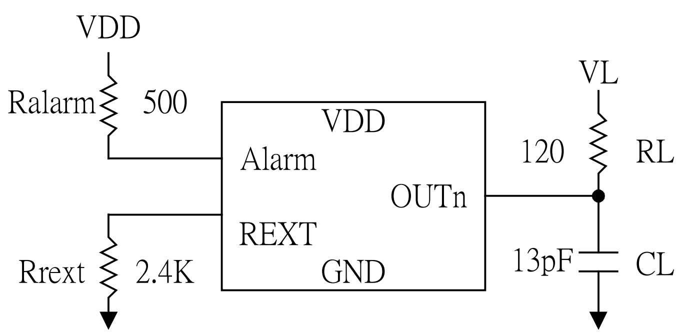
CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Input Voltage "H" Level	VIH	—	0.8VDD	—	VDD	V
Input Voltage "L" Level	VIL	—	GND	—	0.2VDD	V
Output Leakage Current	IOH	VOH = 17 V	—	—	±1.0	uA
Output Voltage (S - OUT)	VOL	IOL = 1.0 mA	—	—	0.3	V
	VOH	IOH = -1.0 mA	VDD-0.3	—	—	V
Output Current (Bit-Bit)[1]	IOL1	VOUT = 0.4V, **Rrext** = 4.8KΩ VDD=3.3V, (1 channel on)	—	—	±4	%
Output Current (Chip-Chip)[2]	IOL2	VOUT = 0.4V, **Rrext** = 4.8KΩ VDD=3.3V, (1 channel on)	10.2	11.4	12.6	mA
Output Voltage Regulation	% / VOUT	**Rrext** = 4.8KΩ, VOUT = 1V to 3V	—	±0.1	±0.5	% / V
Supply Voltage Regulation	% / VDD	**Rrext** = 4.8KΩ	—	±2.0	±4.0	% / V
Differential Linearity	DLE		-1.0		1.0	LSB
Thermal Alarm Detection Temperature	T(tsd)	Junction temperature	140	150	160	℃
LED Open Detection Voltage	V(od)		—	0.3	—	V
Pull-Up Resistor	RIN(up)	—	150	300	600	KΩ
Pull-Down Resistor	RIN(down)	—	100	200	400	KΩ
Supply Current "OFF"	IDD(off)1	Input Signal is static, **Rrext** = OPEN, OUT0~15 = off	—	8	—	mA
	IDD(0ff)2	Input Signal is static, **Rrext** = 2.8KΩ, OUT0~15 = off	—	8.5	—	mA
	IDD(off)3	Input Signal is static, **Rrext** = 1.4KΩ, OUT0~15 = off	—	11	—	mA
Supply Current "ON"	IDD(on)1	Input Signal is static, **Rrext** = 2.8KΩ, OUT0~15 = on	—	13	—	mA
	IDD(on)2	Input Signal is static, **Rrext** = 1.4KΩ, OUT0~15 = on	—	16	—	mA

[1] Bit-Bit skew of the IC is defined as the ratio between (any Iout – average Iout) and average Iout, where average Iout = (Imax + Imin) / 2.
[2] Chip-Chip skew is defined the range into which any output current of any IC falls".

Switching Characteristics (Ta = 25 °C unless otherwise noted)

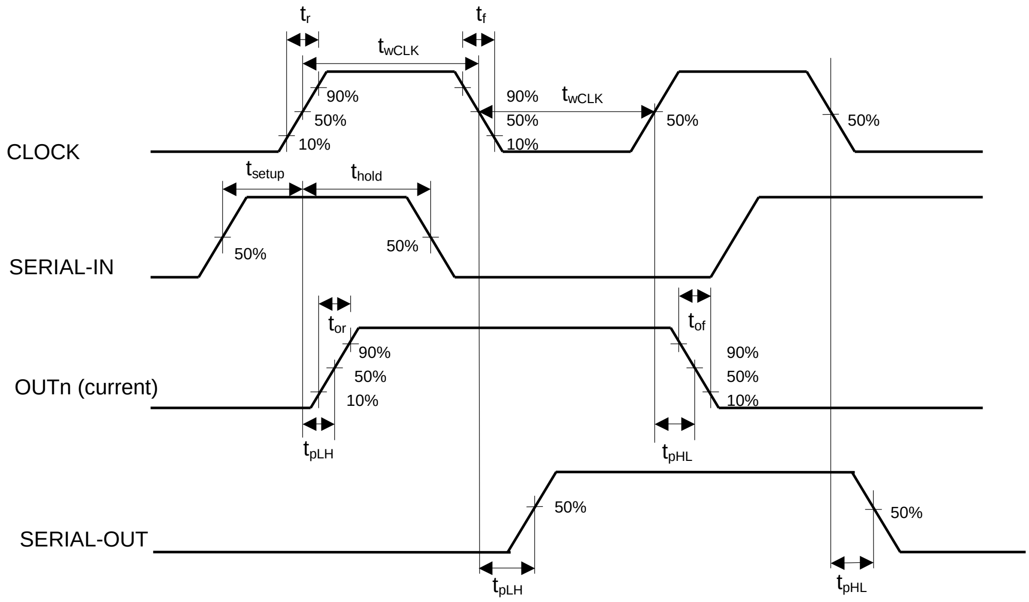
CHARACTERISTIC		SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Propagation Delay Time (“L” to “H”)	$\overline{ENABLE}$-OUTn	tpLH	VDD=5.0V VIH=VDD VIL=GND Rrext=2.4KΩ VL=3.3V RL=120Ω CL=13pF Ralarm=500Ω	—	40	—	ns
	OUTn-Alarm(on)			—	70	—	ns
Propagation Delay Time (“H” to “L”)	$\overline{ENABLE}$-OUTn	tpHL		—	130	—	ns
	OUTn-Alarm(off)			—	100	—	ns
Output Current Rise Time		tor		—	50	—	ns
Output Current Fall Time		tof		—	25	—	ns

CHARACTERISTIC		SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Propagation Delay Time (“L” to “H”)	$\overline{ENABLE}$-OUTn	tpLH	VDD=3.3V VIH=VDD VIL=GND Rrext=2.4KΩ VL=3.3V RL=120Ω CL=13pF Ralarm=500Ω	—	50	—	ns
	OUTn-Alarm(on)			—	70	—	ns
Propagation Delay Time (“H” to “L”)	$\overline{ENABLE}$-OUTn	tpHL		—	160	—	ns
	OUTn-Alarm(off)			—	100	—	ns
Output Current Rise Time		tor		—	60	—	ns
Output Current Fall Time		tof		—	25	—	ns

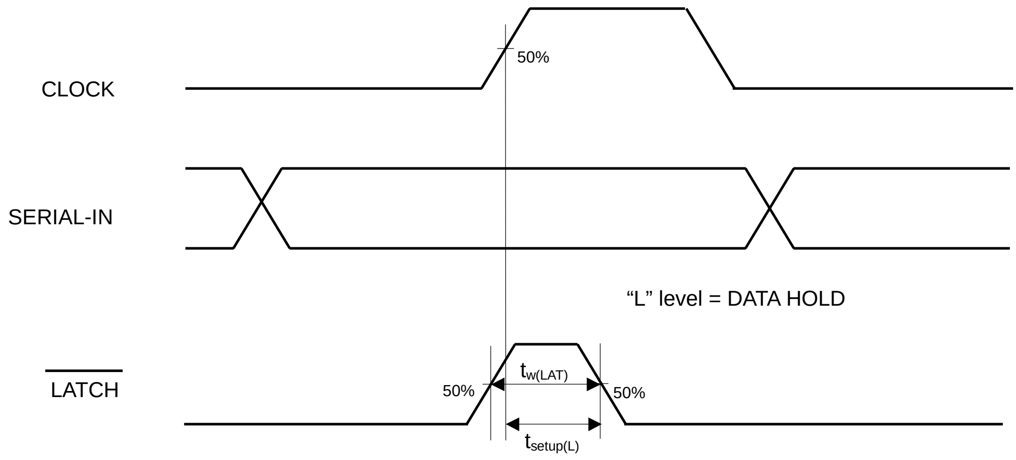


Timing Diagram

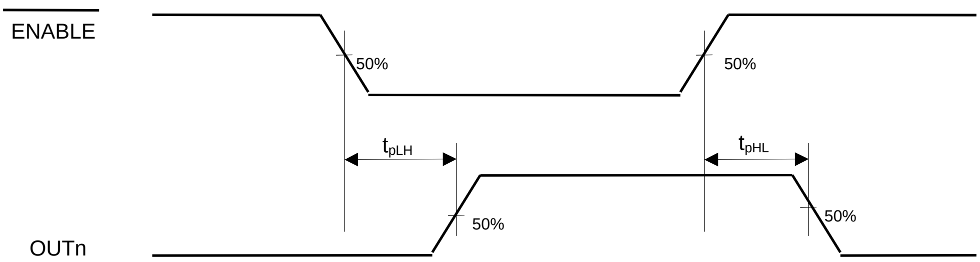
1. CLOCK-SERIAL-IN, SERIAL-OUT, OUTn



2. CLOCK-$\overline{\text{LATCH}}$



3. $\overline{\text{ENABLE}}$-OUTn(current)

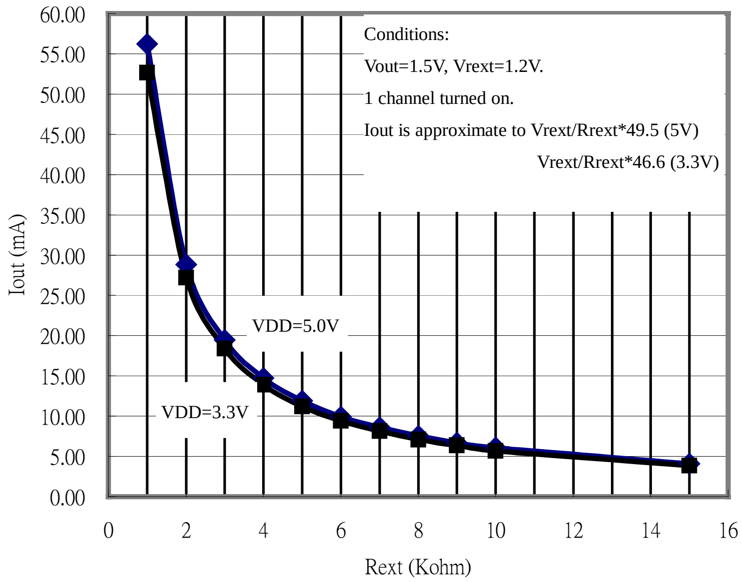


Detailed Description

1)Constant Current Output Value Setting

The output current is determined by resistor value multiplying a ratio. The resistor connected between REXT pin and GND decides the base current output. The resistor should be located as close to REXT terminal as possible to avoid the noise influence. The graph below shows the approximate relation between resistor value and output current value.

In the monochrome or full color LED display cases, for obtaining the uniformity or for the white balance between modules or ICs, the DM133 offers a more convenient way to let control system to reach the goal by fine tuning the output current. To further adjust the current level, the system shall set the DATASEL pin to low and then shift in 6 bits data code through SERIAL_IN pin. The MSB should be shifted-in first. Take the input code = (MSB)100101(LSB) for example. The new current is then equal to the base current multiplied by $(2^5+2^2+2^0)/(2^5+2^4+2^3+2^2+2^1+2^0+1)$. The 6 bits data won't be changed until the next new data is latched. For some cases, the data only need to be shifted once after power-on. Note that code: 011111 exists in chip when power on so that the output current is nearly half amount of the base current.



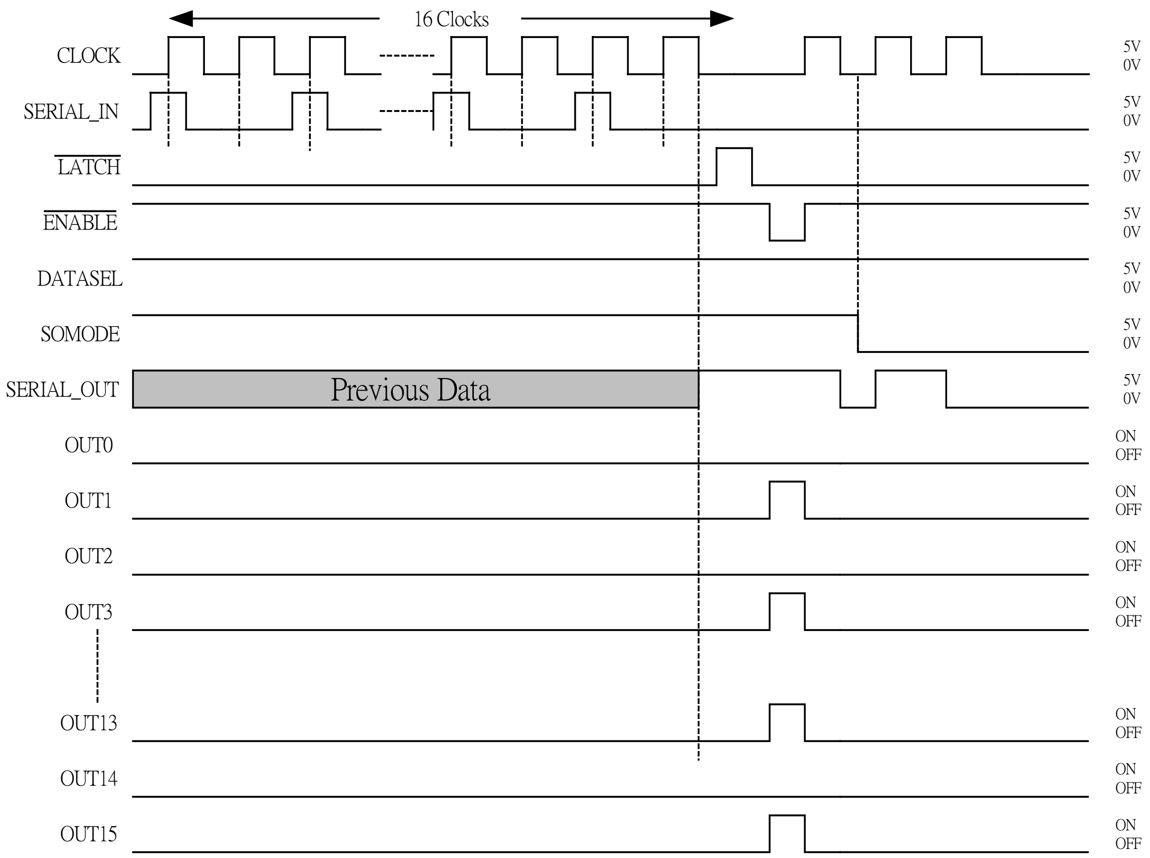
2)Serial_In Data and Latch

As the DATASEL pin is set high, the SERIAL_IN data will be clocked into the 16 bits shift register synchronized on the rising edge of CLOCK. And the data '1' represents the corresponding current output 'ON', while the data '0' stands for 'OFF'. The data will be transferred into the latch as the $\overline{\text{LATCH}}$ pin goes high. And the data will be latched when $\overline{\text{LATCH}}$ goes low.

3)Serial_Out Timing Selection

The SERIAL_OUT output timing can be changed by the level of SOMODE. When SOMODE is set high, data is shifted out on synchronization to the falling edge of CLOCK, and when SOMODE is set low, data is clocked out to SERIAL_OUT synchronized on the rising edge of CLOCK.

The graph below depicts the timing of data serial-in and serial-out.



4)Thermal Alarm

The open-drain ALARM pin will go low when the IC junction temperature is approximately above 150℃. As the thermal alarm is issued, the system should cool down the temperature (by lowering the PWM current output, or by turning on the fan system, …etc.).

The ALARM pin will return to high when the IC junction temperature is approximately below 100℃ or when the power is turned on again after turned off for several seconds. Operation in a thermal alarm situation for long time may cause permanent damage to the IC.

5)LED Open Detection

The DM133 monitors the whole system, but its alarm mechanism won't burden the control system until some fault happens. The ALARM pin is used for both signaling the thermal alarm and LED disconnection. When ALARM is low, either overheating or LED disconnection occurs. And when ALARM returns to high, either the LED is re-connected or the temperature is lowered down. Therefore, $\overline{\text{ENABLE}}$ is used to tell which situation occurs when ALARM goes low.

Assume $\overline{\text{ENABLE}}$ is low and ALARM is low now. By turning $\overline{\text{ENABLE}}$ high, all the current outputs are off and hence, LED open detection is disabled. Then, if ALARM is changed to high, LED disconnection must have occurred. On the other hand, if the ALARM remains low, then, the IC is obviously overheated. The constant current output can be turned on sequentially to identify which output's LED is disconnected. Table 1 shows the detectimg operation and the corresponding occurance.

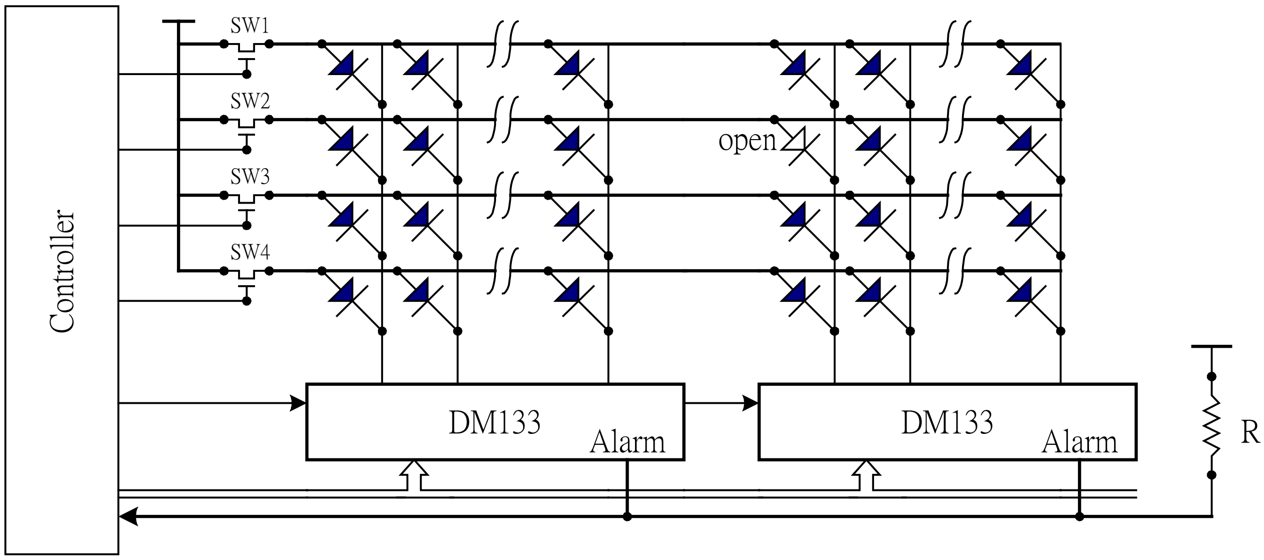
ENABLE	ALARM	OCCURANCE
Low→High	Low→High	LED Disconnection
	Low→Low	Thermal Alarm

LED Number	1	2	3	4
LED Status	Good	Not-Good	Good	Not-Good
OUTn	On	On	On	On
Detection Result	Good	Not-Good	Good	Not-Good
ALARM	Low (case 2, 4)			
LED Number	1	2	3	4
LED Status	Good	Not-Good	Good	Not-Good
OUTn	On	On	Off	Off
Detection Result	Good	Not-Good	Good	Good
ALARM	Low (case 2)			
LED Number	1	2	3	4
LED Status	Good	Not-Good	Good	Not-Good
OUTn	Off	Off	Off	Off
Detection Result	Good	Good	Good	Good
ALARM	High			

Table 1. ALARM pin Output Example

The open-drain ALARM pin will go low when the current output pins are turned on and below 0.3V. Hence, to prevent the ALARM from going low when LED is in the normal condition, the supply voltage for LED should be set so that the driver output voltage goes above 0.4V. Note that it takes 0.2us for the detection function to work (R_{alarm}=500Ω).

There's a simple procedure to implement the sequence of open detection for a specified LED module.



Example:

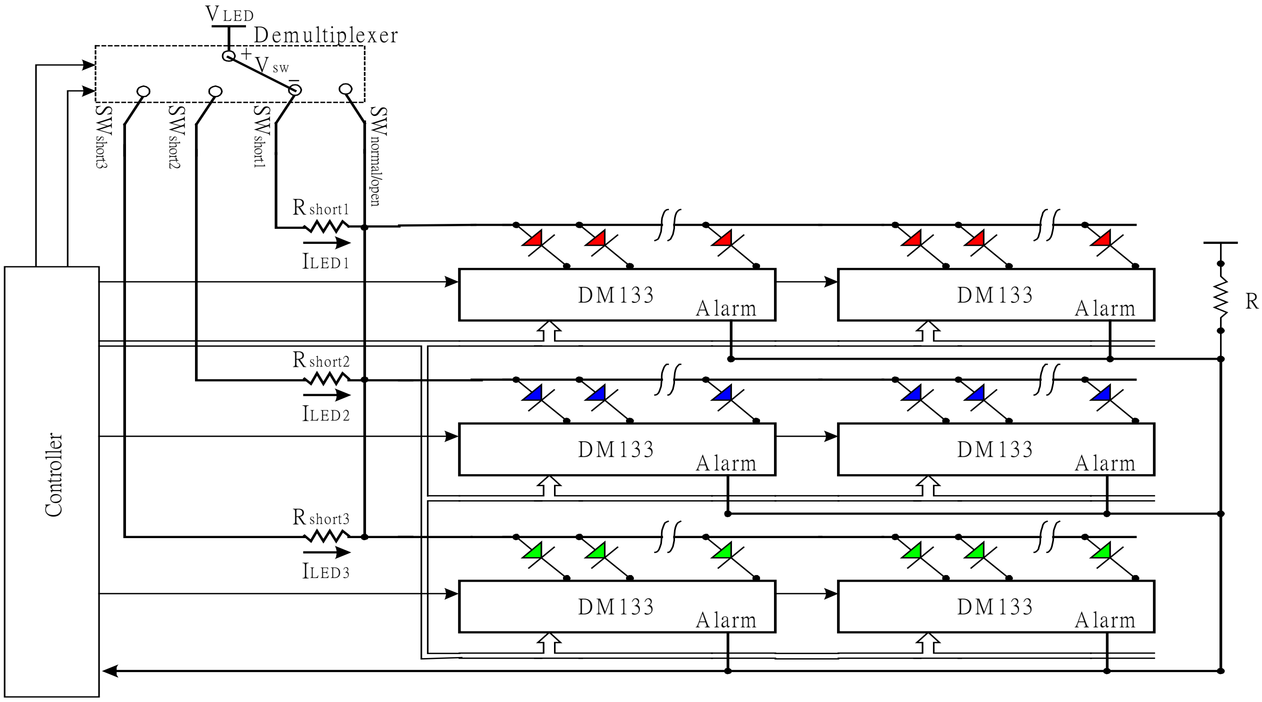
Take the 4x32 LED module as an example. Once the controller received the alarm signal, then

1. Set $\overline{\text{ENABLE}}$=H, check that the V_{alarm} remains 'H' or 'L' to see if any IC is in thermal alarm mode.
2. Set DATASEL=H and Shift 32 clocks of '1' into the ICs to turn on all 32 outputs, then set $\overline{\text{LATCH}}$=H ,$\overline{\text{ENABLE}}$=L.
3. Turn on the SW1 and watch the alarm line to see whether its voltage level is from 'H' to 'L' or not. Scan all the lines to identify which row has problem.
4. Once any row has problem.
5. Shift 32 clocks of '0' into the ICs to turn off all 32 outputs.
6. Shift an '1' and follow the other 31 '0's to the LED module clock-by-clock, then the controller can watch the alarm line to see whether its voltage level is from 'H' to 'L' or not. Then the opened LED will be identified.
7. Switch to the next problem row and repeat the step 6.

Follow the above steps, we recognize which LED fails as the controller receives an '0' at 17th clock on the second scan line. Then we can identify the opened LED on the LED module.

The procedure described above is easy for implementation, the control system doesn't need an extra memory to handle the patterns comparison or to switch modes back and forth.

LED Short Detection



Example:

Consider the following conditions: LED's (R, G, B) Vf variations are between 1.7V to 4.0V (R:1.7~2.4V, G/B: 3.0~4.0V), V_{LED}=5V, I_{LED} =20mA (R), 15mA (G) and 10mA (B).

In order to detect the short LED, we need to add four components in the LED drive system: a demultiplexer ($SW_{normal/open}$, SW_{short}) and three R_{short}s. And assume the Vsw is 0.1V in all current condition. The algorithm for detecting the short LED is based on the forward voltage of the LED in different conditions (normal/short/open circuit).

First, we need to decide the value of R_{short}. Two inequalities are follows:

$V_{LED} - V_{SW} - I_{LED} \times R_{short} - V_f < 0.3V$ (LED is OK or Open) **(1)**

$V_{LED} - V_{SW} - I_{LED} \times R_{short} > 0.4V$ (LED is Short) **(2)**

Let's take the B LED as an example. From **(1)**, $R_{short} > 160\Omega$ (Vf=3.0V) and $R_{short} > 60\Omega$ (Vf=4.0V). Then we choose $R_{short} > 160\Omega$. From **(2)**, we can calculate the $R_{short} < 450\Omega$. Finally, we take a proper R_{short} = (160+450)/2 = 305Ω. Follow the same steps, we can get 203Ω for G LED. Note: as I_{LED} is larger than 15mA (ex. I_{LED} =20mA (R)), we still put the 15mA in the above two equations. Then we'll get the 247Ω for R LED.

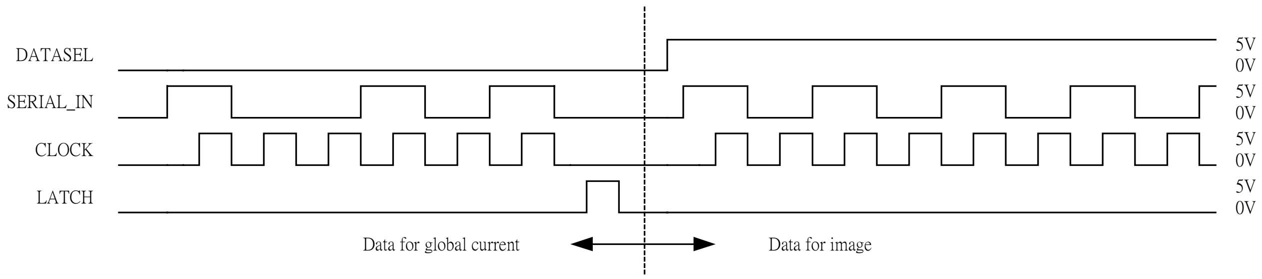
Turn on the SW_{short} switches one after one. Then follow the LED open detection procedure; turn on only one LED in the scan process. The V_{alarm} will be "L" as LED is normal or open. Once the LED is short, The V_{alarm} will be changed to "H".

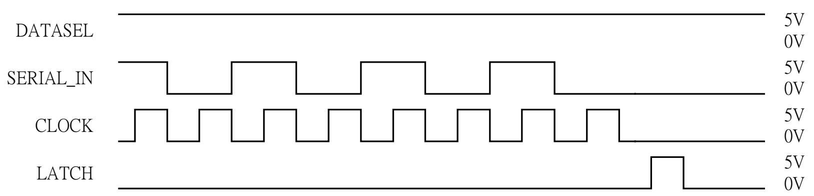
6)Data Transfer Timing Chart

We assume that the chip's output current level will be programmed first in order to set the whole panel global brightness or to set the white balance after power-on sequence and then the image data will follow.

For example, in the following graph, the data for global current is set to '100101', and the image data is set to '1010101010101010'. At first, we should set the DATASEL low and then send the current data to SERIAL_IN pin. After 6 clock pulses pass, the data will be latched by sending a high latch pulse. Then tune the DATASEL to high and send the image data. The data will be transfered into the shift register after 16 clock pulses and latched.

If the global current level will still stay the same, then the user only need to shift the current data once. The data latched will be kept until the next new data shifts in.

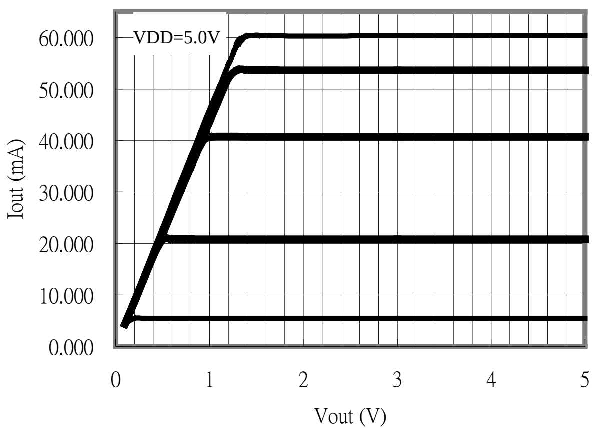


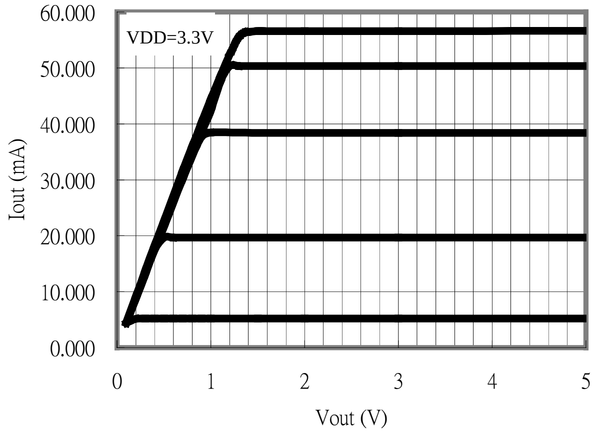


7)Thermal Pad

The IC's thermal pad which is internally connected to the bottom side of chip should be connected to GND. And, good PCB layout pattern conducted to thermal pad will have better heat dissipation.

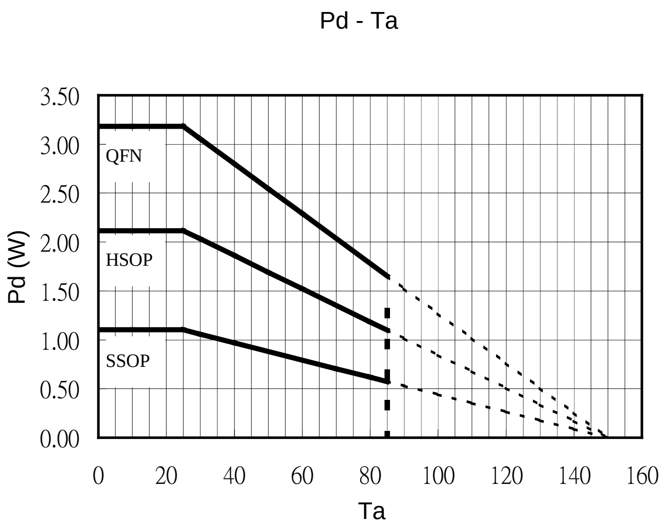
8)Output Current Performance vs. Output Voltage





In order to obtain a good constant current output, a suitable output voltage is necessary. Users can get related information about the minimum output voltage from the above graph.

9)Power Dissipation



Note

As the power dissipation of a semiconductor chip is limited by its package and ambient temperature, this device requires a maximum output current given by an operating condition. The maximum allowable power consumption (Pd (max)) of this device is calculated as follows:

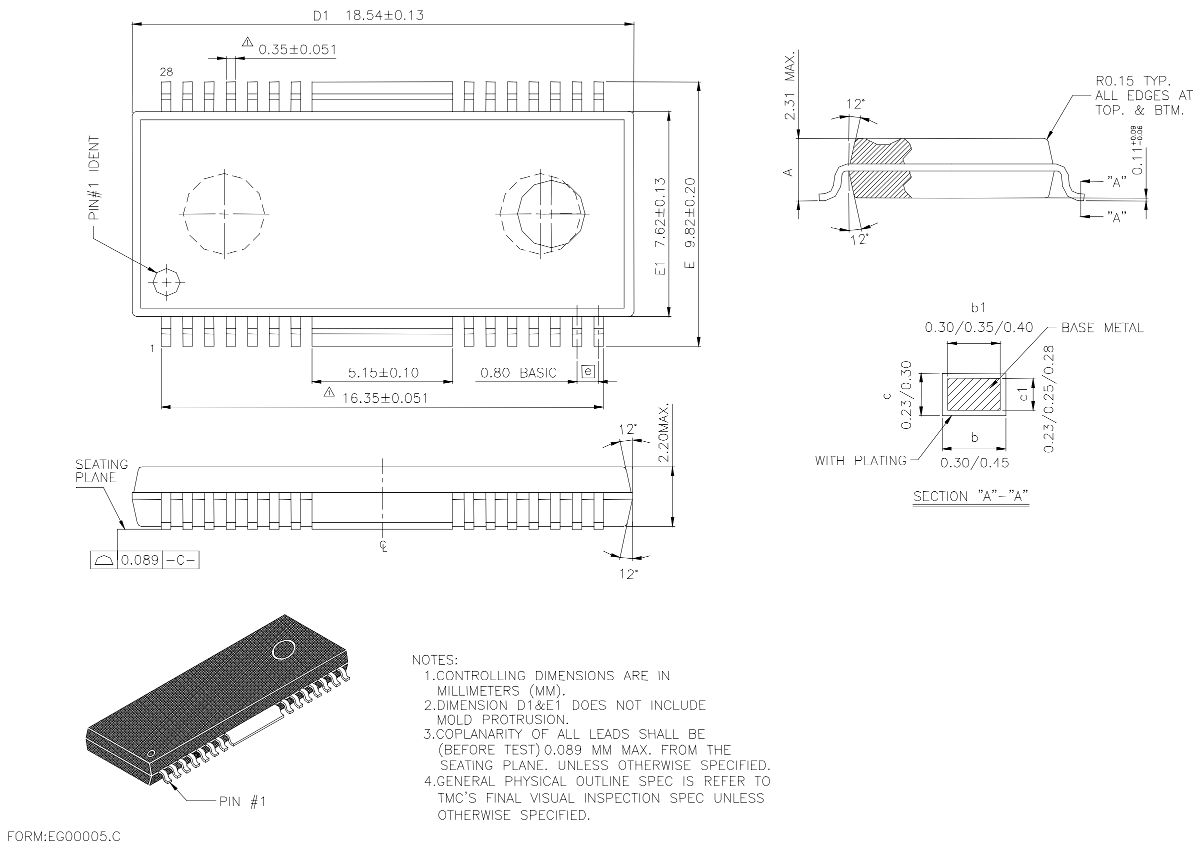
$$Pd(\max)(Watt) = \frac{(\text{Tj (junction temperature) (max) - Ta (ambient temperature) })(°C)}{\text{Rth } (°C / Watt)}$$

Based on the Pd (max), the maximum allowable current can be calculated as follows:

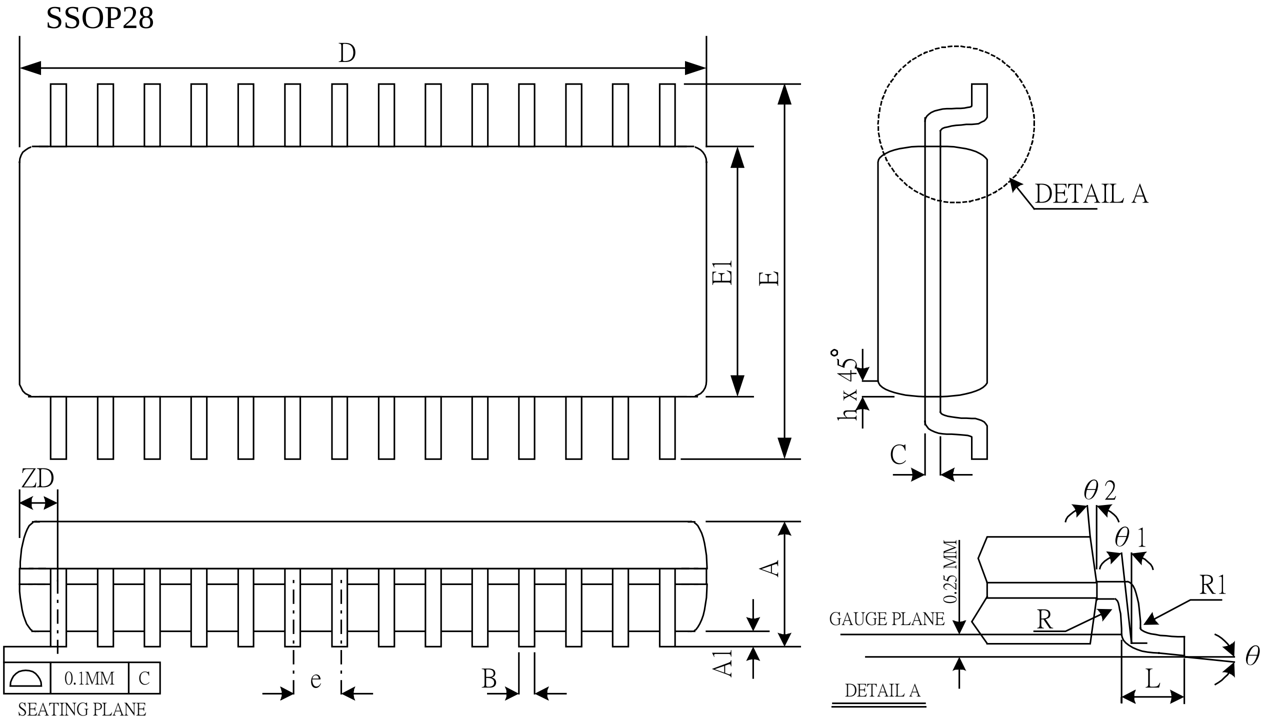
$$\text{Iout} = (\text{ Pd} - V_{DD} \cdot I_{DD}) / (\text{ \# outputs} \cdot \text{Vo} \cdot \text{Duty })$$

Package Outline

HSOP28



Package Outline

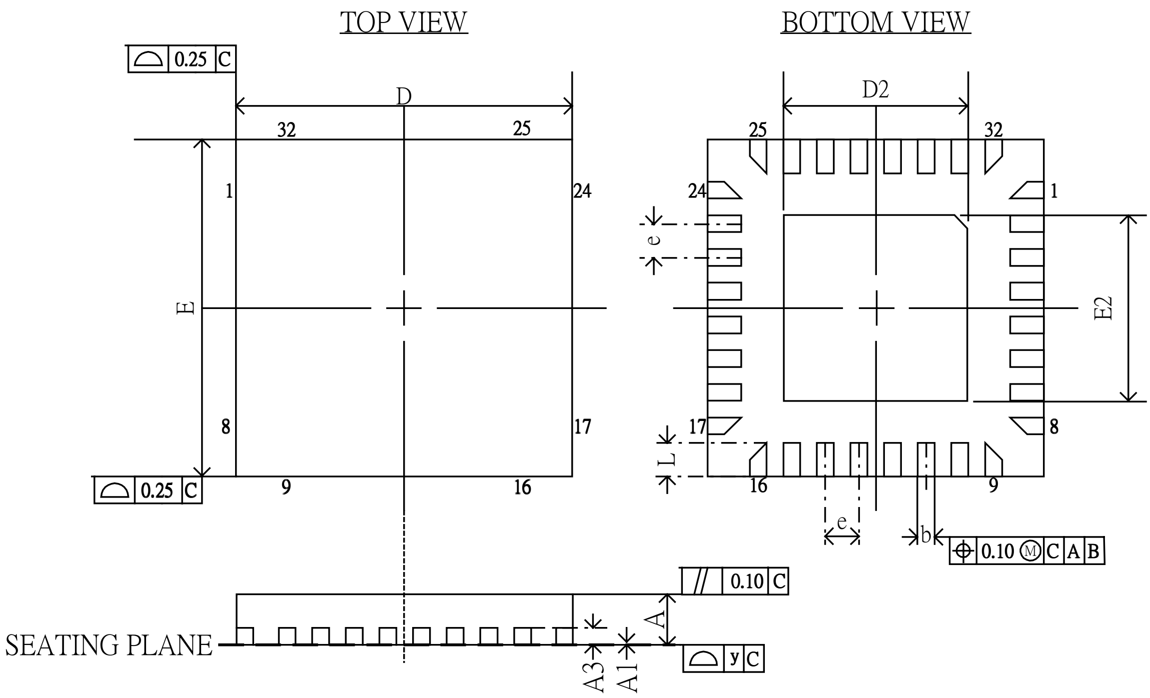


NOTES: DIMENSION D DOES NOT INCLUDE MODE PROTRUSIONS OR GATE BURRS.
MOLD PROTRUSIONS AND GATE BURRS SHALL NOT EXCEED 0.006 INCH PER SIDE

SYMBOL	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	1.35	1.63	1.75	0.053	0.064	0.069
A1	0.1	0.15	0.25	0.004	0.006	0.01
A2			1.5			0.059
B	0.2		0.3	0.008		0.012
C	0.18		0.25	0.007		0.01
e	0.635 BASIC			0.025 BASIC		
D	9.80	9.91	10.01	0.386	0.39	0.394
E	5.79	5.99	6.20	0.228	0.236	0.244
E1	3.81	3.91	3.99	0.150	0.154	0.157
L	0.41	0.635	1.27	0.016	0.025	0.05
h	0.25		0.5	0.01		0.02
ZD	0.838 REF			0.033 REF		
R1	0.2		0.33	0.008		0.013
R	0.2			0.008		
θ	0		8	0		8
$\theta 1$	0			0		
$\theta 2$	5	10	15	5	10	15
JEDEC	MO - 137 (AF)					

Package Outline

QFN32



SYMBOL	DIMENSION (mm)			DIMENSION (MIL)		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	27.6	29.5	31.5
A1	0	0.02	0.05	0	0.79	1.97
A3	0.25 REF			9.84 REF		
b	0.18	0.23	0.30	7.09	9.06	11.81
D	5.00 BSC			196.85 BSC		
D2	1.25	2.70	3.25	49.21	106.30	127.95
E	5.00 BSC			196.85 BSC		
E2	1.25	2.70	3.25	49.21	106.30	127.95
e	0.50 BSC			19.69 BSC		
L	0.30	0.40	0.50	11.81	15.75	19.69
y	0.10			3.94		

Note: 1.DIMENSIONING AND TOLERANCING CONFORM TO ASME Y145.5M-1994.

2. REFER TO JEDEC STD. MO-220 WHHD-2 ISSUE A

The products listed herein are designed for ordinary electronic applications, such as electrical appliances, audio-visual equipment, communications devices and so on. Hence, it is advisable that the devices should not be used in medical instruments, surgical implants, aerospace machinery, nuclear power control systems, disaster/crime-prevention equipment and the like. Misusing those products may directly or indirectly endanger human life, or cause injury and property loss.
Silicon Touch Technology, Inc. will not take any responsibilities regarding the misusage of the products mentioned above. Anyone who purchases any products described herein with the above-mentioned intention or with such misused applications should accept full responsibility and indemnify. Silicon Touch Technology, Inc. and its distributors and all their officers and employees shall defend jointly and severally against any and all claims and litigation and all damages, cost and expenses associated with such intention and manipulation.