Version : *SE13C_ENG_V11*
Issue Date : *2008/05/08*
File Name : *SE13C_ENG.pdf*
Total Pages : *20*

16-bit Constant Current LED Driver with Error Detection

SE13C

16-bit Constant Current LED Driver with Error Detection

General Description

SE13C is a constant-current sink driver specifically designed for LED display applications. The device incorporates shift registers, data latches, and constant current circuitry on the silicon CMOS chip. The maximum output current value of all 16 channels is adjustable by a single external resistor. Its built-in open/short detection circuits help users detect LED failures. System retrieve the error messages to indicate which channel has failure by serial output data. The thermal shutdown function provides the over temperature protection.

Features

- ✧ Constant-current outputs: 20mA to 90mA adjustable by one external resistor
- ✧ Maximum output voltage: 17V
- ✧ Maximum clock frequency: 25MHz
- ✧ Built-in real-time LED open/short detection
- ✧ Fast detecting response: 0.1us (min.)
- ✧ Over temperature protection: thermal shutdown (junction temperature > 180°C)
- ✧ Package and pin assignment compatible to conventional LED drivers (STP16CP05 ST2221C, DM134B, MBI5026)
- ✧ Power supply voltage: 4.5V to 5.5V

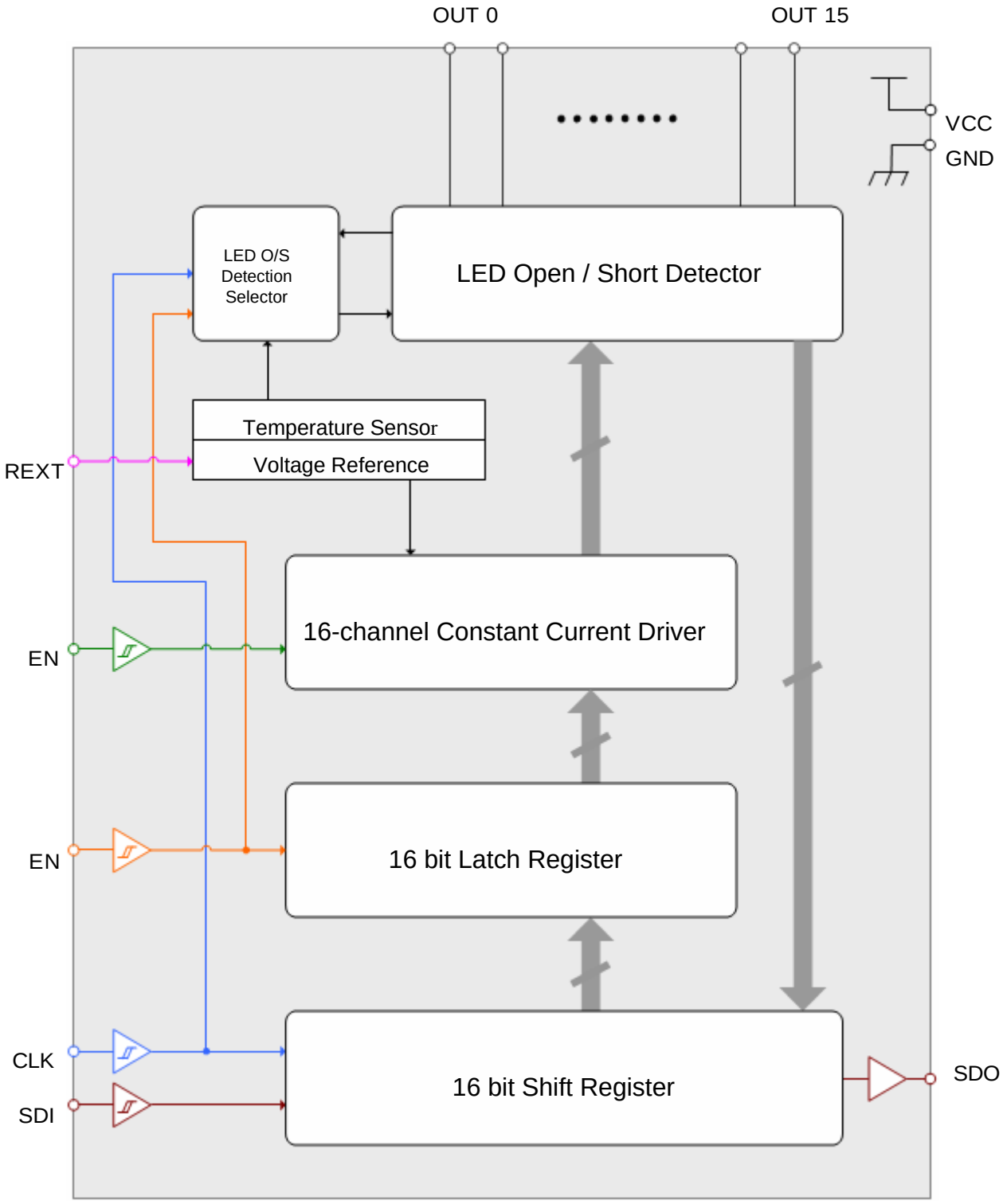
Applications

- ✧ Indoor/Outdoor LED Video Display
- ✧ LED Variable Message Signs (VMS) System

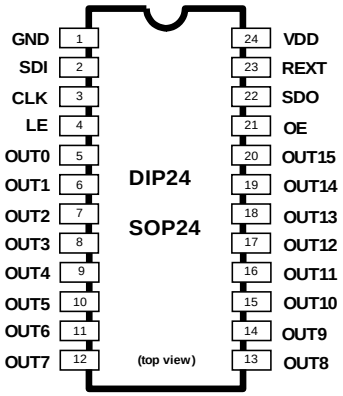
Package Types

DIP24、SDIP24、SOP24

Block Diagram



Pin Connection

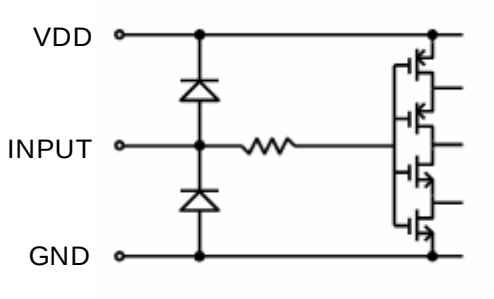


Pin Description

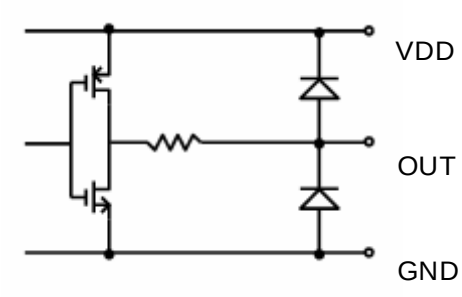
PIN No.	PIN NAME	FUCTION
1	GND	Ground terminal.
2	SDI	serial data input terminal.
3	CLK	Synchronous clock input terminal for serial data transfer. Data is sampled at the rising edge of CLK.
4	LE	Input terminal of data strobe. Data on shift register goes through at the rising edge of LE(edge trigger). Otherwise, data is latched.
5~20	OUT0~15	Sink constant-current outputs (open-drain).
21	OE	Output enable terminal: **'H'** for all outputs are turned off **'L'** for all outputs are active.
22	SDO	Serial data output terminal.
23	REXT	External resistors connected between REXT and GND for output current value setting.
24	VDD	Supply voltage terminal.

Equivalent Circuit of Inputs and Outputs

1. CLK、SDI、LE、OE terminals



2. SDO terminal



Maximum Ratings (Ta=25°C, Tj(max) = 120°C)

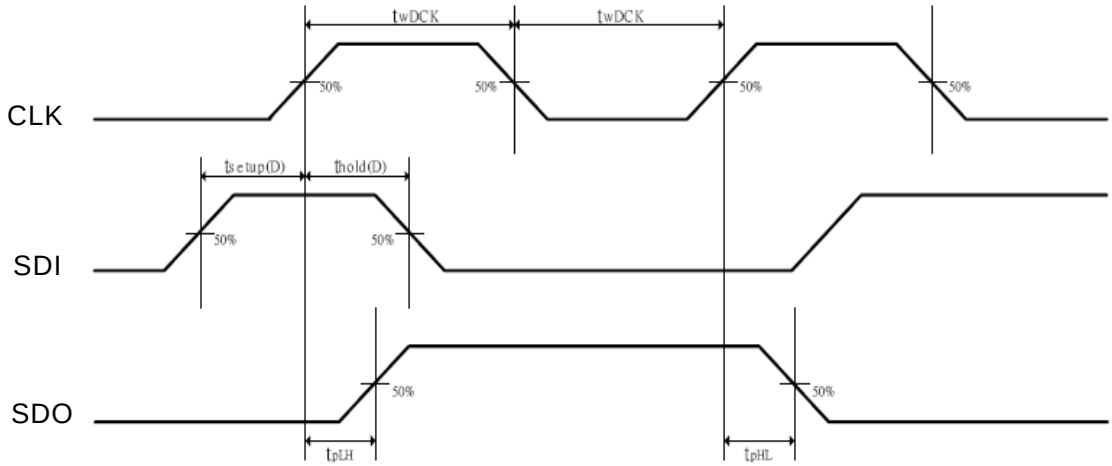
CHARACTERISTIC	SYMBOL	RATING	UNIT
Supply Voltage	VDD	-0.3 ~ 7.0	V
Input Voltage	VIN	-0.3 ~ VCC+0.3	V
Output Current	IOUT	100	mA
Output Voltage	VOUT	-0.3 ~ 17	V
Input Clock Frequency	FDCK	25	MHz
GND Terminal Current	IGND	1600	mA
Power Dissipation(4 layer PCB)	PD	1.9(DIP24 : Ta=25°C)	W
		1.2 (SOP24 : Ta=25°C)	
Thermal Resistance	Rth(j-a)	50.0 (PDIP24)	°C/W
		79.2 (SOP24)	
Operating Temperature	Top	-40 ~ 85	°C
Storage Temperature	Tstg	-55 ~ 150	°C

Recommended Operating Condition

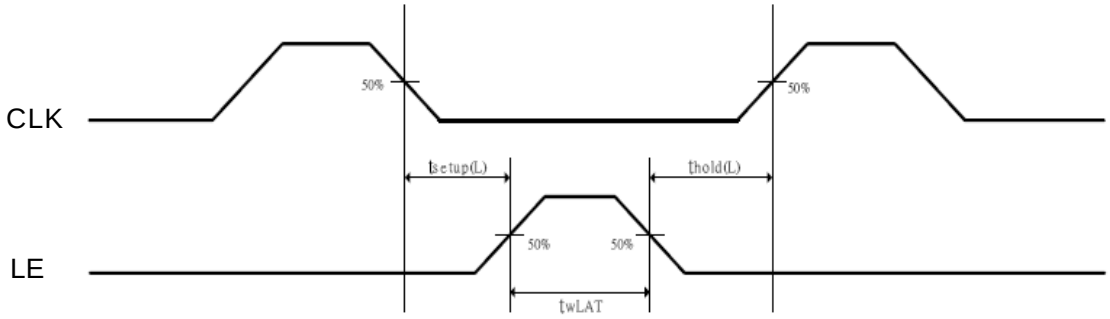
CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Supply Voltage	VDD	—	4.5	5.0	5.5	V
Output Voltage	VOUT	Driver On*1	1.0	—	0.5VCC	V
Output Voltage	VOUT	Driver Off*2	—	—	17	
Output Current	IO	OUTn	20	—	90	mA
	IOH	VOH = VCC - 0.2V	—	—	+1.2	
	IOL	VOL = 0.2V	—	—	-1.4	
Input Voltage	VIH	VCC = 4.5V ~ 5.5V	0.8VCC	—	VCC	V
	VIL		0	—	0.2VCC	V
Input Clock Frequency	FDCK	Single Chip Operation	—	—	25	MHz
LAT Pulse Width	tw LE	VCC = 5.0V	TBD	—	—	ns
DCK Pulse Width	tw CLK		TBD	—	—	
Set-up Time for DAI	tw OE		TBD	—	—	
Hold Time for DAI	tsetup(D)		TBD	—	—	
Set-up Time for LAT	thold(D)		TBD	—	—	
Hold Time for LAT	tsetup(L)		TBD	—	—	
Set-up Time for Open/Short	thold(L)		TBD	—	—	
Open/Short Detection Response	tsetup(OS)		TBD	—	—	
Input Clock Frequency	tdet		TBD	—	—	

Timing Diagram

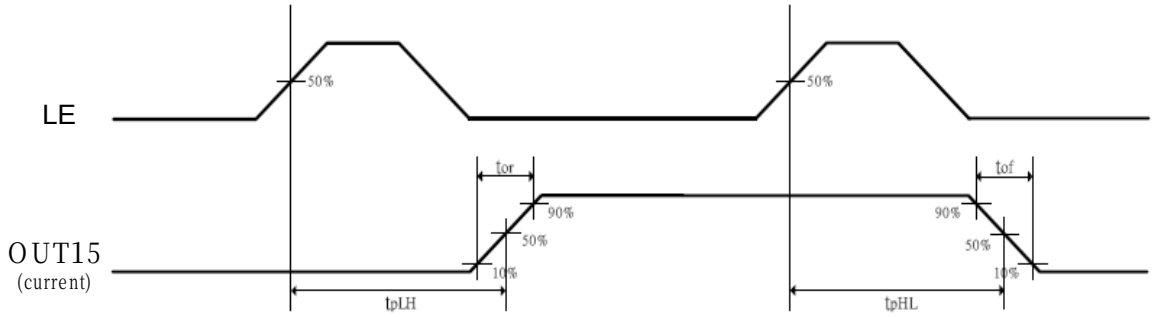
1. CLK-SDI, SDO



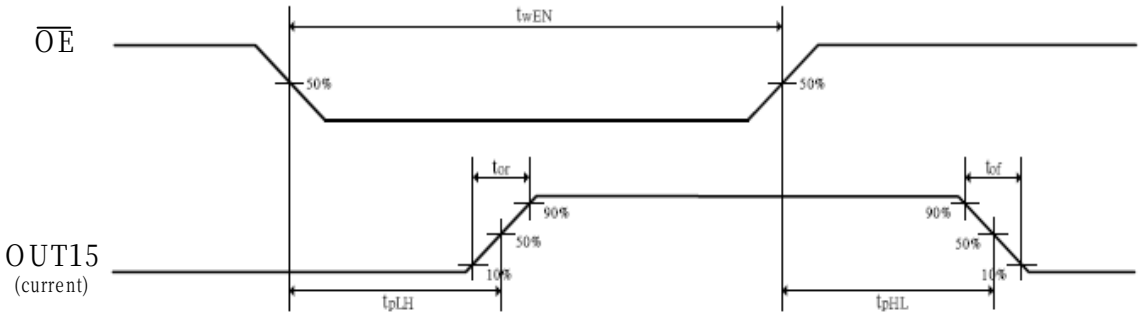
2. CLK-LE



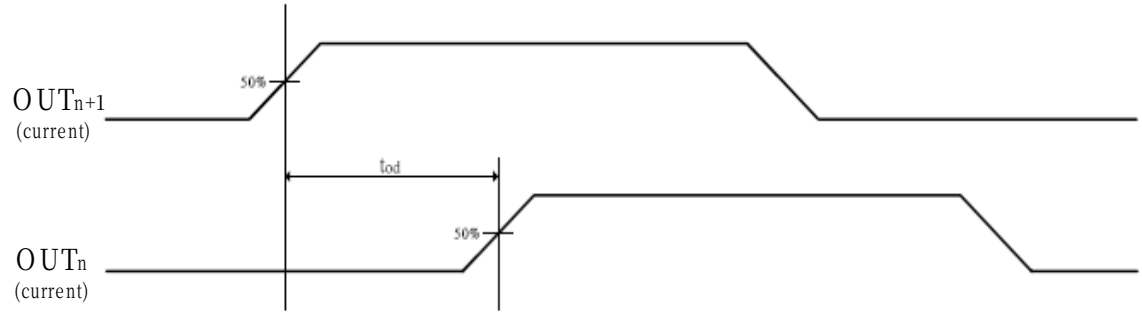
3. LE-OUT15



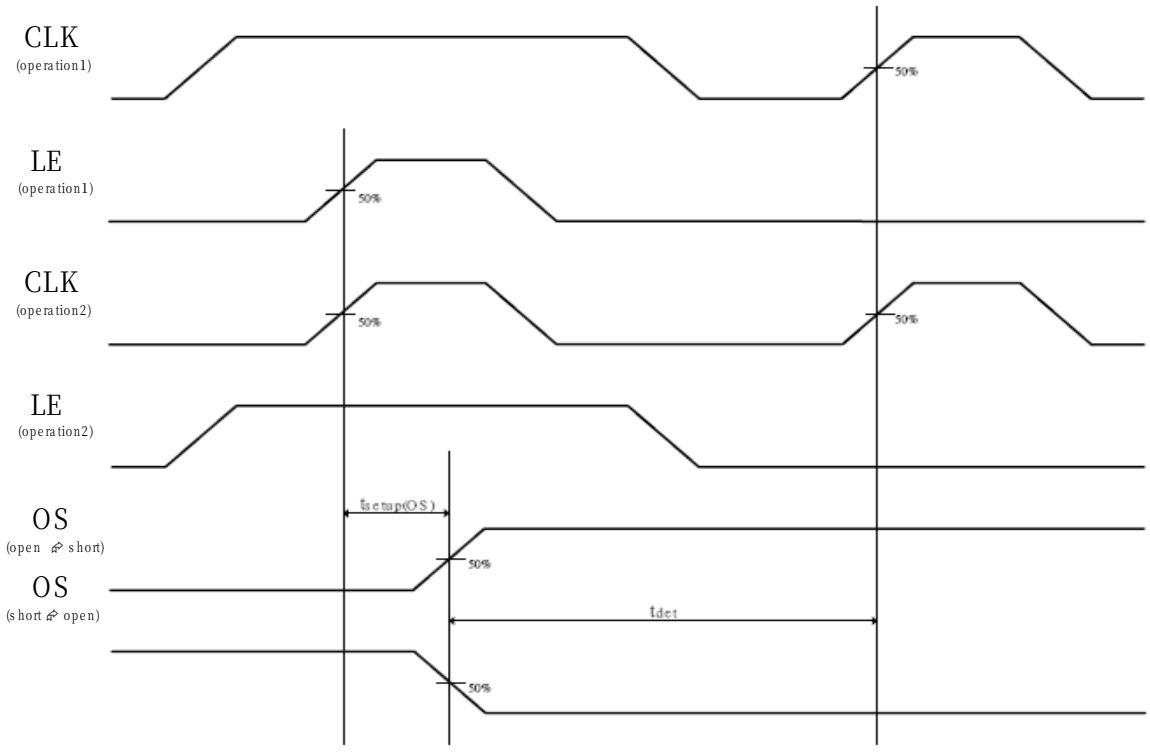
4. $\overline{OE}$-OUT15



5. OUT_{n+1}-OUT_n



6. OS-LE, CLK (OE='L')



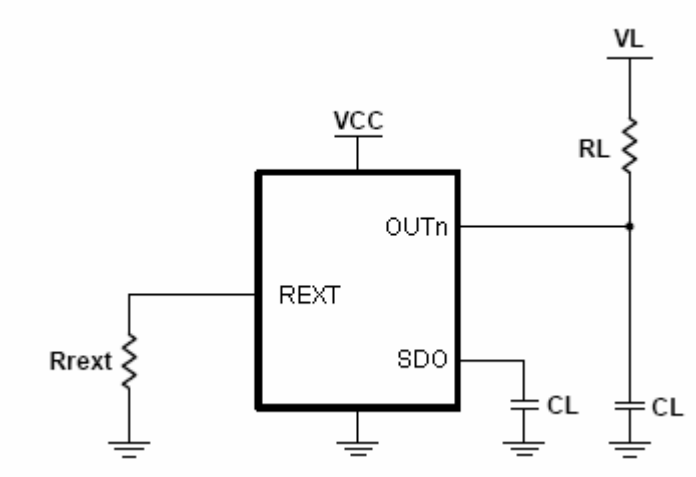
Electrical Characteristics (VCC = 5.0 V, Ta = 25°C unless otherwise noted)

CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Input Voltage "H" Level	VIH	CMOS logic level	0.8VCC	—	VCC	V
Input Voltage "L" Level	VIL	CMOS logic level	GND	—	0.2VCC	
Output Leakage Current	IOL	VOH=17V	—	—	±1.0	uA
Output Voltage(S-OUT)	VOL	IOL=1.4mA	—	—	0.2	V
	VOH	IOL=1.2mA	VCC-0.2	—		
Output Current Skew (Channel-to-Channel)*1	IOL1	VOUT = 1.0V Rrext =250Ω	—	—	±4	%
Output Current Skew (Chip-to-Chip)*2	IOL2		—	—	±10	%
Output Voltage Regulation	% / VOUT	Rrext=250Ω VOUT= 1V~3V	—	±0.1	±0.5	% / V
Supply Voltage Regulation	% / VCC	Rrext=250Ω	—	±1	±4	
LED Open Detection Threshold	V(od)	all outputs turn on	—	0.3	—	V
LED Short Detection Threshold	V(sd)		—	0.5VCC	—	
Thermal Shutdown Threshold	T(sht)	junction temperature	—	180	—	°C
Supply Current*3	IDD(off)	power on all pins are open unless VCC and GND	—	3.0	—	mA
	IDD(off)	input signal is static Rrext = 250Ω all outputs turn off	—	4.9	—	
	IDD(on)	input signal is static Rrext = 250Ω all outputs turn on	—	6.4	—	
	IDD(on)	input signal is static Rrext = 125Ω all outputs turn off	—	12.7	—	
	IDD(on)	input signal is static Rrext = 125Ω all outputs turn on	—	15.4	—	

*1 Channel-to-channel skew is defined as the ratio between (any Iout – average Iout) and average Iout, where average Iout = (Imax + Imin) / 2.
*2 Chip-to-Chip skew is defined as the range into which any output current of any IC falls.
*3 IO excluded.

Switching Characteristics (VCC = 5.0V, Ta = 25°C unless otherwise noted)

CHARACTERISTIC		SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Propagation Delay ('L' to 'H')	OE-to-OUT15	tpLH	VIH = VCC VIL = GND Rrext = 2.2KΩ VL = 5.0V RL = 180Ω CL*1= 13pF	—	64	—	ns
	LE-to-OUT15			—	57	—	
	CLK-to-SDO			—	25	—	
Propagation Delay ('H' to 'L')	OE-to-OUT15	tpHL		—	17.5	—	
	LE-to-OUT15			—	25	—	
	CLK-to-SDO			—	20	—	
Output Current Rise Time		tor		—	50	—	
Output Current Fall Time		tof		—	15	—	
Output Delay Time($OUT_{(n)}$-to$OUT_{(n+1)}$)		tod		—	2.2	—	



Switching Characteristics Test Circuit

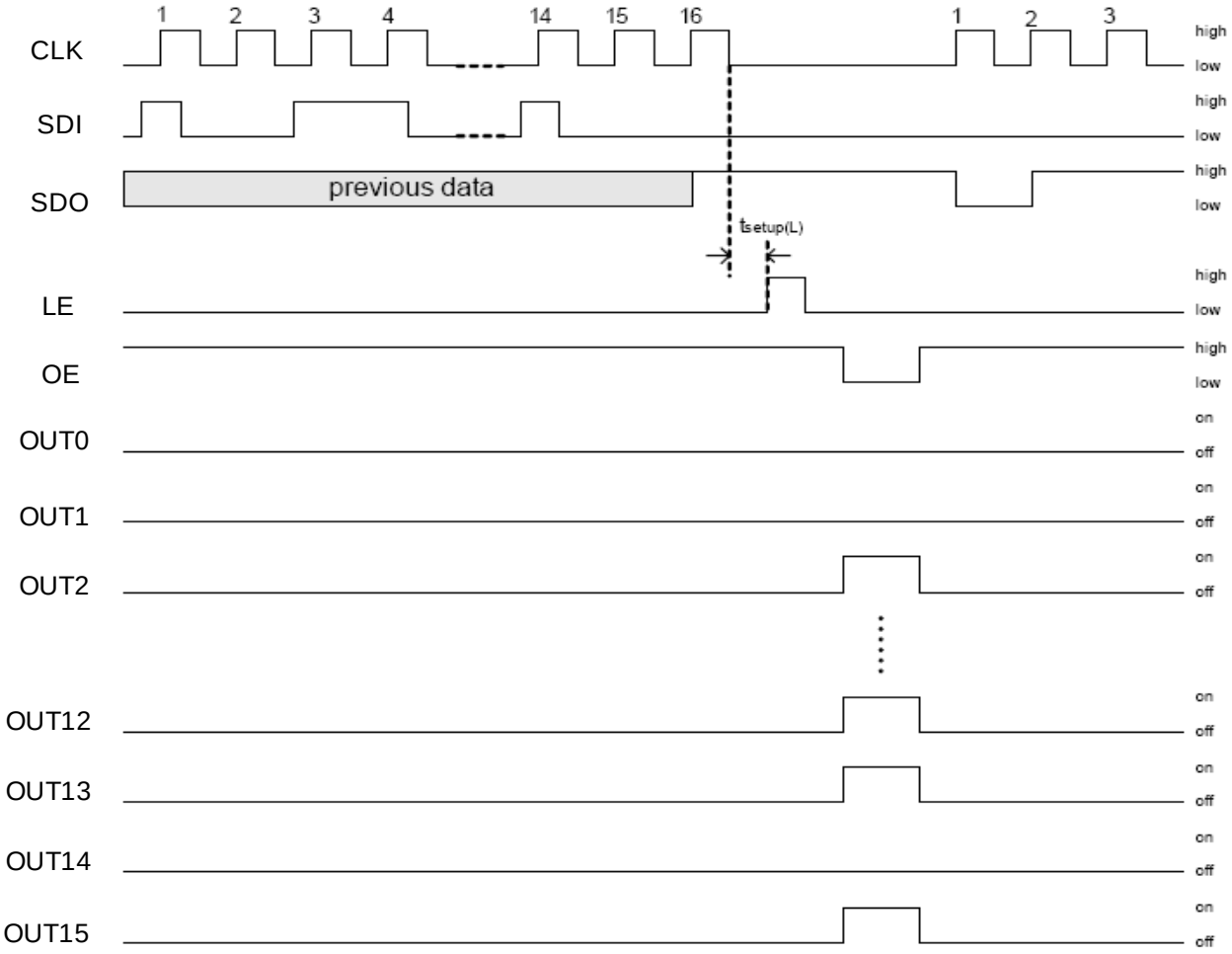
Constant-Current Output

Constant-current value of each output channel is set by an external resistor connected between the REXT ping and GND. Varying the resistor value can adjust the current scale ranging from 20mA to 90mA. The reference voltage of REXT terminal (Vrext) is approximately 1.2V. Both values of current and Rext are as tabled below：

Iout(mA)	90	80	70	60	50	40	30	20
Rext(Ω)	95	110	125	150	180	230	310	480

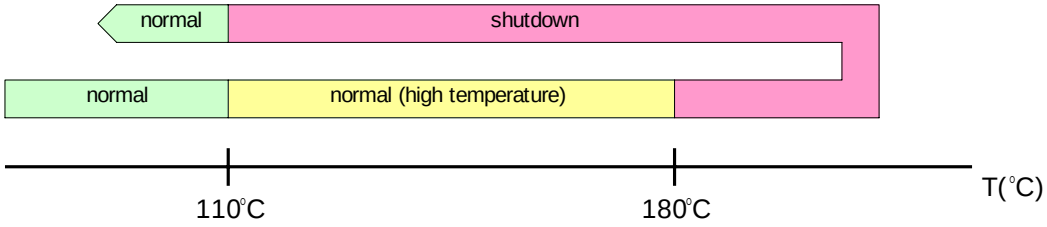
Serial Data Interface

The serial-in data (SDI) will be clocked into 16 bit shift register synchronized on the rising edge of the clock (CLK). The data '1' represents the corresponding current output 'ON', while the data '0' stands for 'OFF'. The data will be transferred into the 16 bit latch synchronized on the rising edge (edge trigger) of the strobe signal (LE); otherwise, the data will be held. The latch pulse should be sent after the falling edge of the last clock within a frame data. The trigger timing ofthe serial-out data (SDO) will be shifted out on synchronization to the rising edge of the clock. All outputs are turned off while enable terminal (OE) is kept at high level. And they are active when OE shifts to low.



Thermal Shutdown

During operation, when the junction temperature of the IC will reach approximately above 180℃, it will cause the driver to shutdown all the outputs. Basically, the IC will cool down and return to the safe operating temperature which is approximately bellow 110℃. SE13C will restart all the outputs at the same time. Operation in the thermal situation for a long time may cause chip damage permanently.



LED Open/Short Detection

The result of open/short detection of SE13C could be retrieved from serial-out (SDO) data. It will be identified as a LED open failure when the output is turned on but the output voltage is below 0.3V. And then it will be identified as a LED short failure when the output is turned on but the output voltage is above 1/2 VCC.

To set up with the following conditions: (1) the image data written in shift register corresponding to particular output channel is '1'; (2) the output enable terminal is activated (OE='L'); (3) the rising edge of the latch signal (LE), SE13C will execute LED open/short detection then renews the results within the corresponding shift register.

By using the error message retrieved from serial-out data, system can recognize the status of every LED driven by each channel. For either LED open or short detection, the original image data is written to '1' bout '0' is retrieved then a LED failure has occurred. If the image data is written to '0' or the output enable terminal is inactive (OE='H'), it won't execute any detection process for corresponding channel. Therefore, system still retrieves the original image data.

Real-time monitor

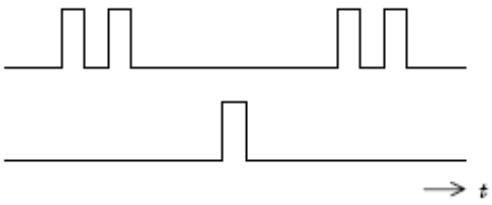
With the above operating principle, system could continuously retrieve LED status from serial-out then compare with the last frame data one by one. Once there is any discrepancy (**'1'→'0'**), we can locate which channel is abnormal precisely. Since the process is ongoing and without shifting between image mode and detection mode, it does not interrupt the image data flow and the output display. The **'**real-time monitor**'** method is suitable for LED Variable Message Signs (VMS) system.

Clocks calculation

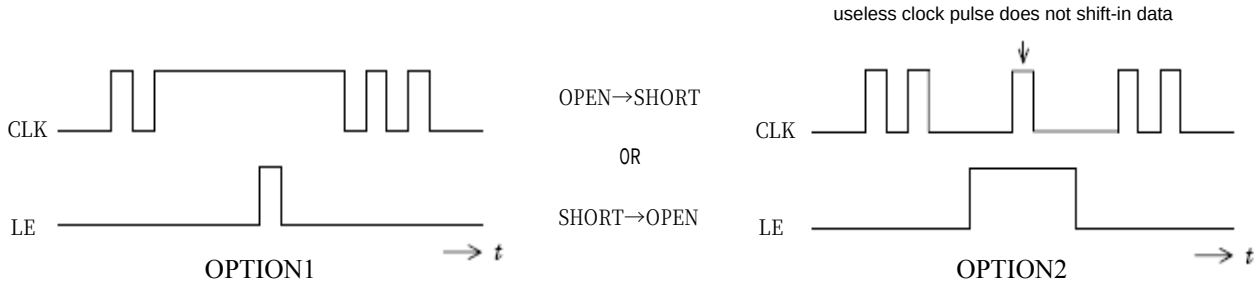
For large LED display applications, ‘real-time monitor’ could be a heavy loading for system because it needs to compare the retrieved information with a lot of frame data. Therefore, to write the image data of all channels to ‘1’, all failure status will be identified when there will be any ‘0’ retrieved. By calculating the numbers of clock pulses, the locations of abnormal channel could be pointed out easily. The “clocks calculation” method helps to minimize the loading and memory resources of system.

Selection of Open/Short Detection

The default detection type provided by DM13C is LED **open** detection after power-on. Users could switch LED open to short detection (or short to open detection) by following timing sequence. There are two alternative options could be selected. The option 1 shows triggering latch pulse when the last clock of the frame data kept at high level. The option 2 shows sending one useless clock pulse which will not shift-in data while the latch signal is kept at high level.

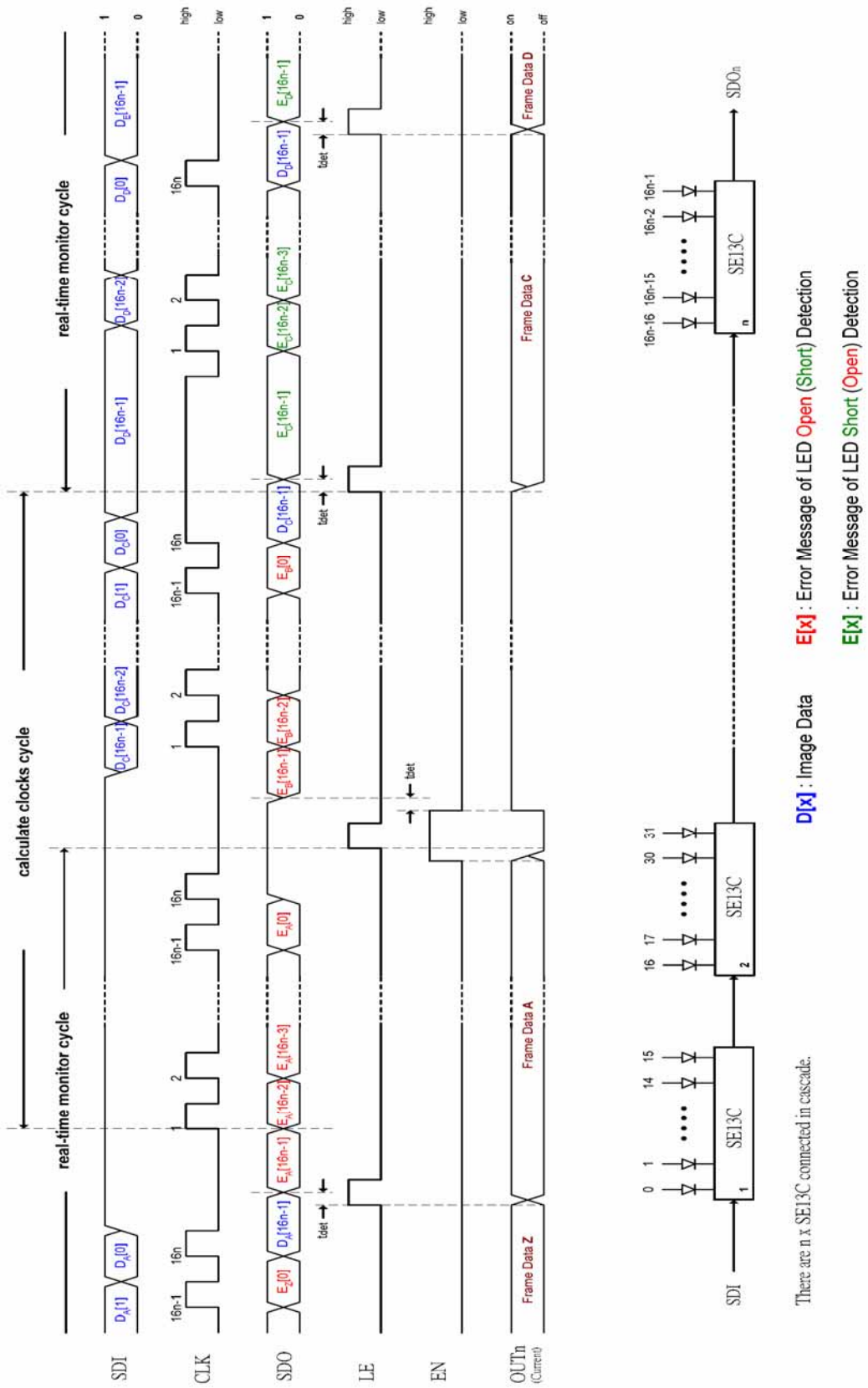


Normal Operation



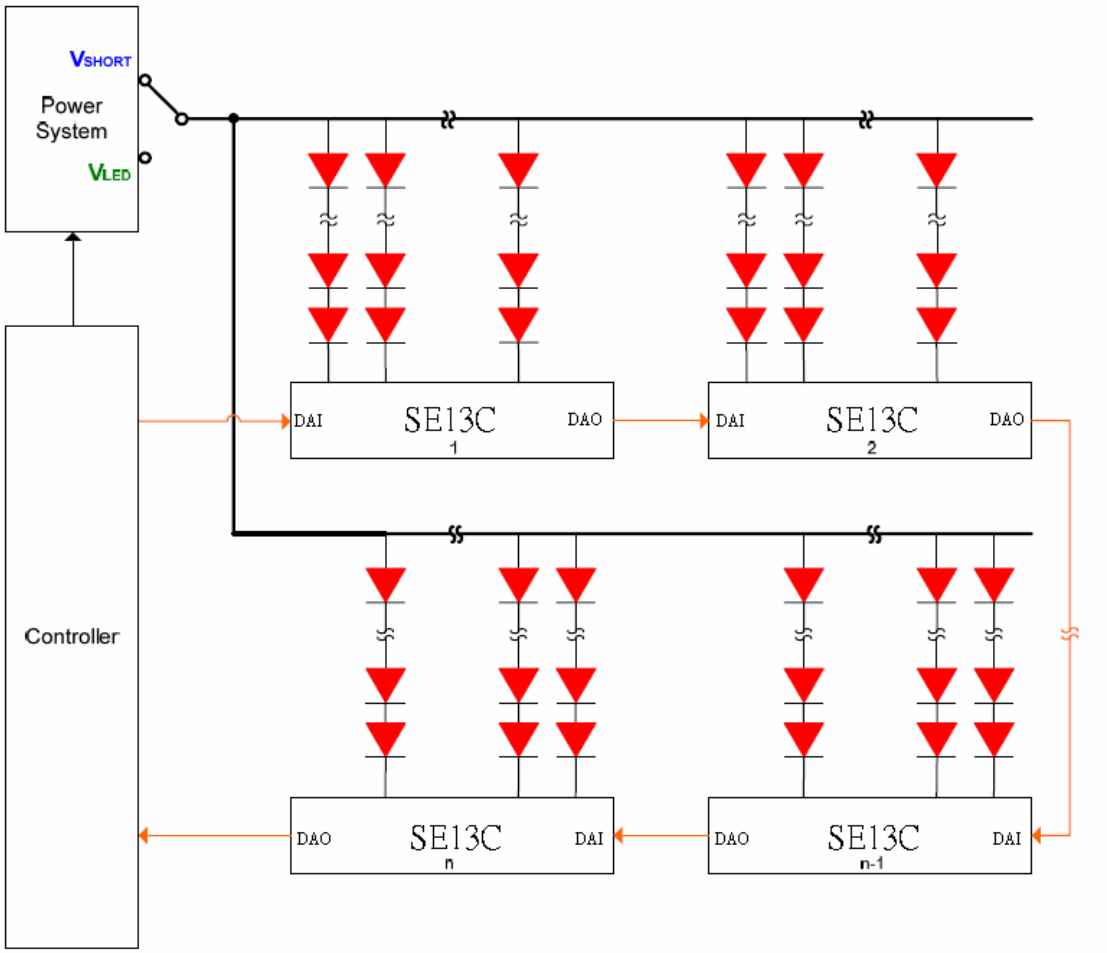
OPTION1 OPTION2

Timing Diagram of LED Open/Short Detection



Threshold of Short Detection

The default threshold voltage for LED short detection of SE13C is 1/2 VCC. One could change the default voltage by switching or setting a new voltage of V_{LED} during short detection is going on. Please see the example below for reference:



Example for shifting the threshold of LED short Detection

Note that the V_{SHORT} should be satisfied with the following inequality：

$$\frac{1}{2}VCC < V_{SHORT} < \frac{1}{2}VCC + V_{F(\text{LED forward voltage})} \times N_{(\text{Numbers of LED in a string})}$$

The new threshold voltage of short detection will be equivalent to：

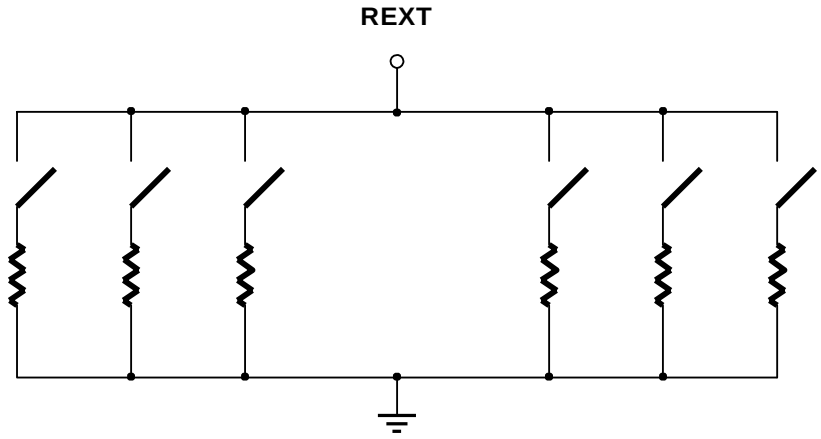
$$\frac{1}{2}VCC + (V_{LED} - V_{SHORT})$$

Outputs Delay

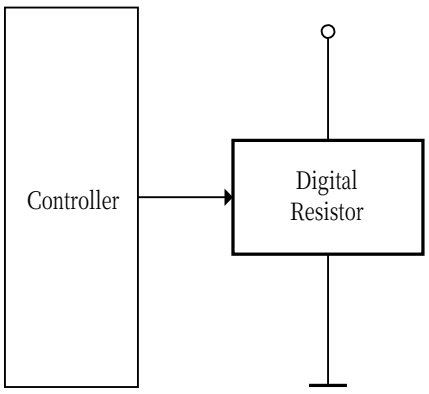
Large in-rush currents will occur when the system activates all the outputs at once. To reduce this effect, SE13C is designed to have a constant unit of delay (around 1.5ns) between outputs. The delay for every output goes like this: there is no delay for OUT15 and OUT7, 1 unit of delay for OUT14 and OUT6, 2 units of delay for OUT13 and OUT5 and so on.

Outputs Delay

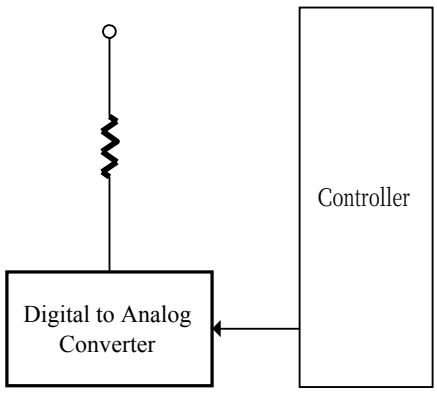
DM13C has no built-in global brightness control feature. In order to obtain a lower resolution of global brightness control effect, two methods could be utilized. One is providing PWM signal synchronized on latch pulse to modulate the output enable terminal (OE pin). The other is to adjust the Rrext value or voltage drop across the external resistor. Please see the reference circuit below:



Global Brightness Control with Resistor Ladder



Global Brightness Control
whit DigiTal Resistor



Global Brightness Control
whit D/A converter

Power Dissipation

The power dissipation of a semiconductor chip is limited to its package and ambient temperature, in which the device requires the maximum output current calculated for given operating conditions. The maximum allowable power consumption can be calculated by the following equation:

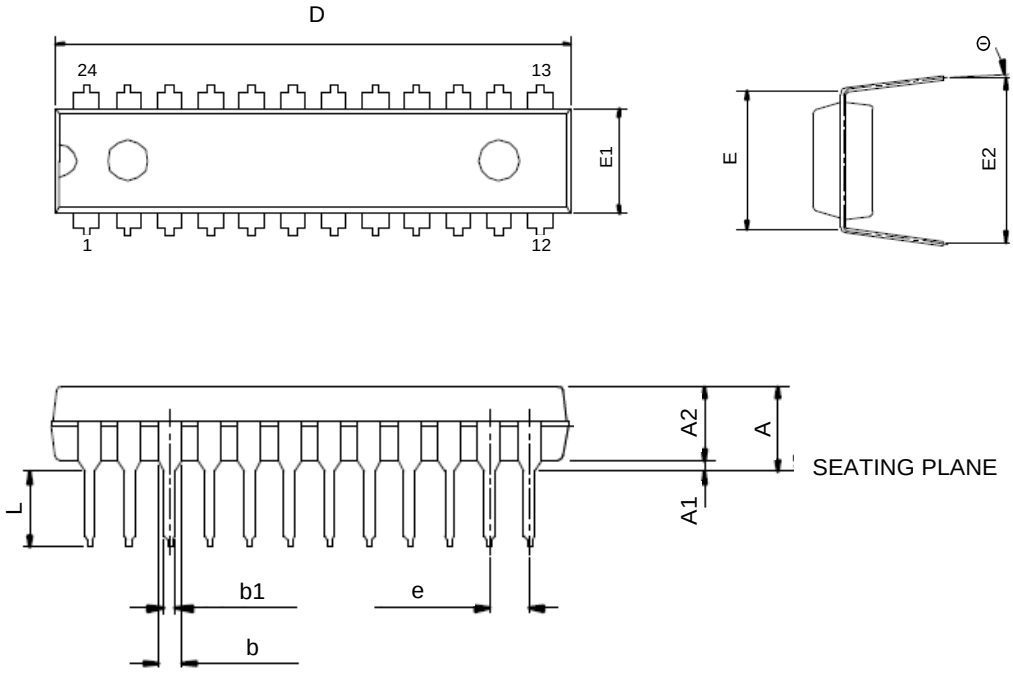
$$Pd(max)(Watt) = \frac{Tj(junction\ temperature)(max)(^{\circ}C) - Ta(ambient\ temperature)(^{\circ}C)}{Rth(junction\text{-}to\text{-}air\ thermal\ resistance)(^{\circ}C/Watt)}$$

The power consumption of IC can be determined by the following equation and should be less than the maximum allowable power dissipation:

$$Pd(W) = V_{CC}(V) \times I_{DD}(A) + Vout0 \times Iout0 \times Duty0 + \cdots\cdots + Vout15 \times Iout15 \times Pd(max)(W)$$

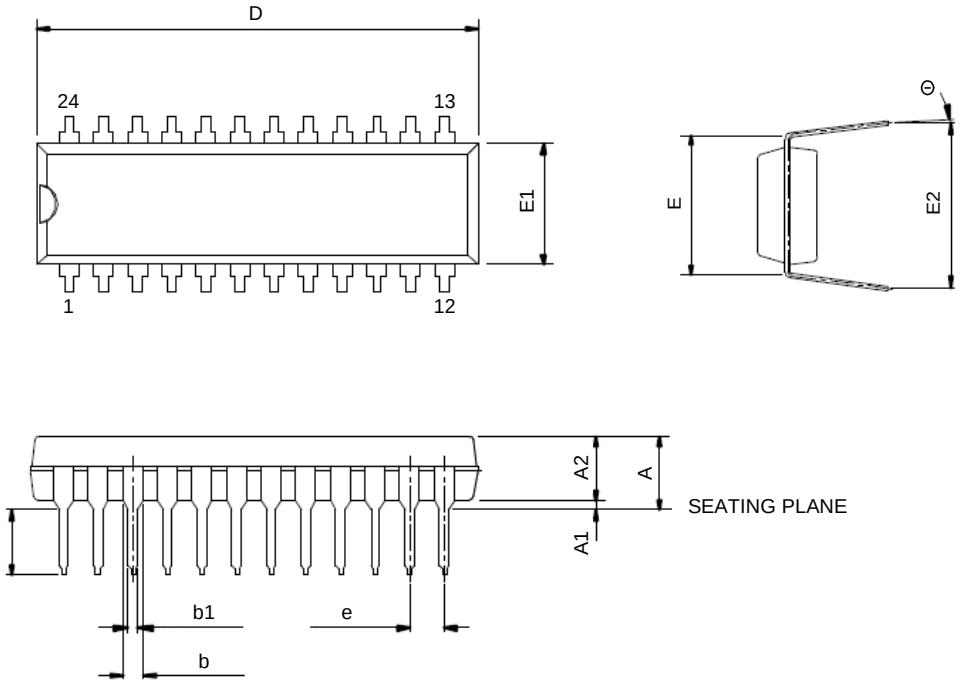
Package Outline Dimension

DIP24



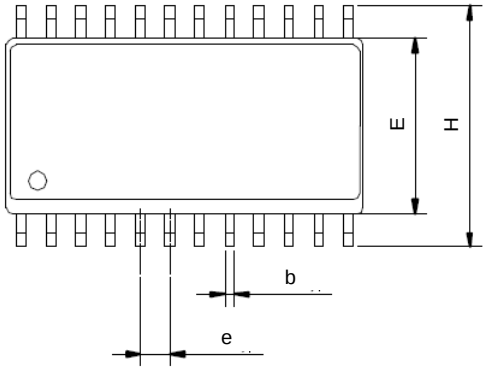
	DIMENSIONS IN INCH		DIMENSIONS IN MM	
SYMBOLS	MIN.	MAX.	MIN.	MIX.
A	—	0.210	—	5.334
A1	0.015	—	0.381	—
A2	0.125	0.135	3.175	3.429
b	0.060TYP.		1.524TYP.	
b1	0.018TYP.		0.457TYP.	
D	1.230	1.280	31.242	32.521
E	0.300TYP.		7.620TYP	
E1	0.253	0.263	6.426	6.680
E2	0.335	0.375	8.509	9.525
e	0.100TYP		2.540TYP	
L	0.115	0.150	2.921	3.810
θ	0°	15°	0°	15°

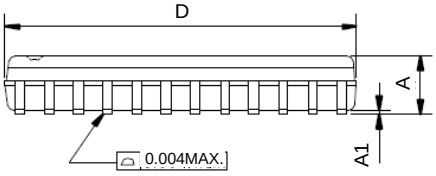
SDIP24

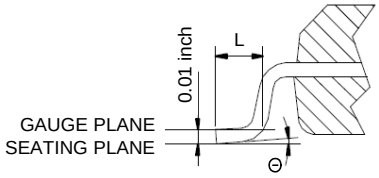


	DIMENSIONS IN INCH		DIMENSIONS IN MM	
SYMBOLS	MIN.	MAX.	MIN.	MIX.
A	—	0.210	—	5.334
A1	0.015	—	0.381	—
A2	0.125	0.135	3.175	3.429
b	0.040TYP.		1.016TYP.	
b1	0.018TYP.		0.457TYP.	
D	0.880	0.920	22.352	23.368
E	0.300TYP.		7.620TYP	
E1	0.245	0.255	6.223	6.477
E2	0.335	0.375	8.509	9.525
e	0.070TYP		1.778TYP	
L	0.115	0.150	2.921	3.810
θ	0°	15°	0°	15°

SOP24







	DIMENSIONS IN INCH		DIMENSIONS IN MM	
SYMBOLS	MIN.	MAX.	MIN.	MIX.
A	0.093	0.104	2.362	2.642
A1	0.004	0.012	0.102	0.305
b	0.016TYP.		0.406TYP.	
D	0.599	0.614	15.215	15.596
E	0.291	0.299	7.391	7.595
e	0.050TYP.		1.270TYP.	
H	0.394	0.419	10.008	10.643
L	0.016	0.050	0.406	1.270
θ	0°	8°	0°	8°

History

Date	Name	Version	Comment
2008/5/8	Jerry	1.0	Initial
2008/5/23	Rong	1.1	Modify Table of Electrical Characteristics