DM11C

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8-bit Constant Current LED Driver

with Error Detection

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DM11C

8-bit Constant Current LED Driver with Error Detection

General Description

DM11C 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 8 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: 5mA to 120mA 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 (ST2221A, DM114/5)
- Power supply voltage: 3.3V to 5.5V

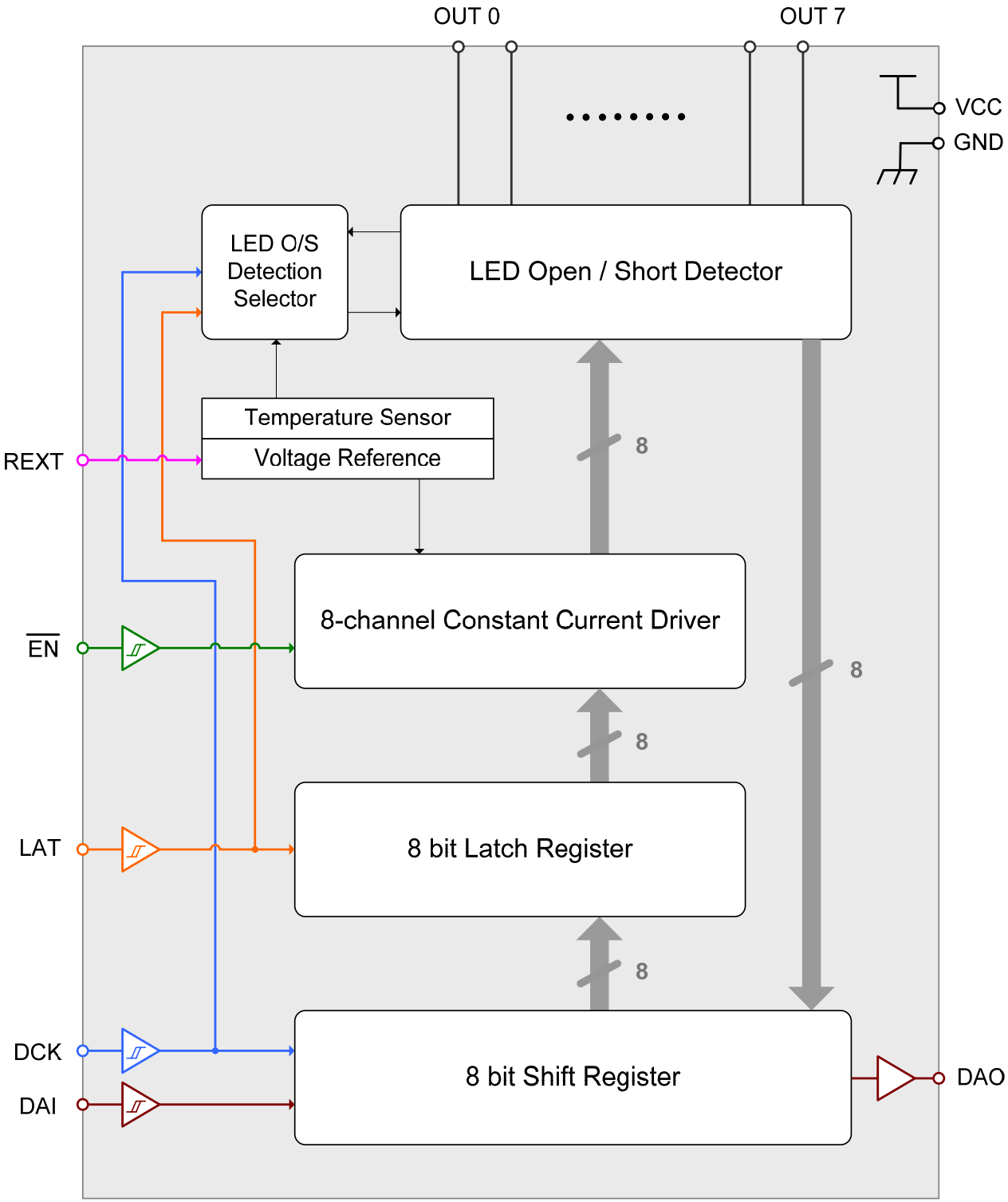
Applications

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

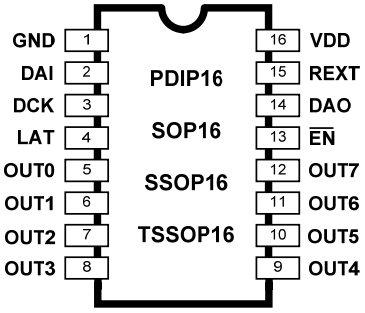
Package Types

- PDIP16, SSOP16, SOP16, SOP16 (with exposed pad), or TSSOP16 (with exposed pad)

Block Diagram



Pin Connection

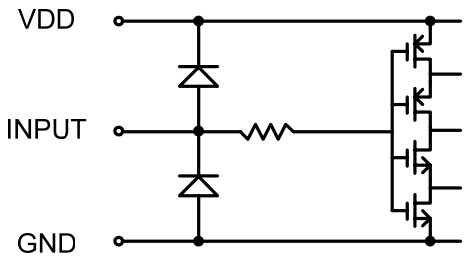


Pin Description

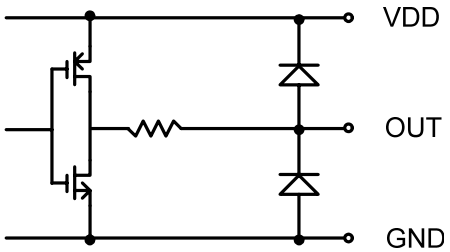
PIN No.	PIN NAME	FUNCTION
1 SOP16/TSSOP16: exposed pad	GND	Ground terminal.
2	DAI	Serial data input terminal.
3	DCK	Synchronous clock input terminal for serial data transfer. Data is sampled at the rising edge of DCK.
4	LAT	Input terminal of data strobe. Data on shift register goes through at the rising edge of LAT (edge trigger). Otherwise, data is latched.
5~12	OUT0~7	Sink constant-current outputs (open-drain).
13	$\overline{EN}$	Output enable terminal: **'H'** for all outputs are turned off , **'L'** for all outputs are active.
14	DAO	Serial data output terminal.
15	REXT	External resistors connected between REXT and GND for output current value setting.
16	VCC	Supply voltage terminal.

Equivalent Circuit of Inputs and Outputs

1. DCK, DAI, LAT, $\overline{EN}$ terminals



2. DAO terminals



Maximum Ratings (Ta=25°C, Tj(max) = 150°C)

CHARACTERISTIC	SYMBOL	RATING	UNIT
Supply Voltage	VCC	-0.3 ~ 7.0	V
Input Voltage	VIN	-0.3 ~ VCC+0.3	V
Output Current	IOUT	120	mA
Output Voltage	VOUT	-0.3 ~ 17	V
Input Clock Frequency	FDCK	25	MHz
GND Terminal Current	IGND	1	A
Power Dissipation (4 layer PCB)	PD	2.27 (TSSOP16 exposed pad: Ta=25°C)	W
		1.54 (SOP16 exposed pad: Ta=25°C)	
		1.47 (PDIP16 : Ta=25°C)	
		1.13 (SOP16(300mil) : Ta=25°C)	
		1.08 (SSOP16 : Ta=25°C)	
Thermal Resistance	Rth(j-a)	55 (TSSOP16 exposed pad)	°C/W
		81.2 (SOP16 exposed pad)	
		85.0 (PDIP16)	
		110.9 (SOP16(300mil))	
		115.9 (SSOP16)	
Operating Temperature	Top	-40 ~ 85	°C
Storage Temperature	Tstg	-55 ~ 150	°C

Recommended Operating Condition

CHARACTERISTIC	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Supply Voltage	VCC	—	3.3	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	5	—	120	mA
	IOH	VOH = VCC – 0.2 V	—	—	+1.5	
	IOL	VOL = 0.2 V	—	—	-1.5	
Input Voltage	VIH	VCC = 3.3 V ~ 5.5V	0.8VCC	—	VCC	V
	VIL		0.0	—	0.2VCC	
Input Clock Frequency	FDCK	Single Chip Operation	—	—	25	MHz
LAT Pulse Width	tw LAT	VCC = 5.0V	15	—	—	ns
DCK Pulse Width	tw DCK		15	—	—	
Set-up Time for DAI	tsetup(D)		10	—	—	
Hold Time for DAI	thold(D)		10	—	—	
Set-up Time for LAT	tsetup(L)		10	—	—	
Hold Time for LAT	thold(L)		10	—	—	
Set-up Time for Open/Short	tsetup(OS)		25	—	—	
Open/Short Detection Response	tdet		100	—	—	

*1 Notice that the power dissipation is limited to its package and ambient temperature.
*2 The driver output voltage including any overshoot stress has to be compliant with the maximum voltage (17V).

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 = 17 V	—	—	±1.0	uA
Output Voltage (S-OUT)	VOL	IOL = 1.5 mA	—	—	0.2	V
	VOH	IOH= 1.5 mA	VCC-0.2	—	—	
Output Current Skew (Channel-to-Channel) *1	IOL1	VOUT = 1.0 V Rrext = 2.2 KΩ	—	—	±3	%
Output Current Skew (Chip-to-Chip) *2	IOL2		23.5	25	26.5	mA
Output Voltage Regulation	% / VOUT	Rrext = 2.2 KΩ VOUT = 1 V ~ 3 V	—	±0.1	±0.5	% / V
Supply Voltage Regulation	% / VCC	Rrext = 2.2 KΩ	—	±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	$I_{DD(off)}$	power on all pins are open unless VCC and GND	—	1.8	—	mA
	$I_{DD(off)}$	input signal is static Rrext = 2.9 KΩ all outputs turn off	—	2.8	—	
	$I_{DD(on)}$	input signal is static Rrext = 2.9 KΩ all outputs turn on	—	3.6	—	
	$I_{DD(off)}$	input signal is static Rrext = 560 Ω all outputs turn off	—	7.1	—	
	$I_{DD(on)}$	input signal is static Rrext = 560 Ω all outputs turn on	—	8.4	—	

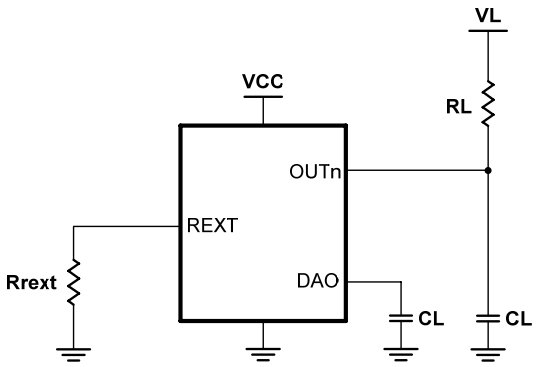
*1 Channel-to-channel skew is defined as the ratio between (any Iout – average Iout) and average Iout, where average Iout = (Imax + Imin) / 2.
*2 Chip-to-Chip skew is defined as the range into which any output current of any IC falls.
*3 IO excluded.

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

CHARACTERISTIC		SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Propagation Delay ('L to 'H')	EN-to-OUT7	tpLH	VIH = VCC VIL = GND Rrext = 2.2 KΩ VL = 5.0 V RL = 180 Ω CL*1 = 13 pF	—	16	—	ns
	LAT-to-OUT7			—	28	—	
	DCK-to-DAO			—	17	—	
Propagation Delay ('H' to 'L')	EN-to-OUT7	tpHL		—	18	—	
	LAT-to-OUT7			—	21.5	—	
	DCK-to-DAO			—	16	—	
Output Current Rise Time		tor		—	17	—	
Output Current Fall Time		tof		—	15	—	
Output Delay Time ($OUT_{(n)}$-to-$OUT_{(n+1)}$)		tod		—	2.2	—	

Switching Characteristics (VCC = 3.3V, Ta = 25°C unless otherwise noted)

CHARACTERISTIC		SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Propagation Delay ('L to 'H')	EN-to-OUT7	tpLH	VIH = VCC VIL = GND Rrext = 2.2 KΩ VL = 5.0 V RL = 180 Ω CL*1 = 13 pF	—	62	—	ns
	LAT-to-OUT7			—	54	—	
	DCK-to-DAO			—	23	—	
Propagation Delay ('H' to 'L')	EN-to-OUT7	tpHL		—	23	—	
	LAT-to-OUT7			—	25	—	
	DCK-to-DAO			—	18.5	—	
Output Current Rise Time		tor		—	50	—	
Output Current Fall Time		tof		—	15	—	
Output Delay Time ($OUT_{(n)}$-to-$OUT_{(n+1)}$)		tod		—	2.2	—	

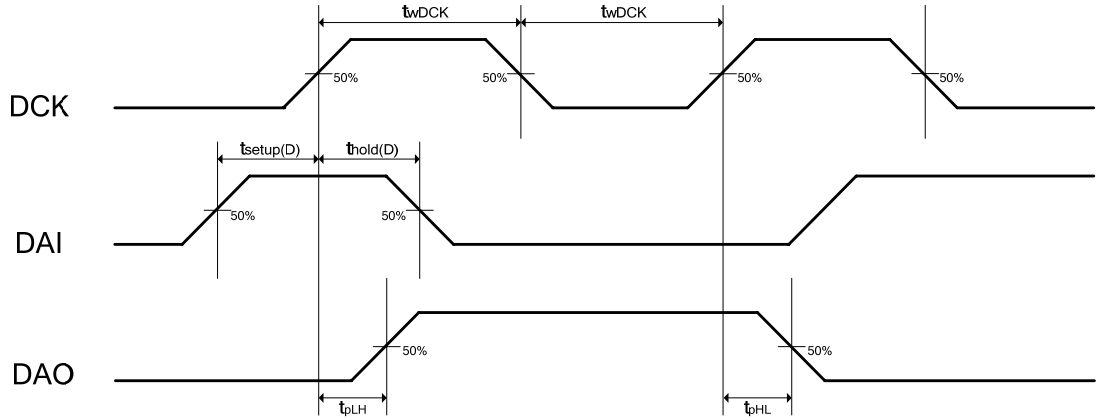


Switching Characteristics Test Circuit

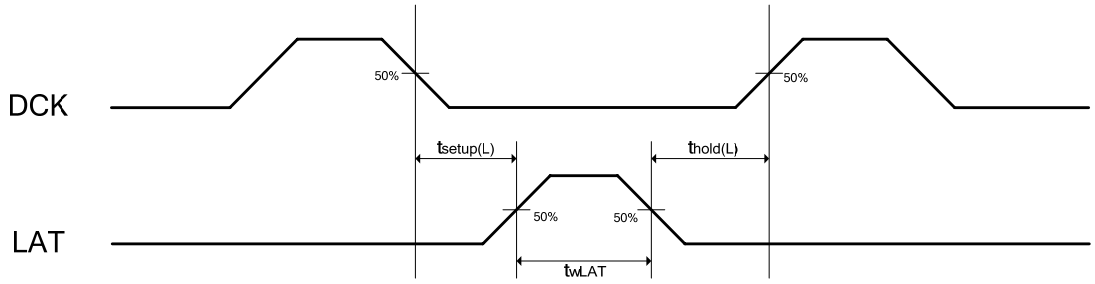
*1 CL means the probe capacitance of oscilloscope.

Timing Diagram

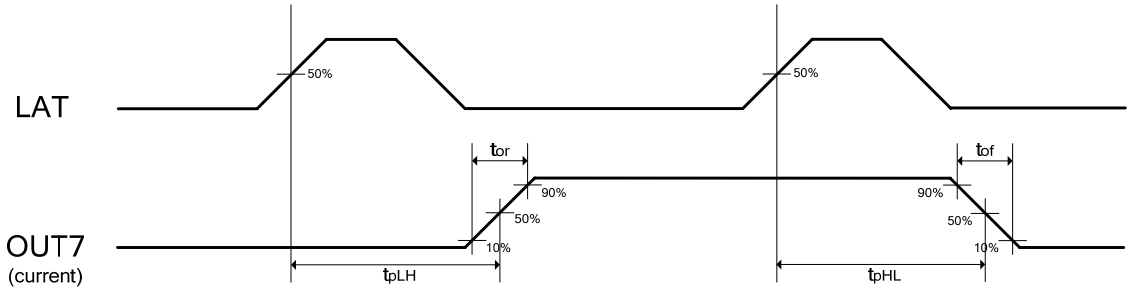
1. DCK-DAI, DAO



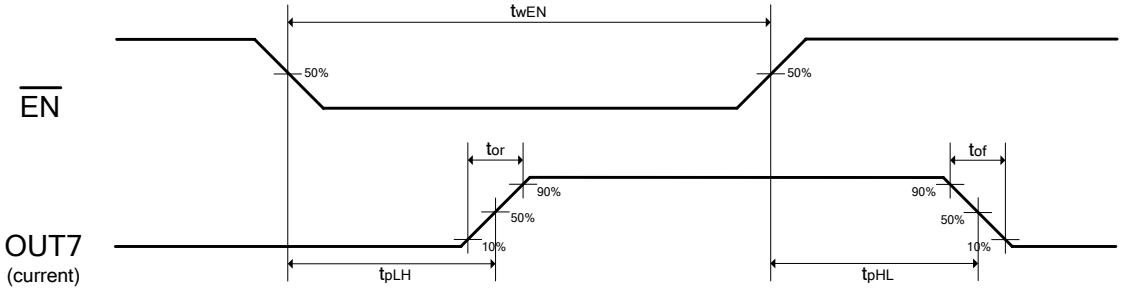
2. DCK-LAT



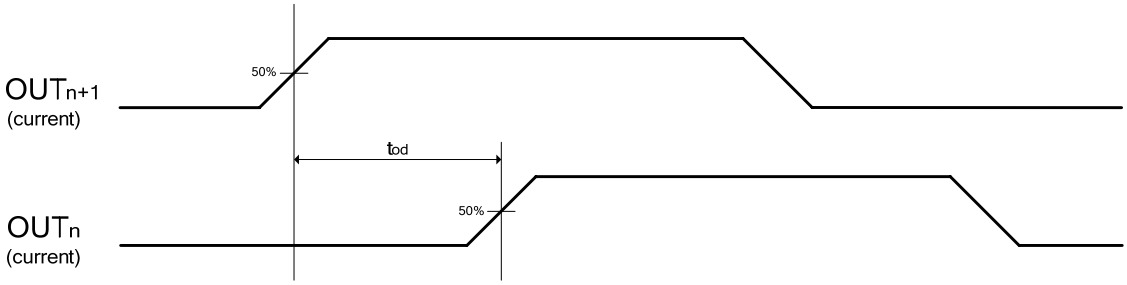
3. LAT-OUT7



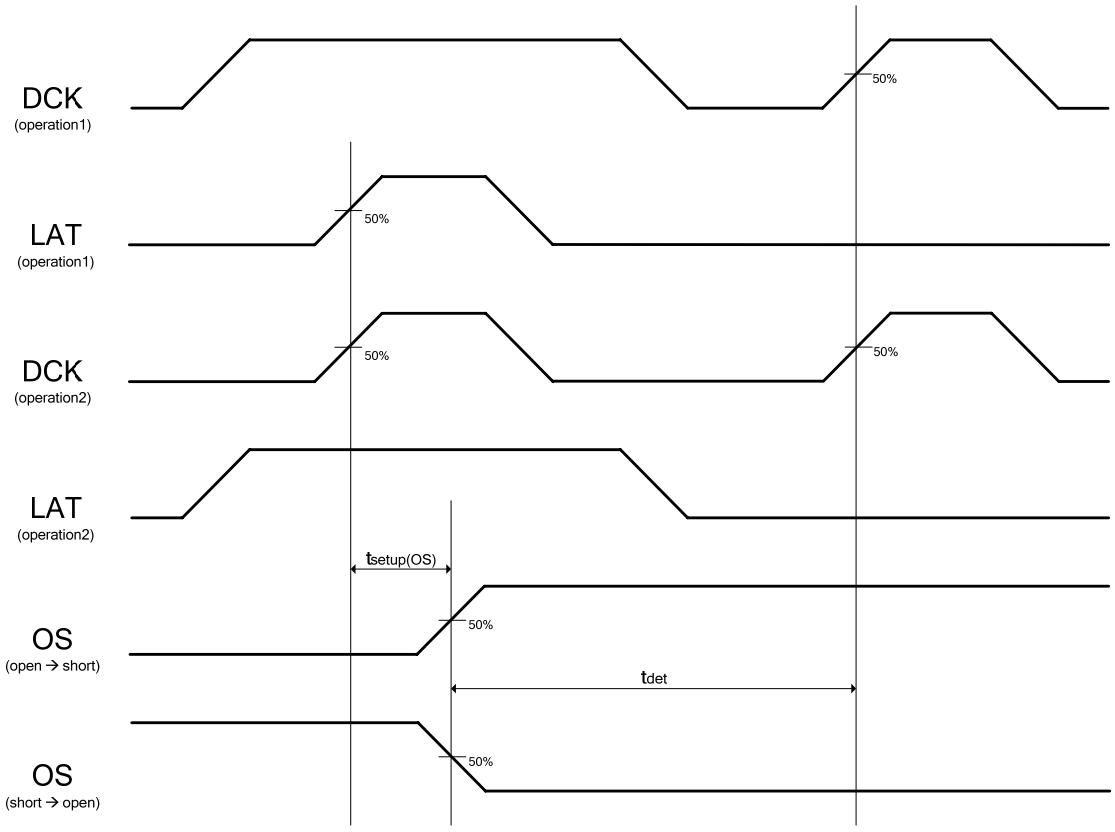
4. $\overline{EN}$-OUT7



5. OUT_{n+1}-OUT_n



6. OS-LAT, DCK ($\overline{EN}$='L')

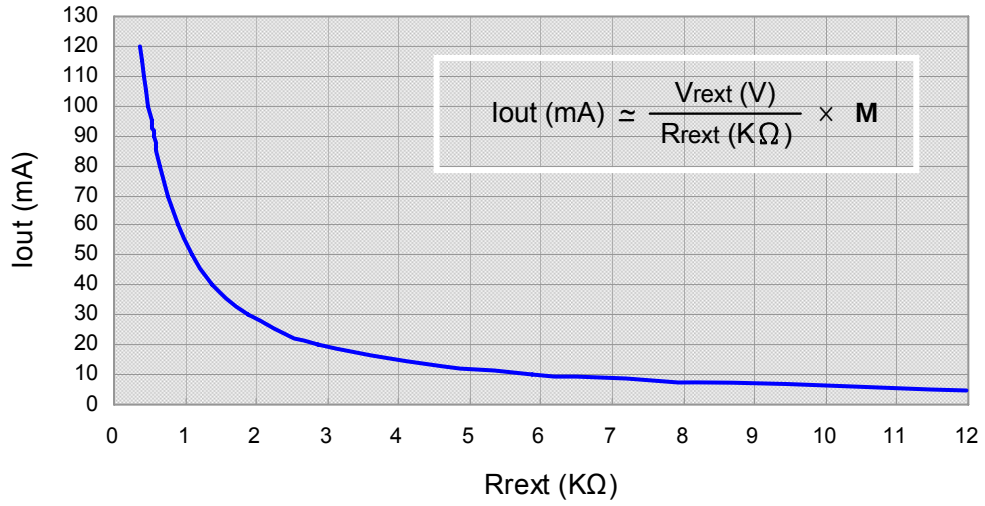


Constant-Current Output

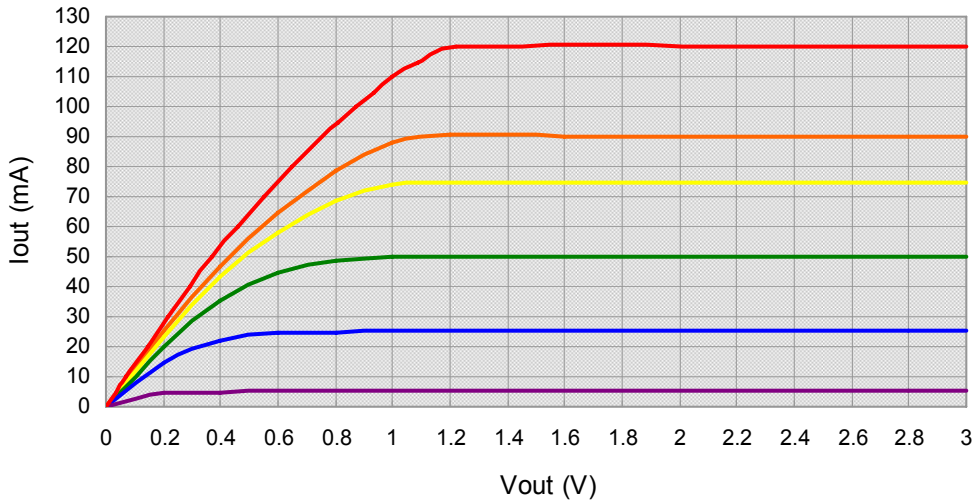
Constant-current value of each output channel is set by an external resistor connected between the REXT pin and GND. Varying the resistor value can adjust the current scale ranging from 5mA to 120mA. The reference voltage of REXT terminal (Vrext) is approximately 0.6V. The output current value is calculated roughly by the following equation:

Iout(mA)	5	10	20	30	40	50	60	70	80	90	100	110	120
M	99.7	98.1	96.0	94.2	92.5	90.8	89.1	87.1	85.1	84.4	80.5	78	70.6

Output Current as a Function of Rrext value



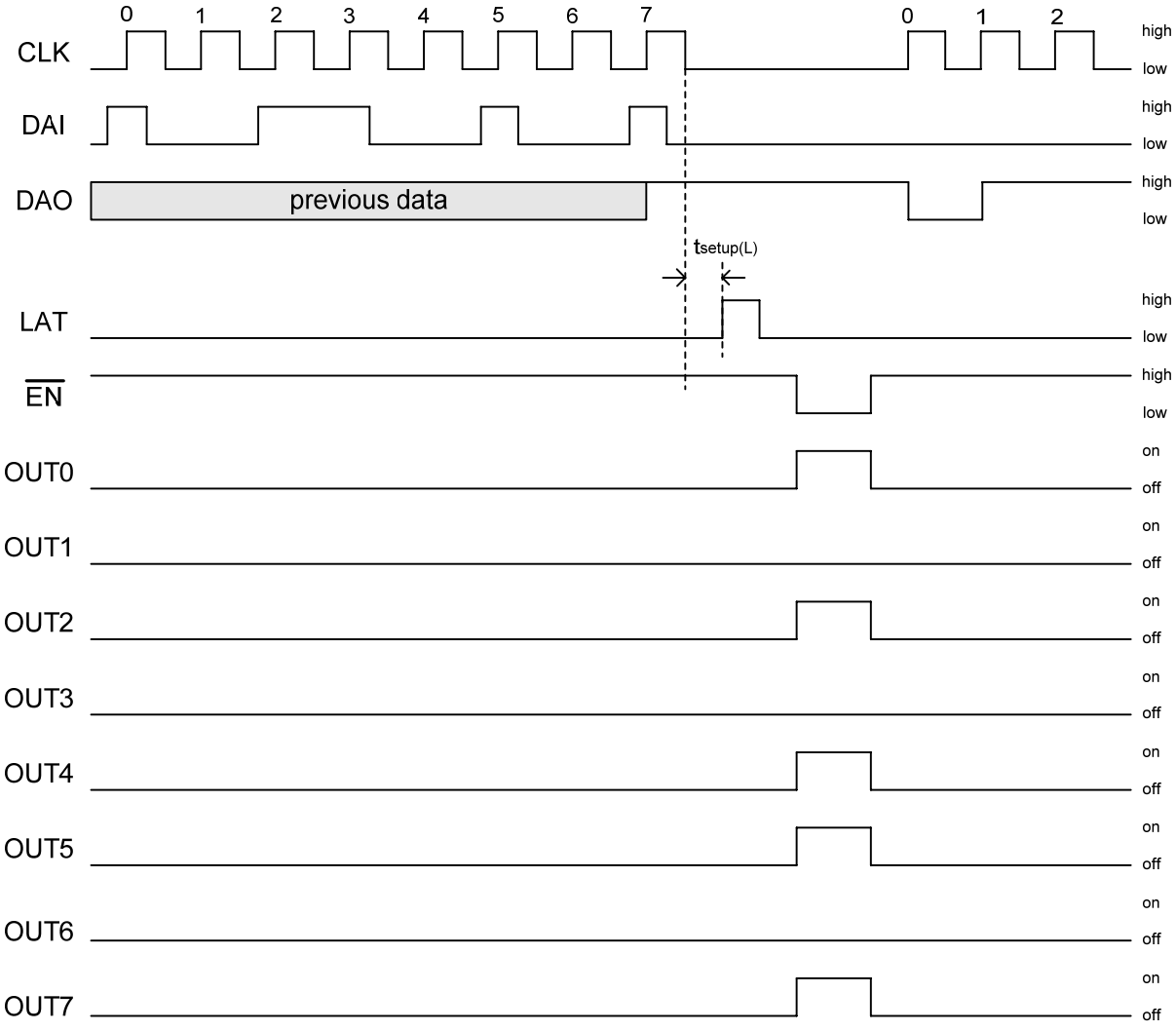
Output Current as a Function of Output Voltage



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

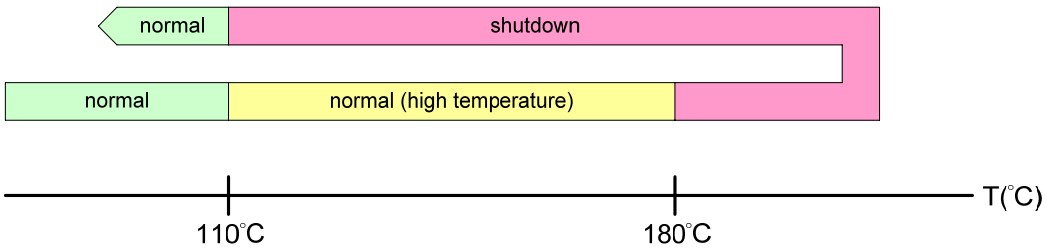
Serial Data Interface

The serial-in data (DAI) will be clocked into 8 bit shift register synchronized on the rising edge of the clock (DCK). The data ‘1’ represents the corresponding current output ‘ON’, while the data ‘0’ stands for ‘OFF’. The data will be transferred into the 8 bit latch synchronized on the rising edge (edge trigger) of the strobe signal (LAT); 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 of the serial-out data (DAO) will be shifted out on synchronization to the rising edge of the clock. All outputs are turned off while enable terminal (EN) is kept at high level. And they are active when EN 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 below 110℃. DM11C will restart all the outputs at the same time. Operation in the thermal situation for a long time may cause chip damage permanently.



Relations between Thermal Shutdown and Junction Temperature

LED Open/Short Detection

The result of open/short detection of DM11C could be retrieved from serial-out (DAO) 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 (EN=‘L’); (3) the rising edge of the latch signal (LAT), DM11C 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’ but ‘0’ is retrieved then a LED failure has occurred. If the image data is written to ‘0’ or the output enable terminal is inactive (EN=‘H’), it will not execute any detection process for the corresponding channel. Therefore, system still retrieves the original image data.

Real-time monitor

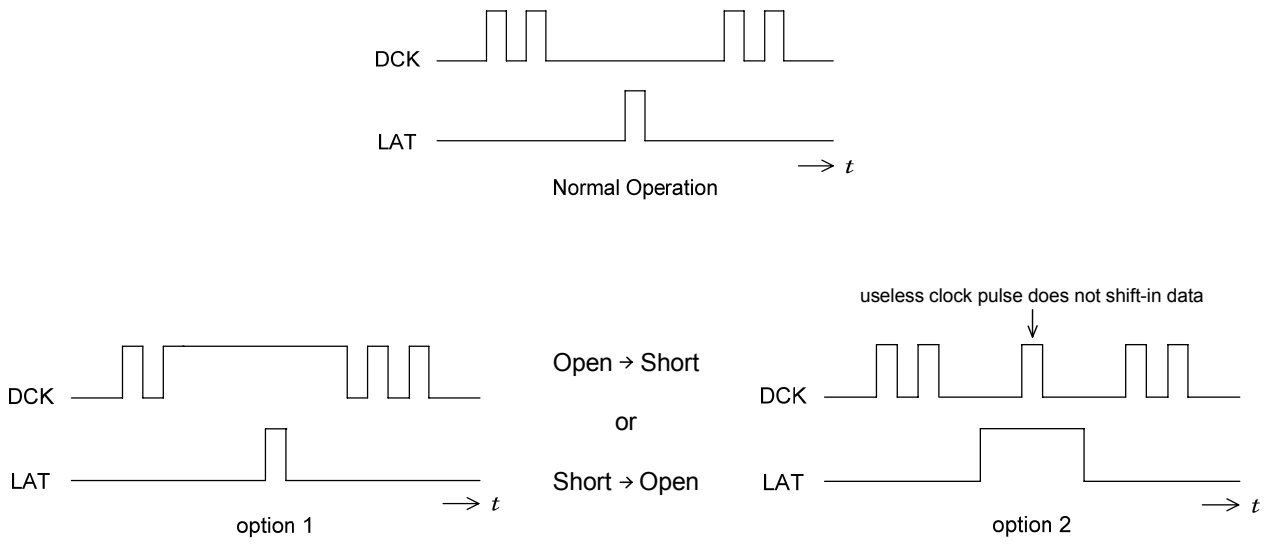
With the above operating principle, system could continuously retrieve LED status from serial-out then compare with the last frame data one by one. Once there is any discrepancy (‘1’→‘0’), we can locate which channel is abnormal precisely. Since the process is ongoing and without shifting between image 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

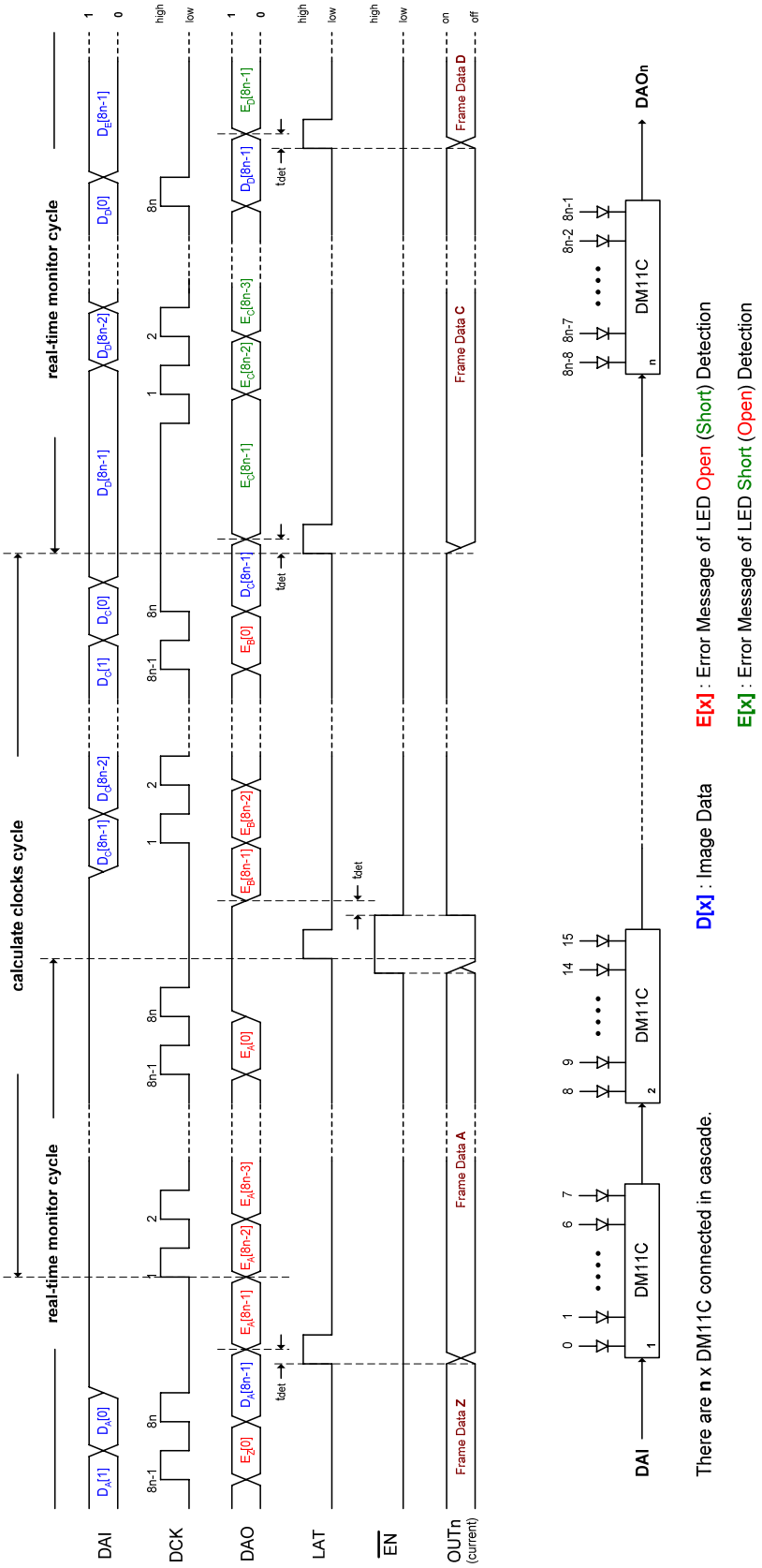
For large LED display applications, ‘real-time monitor’ could be a heavy loading for system because it needs to compare the retrieved information with a lot of frame data. Therefore, to write the image data of all channels to ‘1’, all failure status will be identified when there will be any ‘0’ retrieved. 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 DM11C 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.

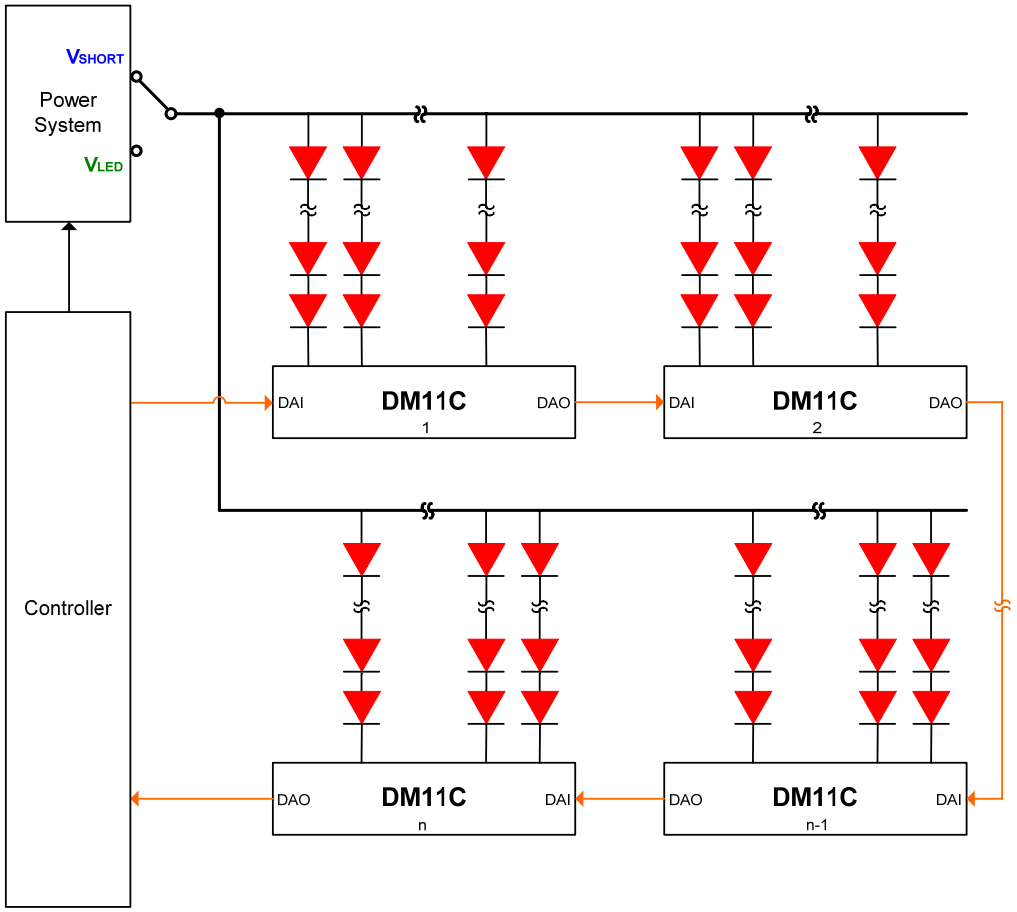


Timing Diagram of LED Open/Short Detection



Threshold of Short Detection

The default threshold voltage for LED short detection of DM11C 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 $\mathbf{V_{SHORT}}$ should be satisfied with the following inequality:

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

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

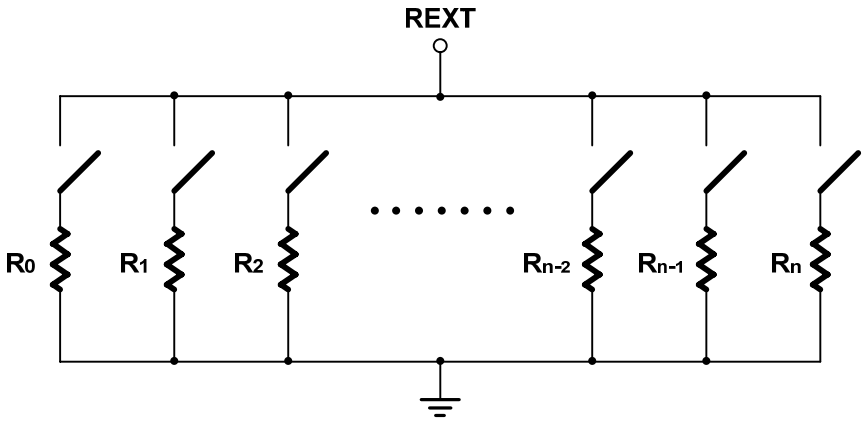
$$\frac{1}{2}VCC + (V_{LED} - V_{SHORT})$$

Outputs Delay

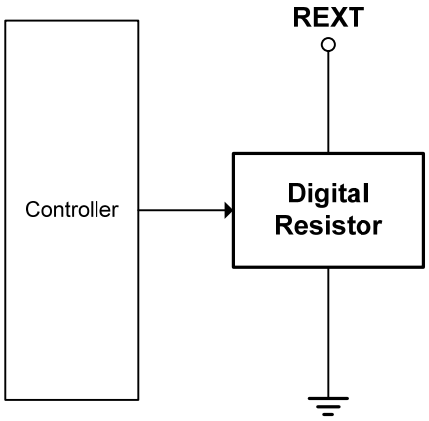
Large in-rush currents will occur when the system activates all the outputs at once. To reduce this effect, DM11C is designed to have a constant unit of delay (around 1.5ns) between every output. The delay for every output goes like this: there is no delay for OUT7, 1 unit of delay for OUT6, 2 units of delay for OUT5 and so on.

Global Brightness Control

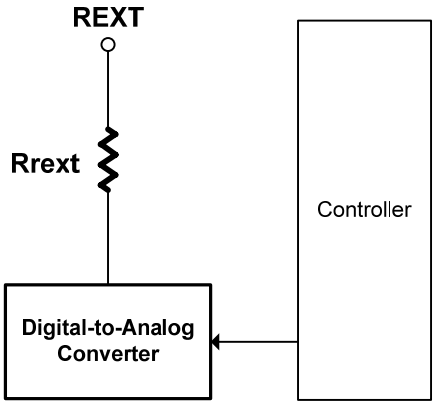
DM11C has no built-in global brightness control feature. In order to obtain a lower resolution of global brightness control effect, two methods could be utilized. One is providing PWM signal synchronized on latch pulse to modulate the output enable terminal ($\overline{EN}$ pin). The other is to adjust 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
with Digital Resistor



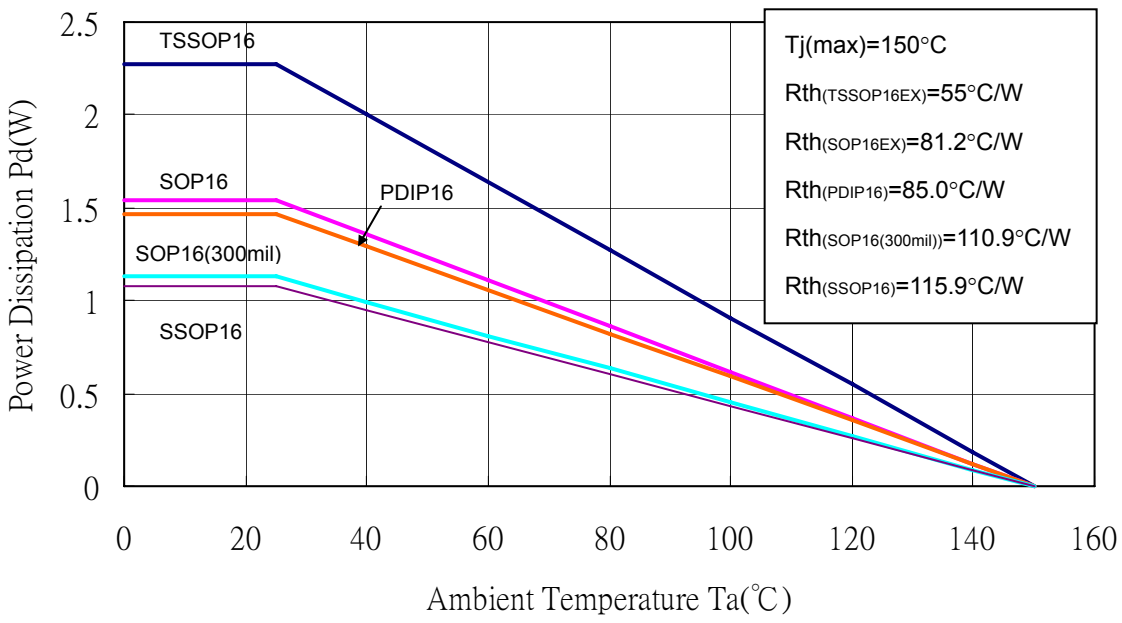
Global Brightness Control
with D/A converter

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:

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

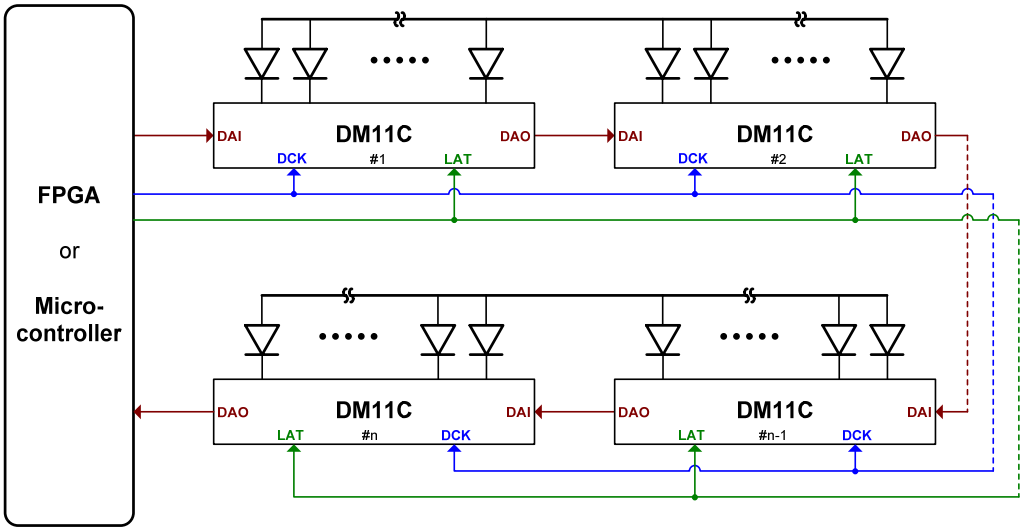
The relationship between power dissipation and operating temperature can be refer to the figure below:



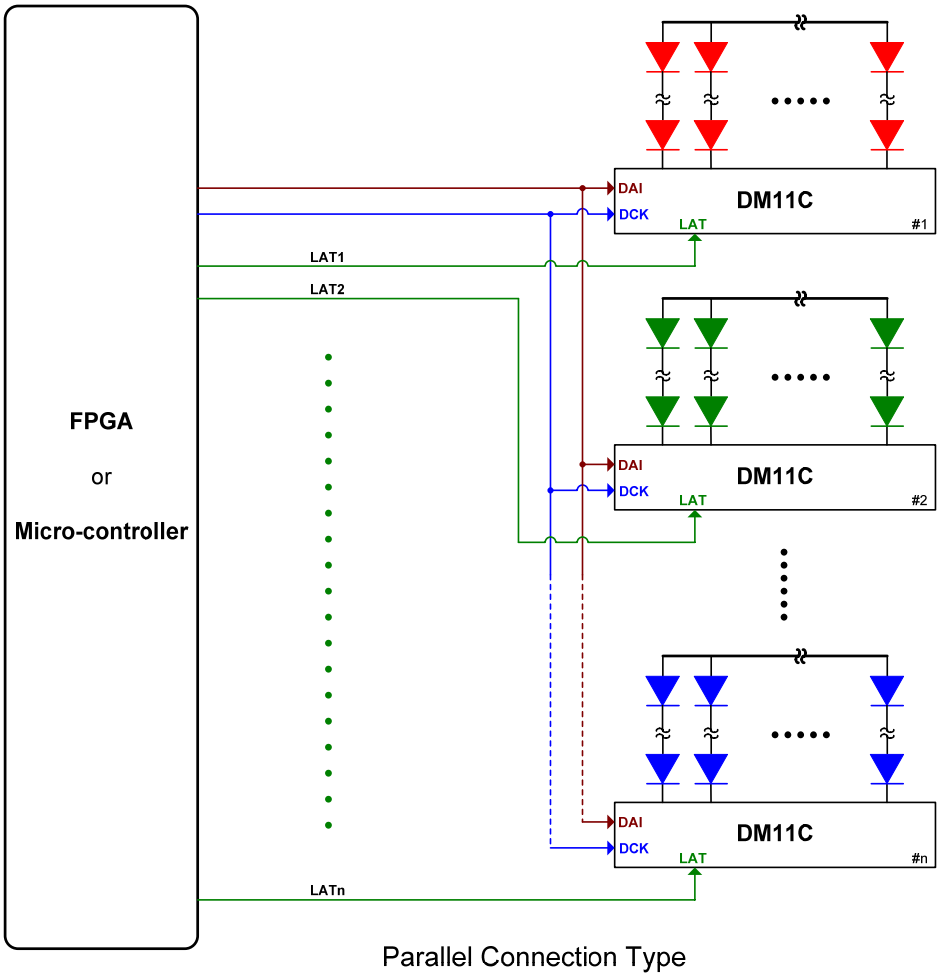
The power consumption of IC can be determined by the following equation and should be less than the maximum allowable power dissipation:

$$Pd(W) = V_{CC}(V) \times I_{DD}(A) + Vout0 \times Iout0 \times Duty0 + \cdots\cdots + Vout7 \times Iout7 \times Duty7 \leq Pd(max)(W)$$

Typical Application



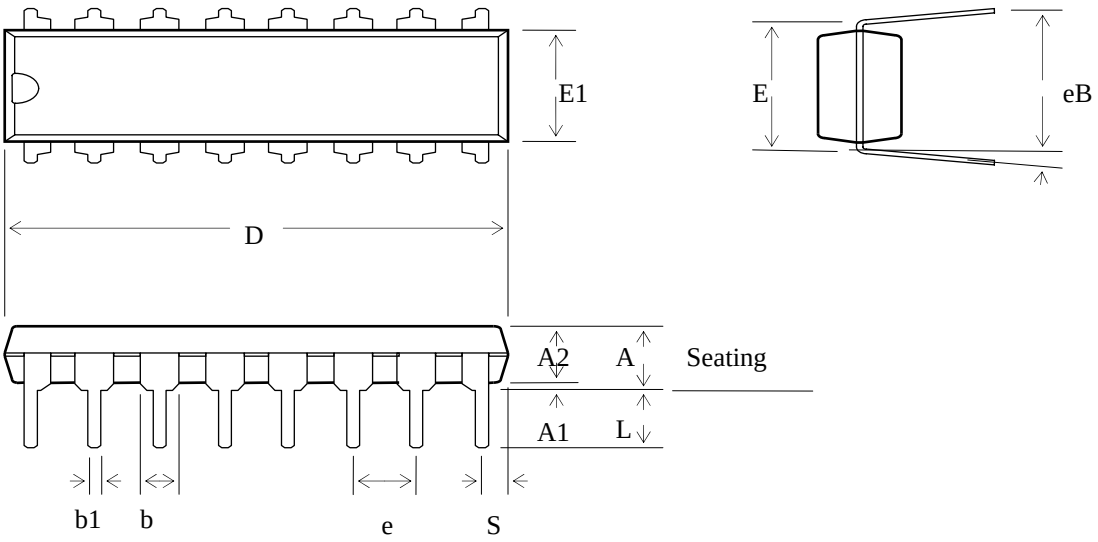
Serial Connection Type



Parallel Connection Type

Package Outline Dimension

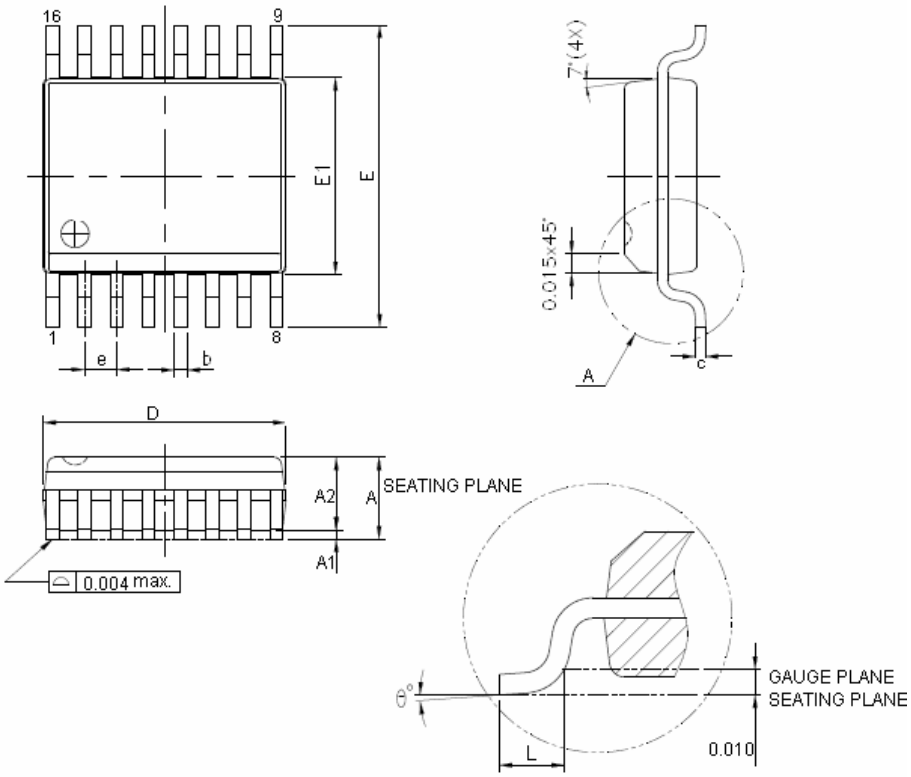
DM11C-DIP16



	DIMENSION IN MM			DIMENSION IN INCH		
SYMBOL	MIN	TYP	MAX	MIN	TYP	MAX
A	-	-	5.334	-	-	0.21
A1	0.381	-	-	0.015	-	-
A2	3.175	3.302	3.429	0.125	0.130	0.135
b	1.300	1.500	1.700	0.05118	0.059	0.06693
b1	0.400	0.480	0.560	0.01575	0.019	0.02205
D	18.669	19.495	20.320	0.735	0.768	0.8
E	7.366	7.620	7.874	0.29	0.300	0.31
E1	6.223	6.812	7.400	0.245	0.268	0.29134
e	2.290	2.540	2.790	0.09016	0.100	0.10984
eB	8.509	9.017	9.525	0.335	0.355	0.375
L	2.540	3.175	3.810	0.1	0.125	0.15
S	-	-	1.120	-	-	0.04409
θ°	0	7	15	0	0.276	0.59055

Package Outline Dimension

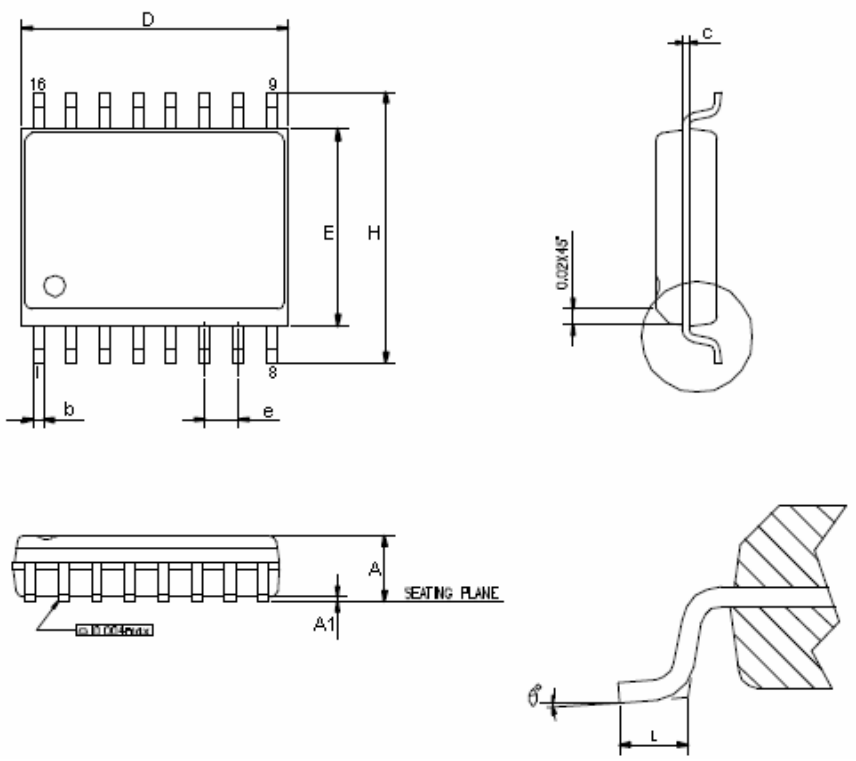
DM11C-SSOP16



	DIMENSION IN MM			DIMENSION IN INCH		
SYMBOL	MIN	TYP	MAX	MIN	TYP	MAX
A	1.346	-	1.753	0.053	-	0.069
A1	0.102	-	0.254	0.004	-	0.010
A2	1.245	-	1.499	0.049	-	0.059
b	0.203	-	0.305	0.008	-	0.012
c	0.178	-	0.254	0.007	-	0.010
D	4.801	4.902	5.004	0.189	0.193	0.197
E	5.791	5.994	6.198	0.228	0.236	0.244
e	0.635 BSC			0.635 BSC		
E1	3.810	3.912	3.988	0.150	0.154	0.157
L	0.406	-	1.270	0.016	-	0.050
θ°	0	-	8	0	-	8

Package Outline Dimension

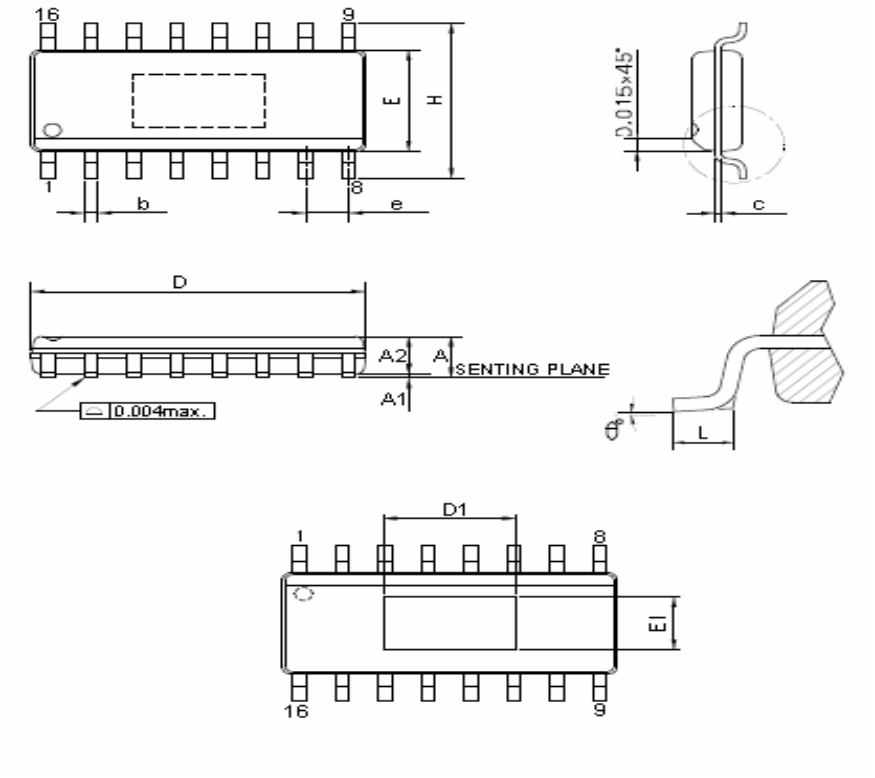
SOP16 (300mil)



	DIMENSION IN MM			DIMENSION IN INCH		
SYMBOL	MIN	TYP	MAX	MIN	TYP	MIN
A	2.362	-	2.642	0.093	-	0.104
A1	0.102	-	0.305	0.004	-	0.012
b	0.406 BSC			0.406 BSC		
c	0.203 BSC			0.203 BSC		
D	10.109	-	10.490	0.398	-	0.413
E	7.391	-	7.595	0.291	-	0.299
e	1.270 BSC			1.270 BSC		
H	10.008	-	10.643	0.394	-	0.419
L	0.406	-	1.270	0.016	-	0.050
θ°	0	-	8	0	-	8

Package Outline Dimension

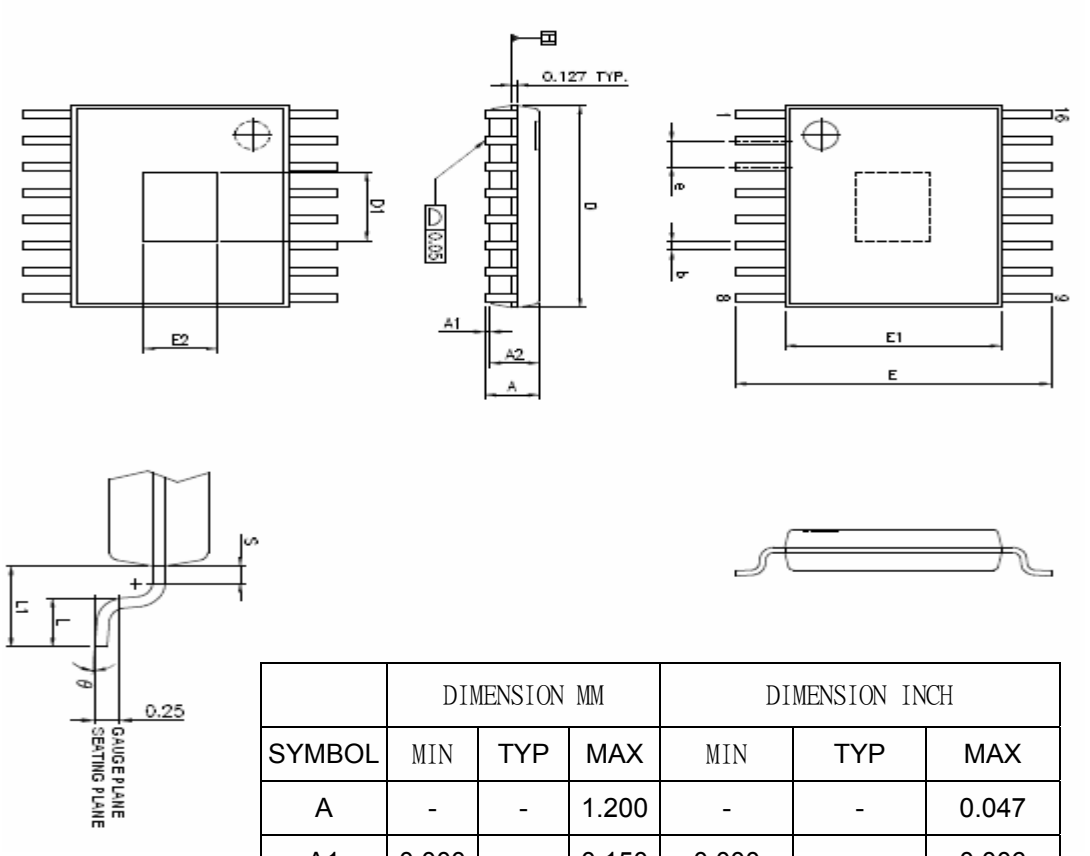
SOP16 (exposed pad)



	DIMENSION IN MM			DIMENSION IN INCH		
SYMBOL	MIN	TYP	MAX	MIN	TYP	MAX
A	1.346	-	1.753	0.053	-	0.069
A1	0.051	-	0.152	0.002	-	0.006
b	0.406 BSC			0.406 BSC		
c	0.203 BSC			0.203 BSC		
D	9.804	-	10.008	0.386	-	0.394
E	3.810	-	3.988	0.150	-	0.157
e	1.270 BSC			1.270 BSC		
H	5.791	-	6.198	0.228	-	0.244
L	0.406	-	1.270	0.016	-	0.050
θ°	0	-	8	0	-	8
PAD SIZE1 (95×18E)						
E1	1.930	-	2.413	0.076	-	0.095
D1	3.658	-	4.572	0.144	-	0.180

Package Outline Dimension

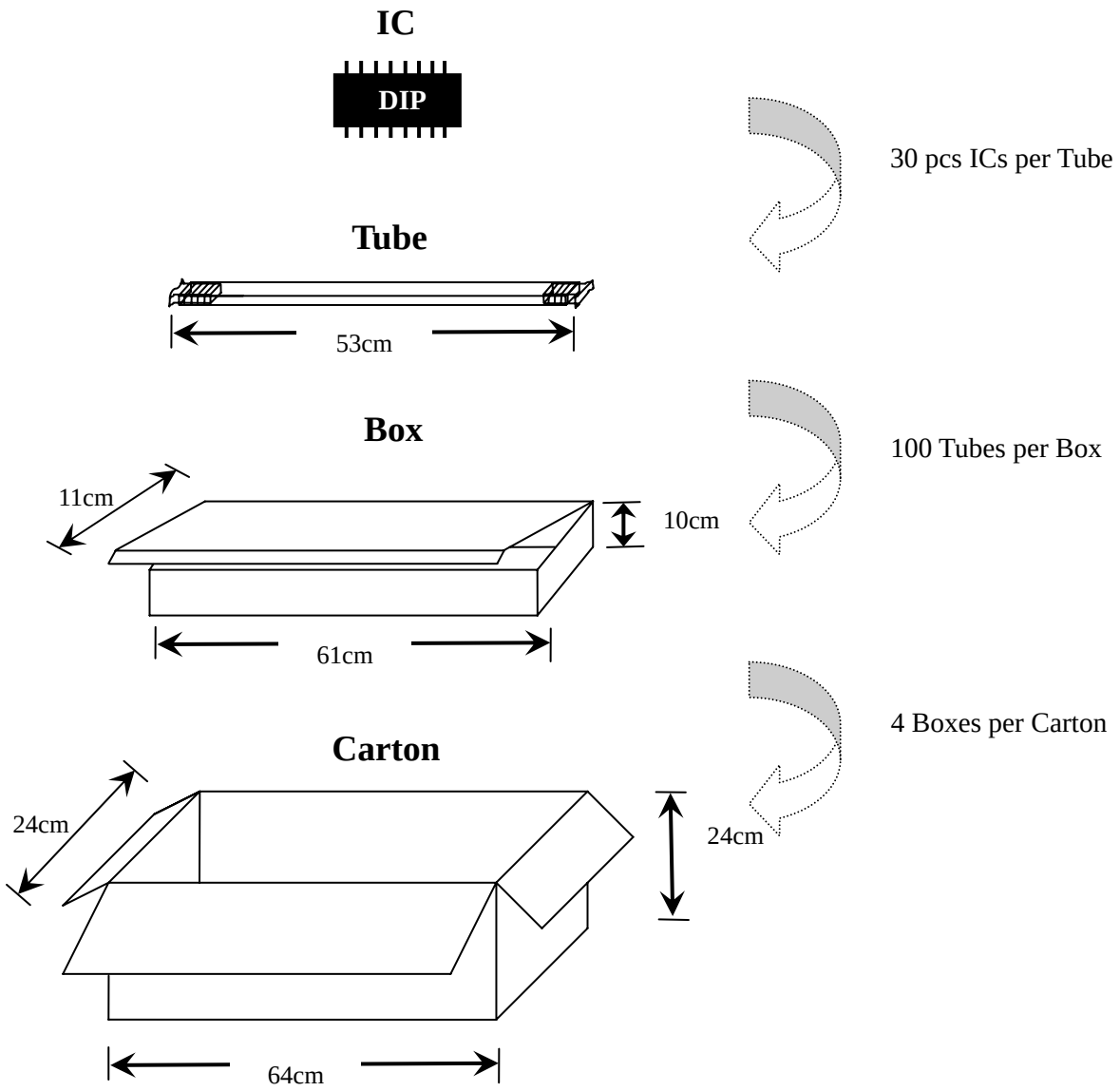
TSSOP16 (exposed pad)



	DIMENSION MM			DIMENSION INCH		
SYMBOL	MIN	TYP	MAX	MIN	TYP	MAX
A	-	-	1.200	-	-	0.047
A1	0.000	-	0.150	0.000	-	0.006
A2	0.800	1.000	1.050	0.031	0.039	0.041
b	0.190	-	0.300	0.190	-	0.300
D	4.900	5.000	5.100	0.193	0.197	0.201
E1	4.300	4.400	4.500	0.043	0.173	0.177
E	6.400 BSC			6.400 BSC		
e	0.650 BSC			0.650 BSC		
L1	1.000 REF			1.000 REF		
L	0.450	0.600	0.750	0.018	0.024	0.030
S	0.200	-	-	0.002	-	-
θ°	0	-	8	0	-	8
PAD SIZE (118×11E)						
E2	2.400	-	3.000	0.094	-	0.118
D1	2.400	-	3.000	0.094	-	0.118

DM11C-DIP Package and Weight（4 Boxes Set）

DIP16 - 300 - 2.54

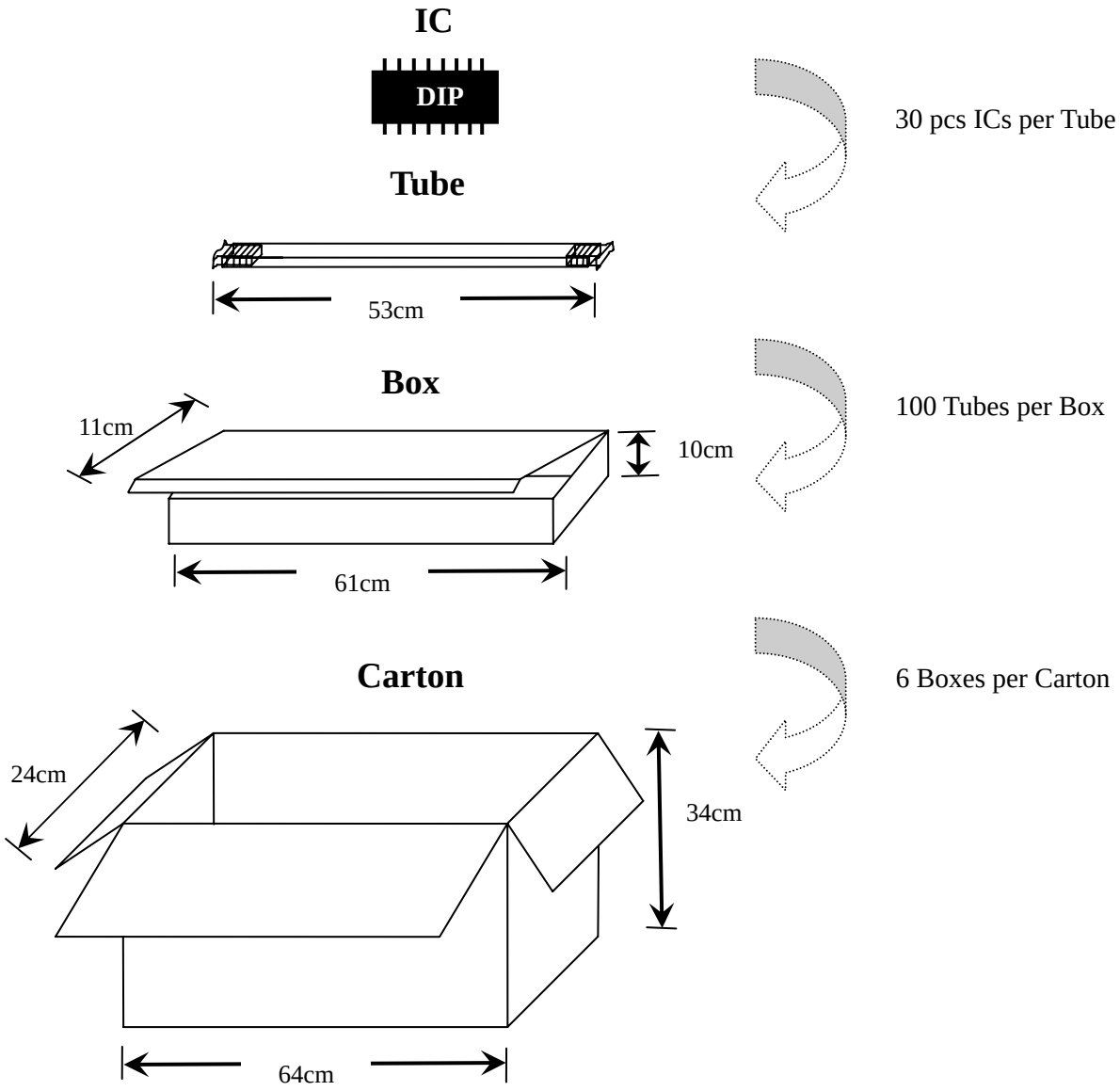


Weight

Item	Description	Weight (Kg)
1	30 pcs DM11C-DIP per Tube	0.06±5%
2	Net Weight of one Box	0.40±5%
3	Net Weight of one Carton	1.24±5%
4	Per Carton Set (4 Boxes, 12,000 pcs)	26.84±5%

DM11C-DIP Package and Weight（6 Boxes Set）

DIP16 - 300 - 2.54

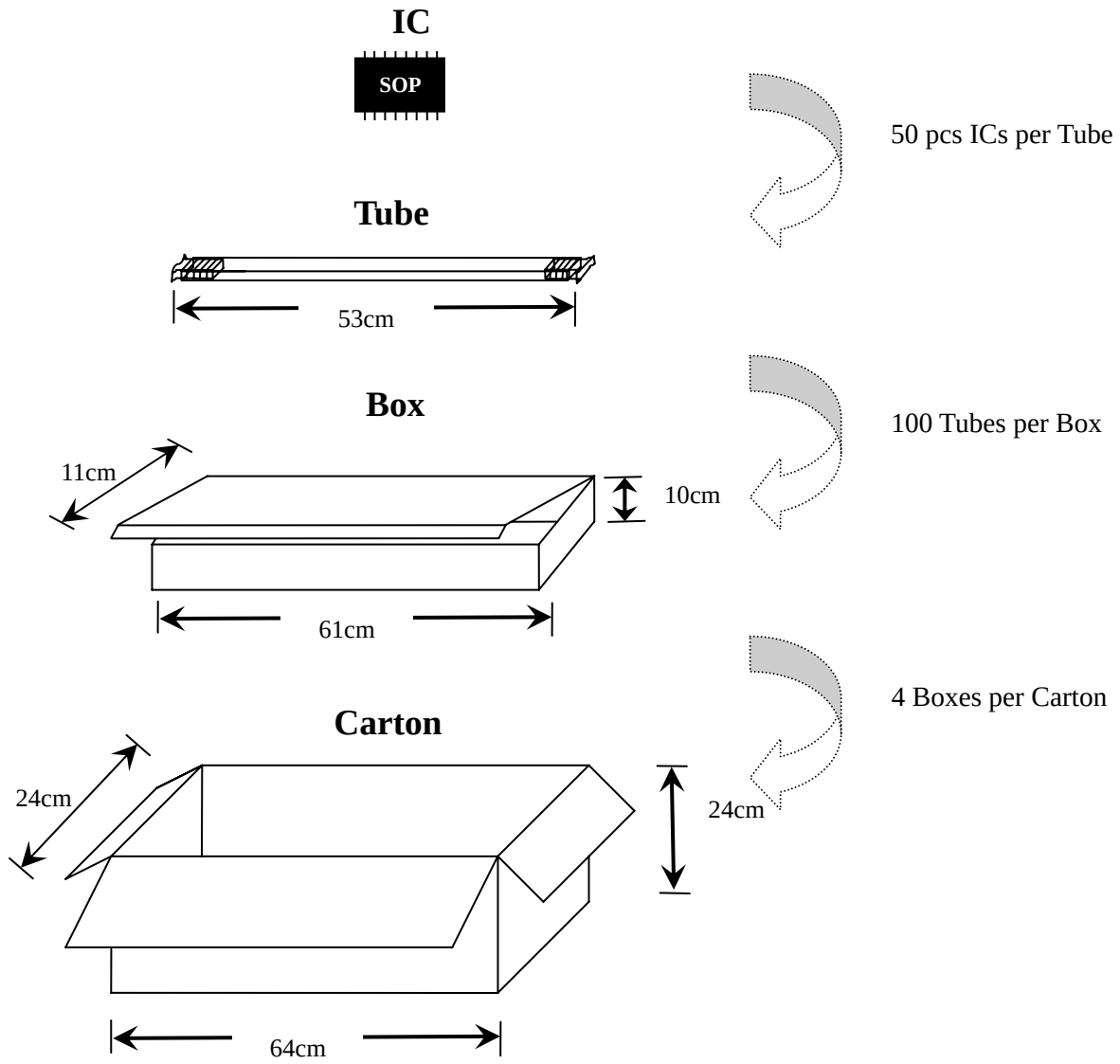


Weight

Item	Description	Weight (Kg)
1	30 pcs DM11C-DIP per Tube	0.06±5%
2	Net Weight of one Box	0.40±5%
3	Net Weight of one Carton	1.44±5%
4	Per Carton Set (6 Boxes, 18,000 pcs)	39.84±5%

DM11C-SOP Package and Weight（4 Boxes Set）

SOP16 - 150 - 1.25

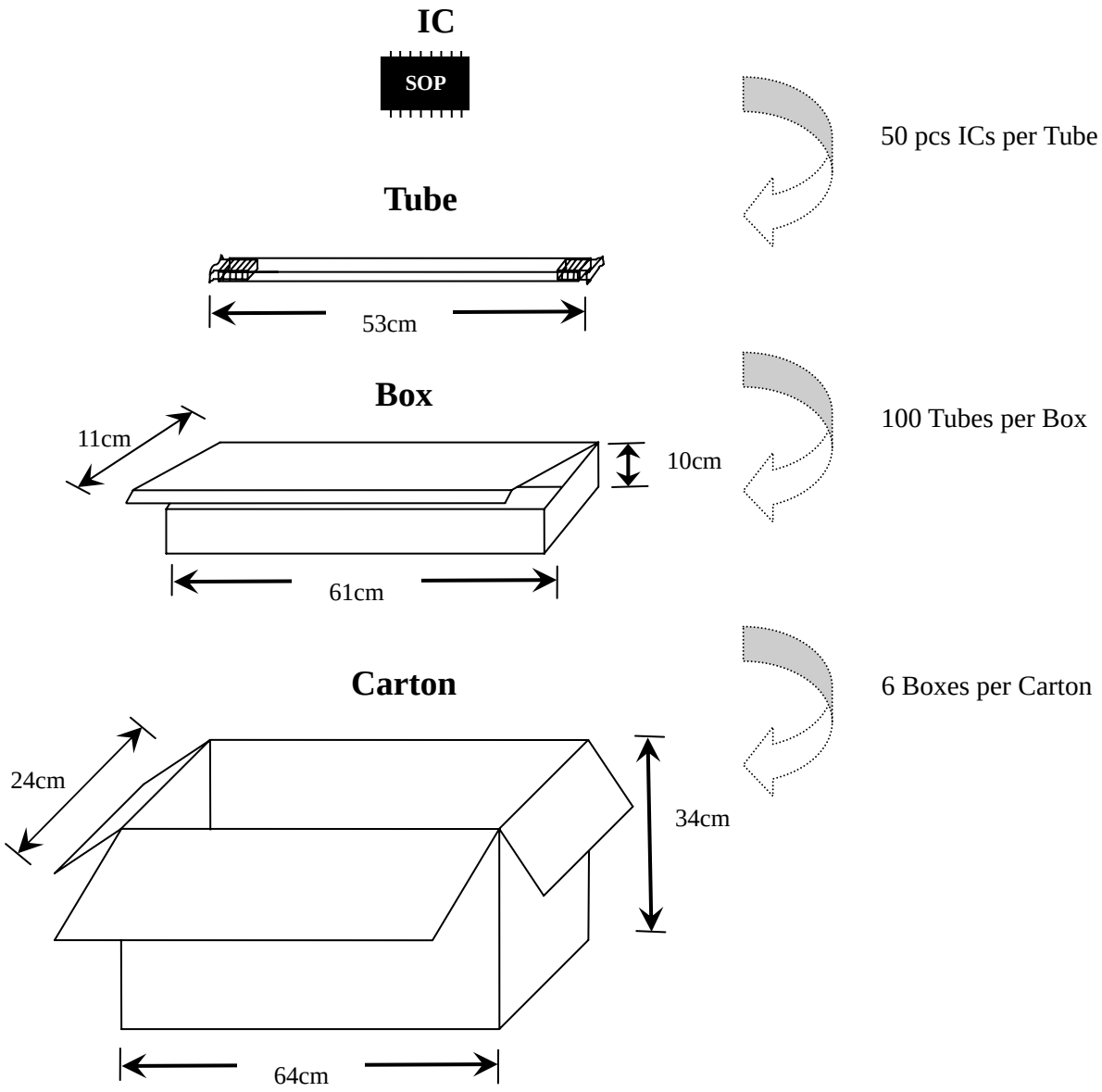


Weight

Item	Description	Weight (Kg)
1	50 pcs DM11C-SOP per Tube	0.0171±5%
2	Net Weight of one Box	0.40±5%
3	Net Weight of one Carton	1.24±5%
4	Per Carton Set (4 Boxes, 20,000 pcs)	9.84±5%

DM11C-SOP Package and Weight（6 Boxes Set）

SOP16 - 150 - 1.25

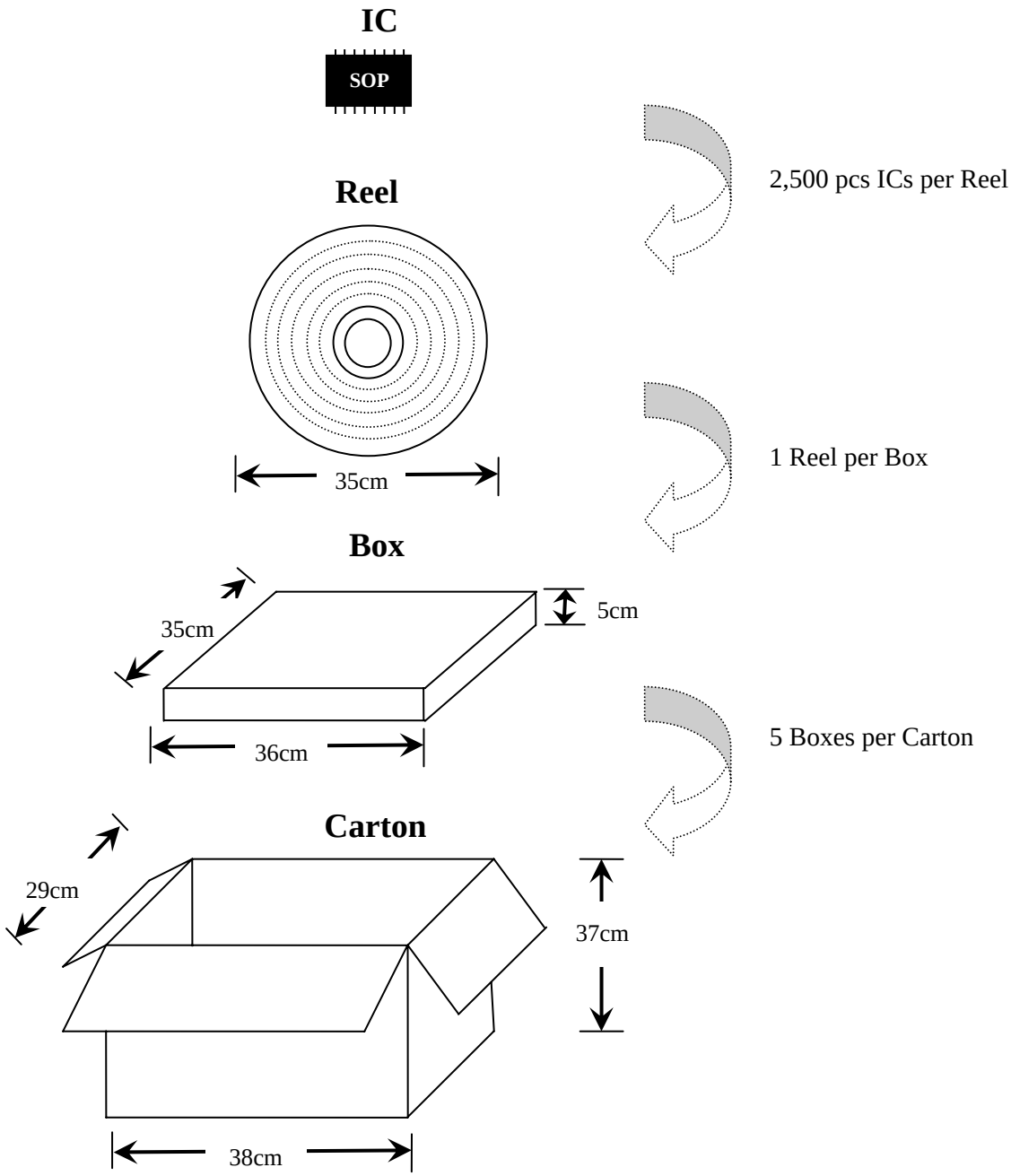


Weight

Item	Description	Weight (Kg)
1	50 pcs DM11C-SOP per Tube	0.0175±5%
2	Net Weight of one Box	0.40±5%
3	Net Weight of one Carton	1.44±5%
4	Per Carton Set (6 Boxes, 30,000 pcs)	14.34±5%

DM11C-SOP Package and Weight

SOP16 - 150 - 1.25

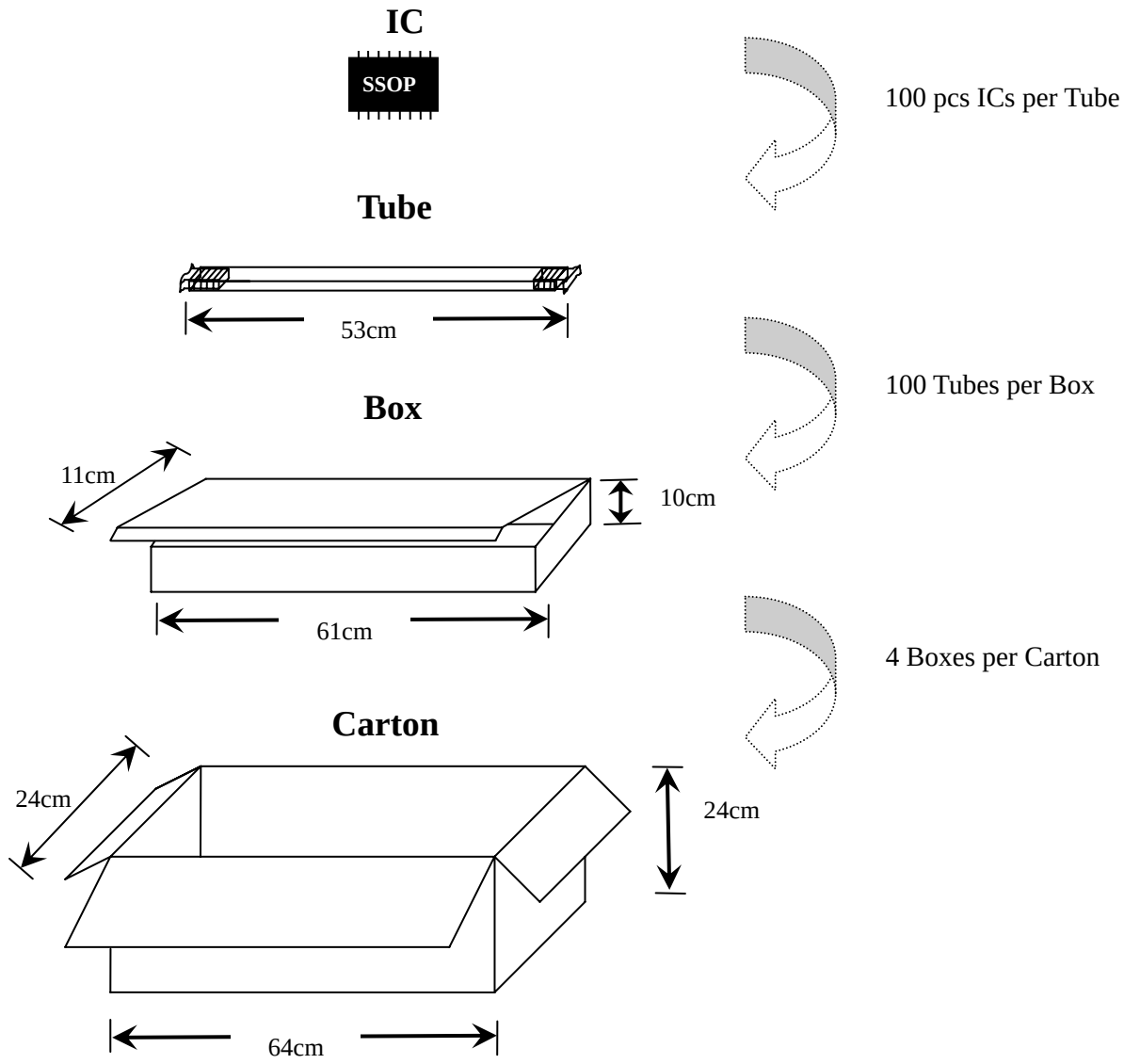


Weight

Item	Description	Weight (Kg)
1	2,500 pcs DM11C-SOP per Reel	1.1±5%
2	Net Weight of one Box	0.24±5%
3	Net Weight of one Carton	0.90±5%
4	Per Carton Set (5 Boxes, 12,500 pcs)	7.6±5%

DM11C-SSOP Package and Weight（4 Boxes Set）

SSOP16 - 150 - 0.635

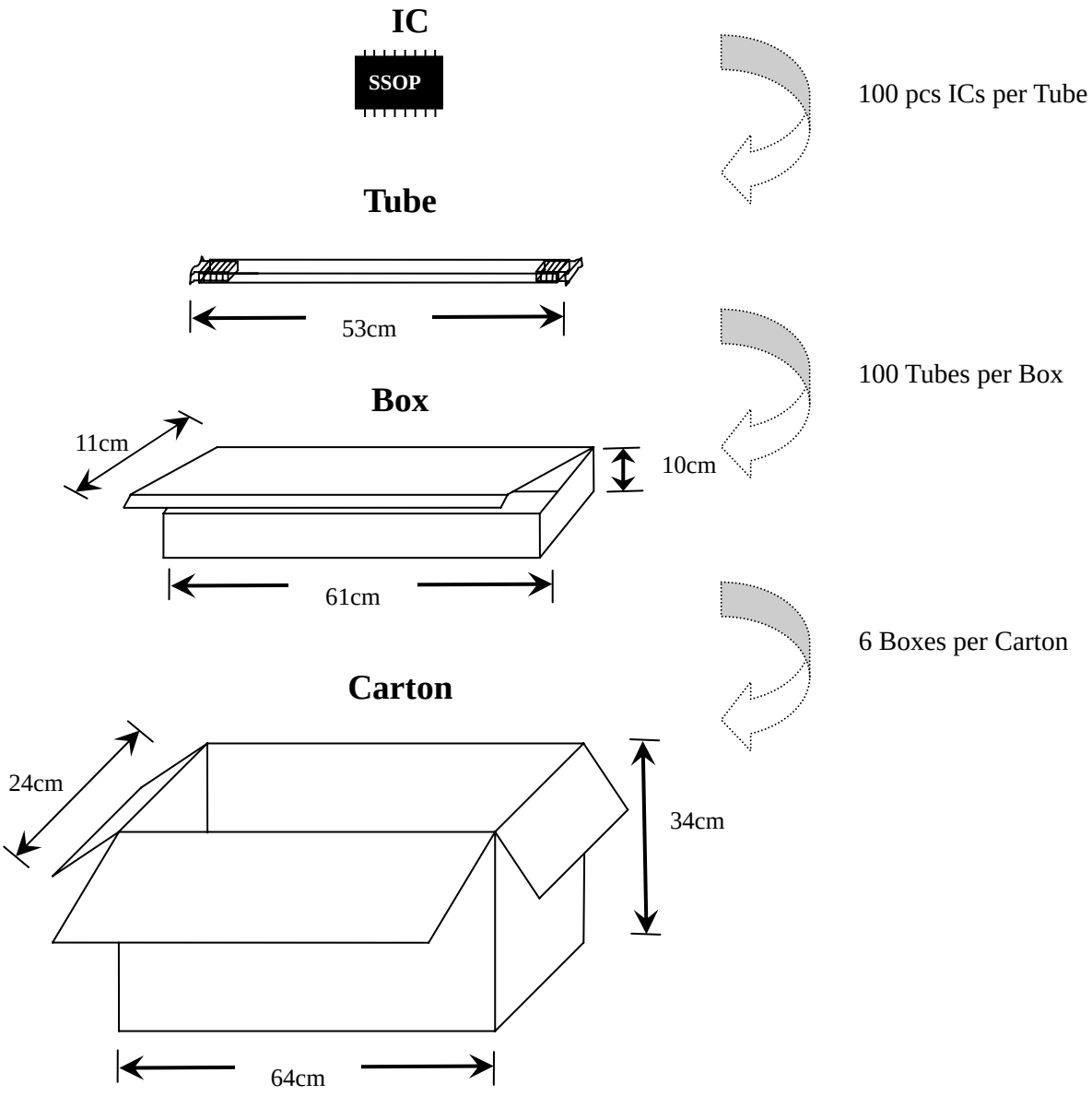


Weight

Item	Description	Weight (Kg)
1	100 pcs DM11C-SSOP per Tube	0.0171±5%
2	Net Weight of one Box	0.40±5%
3	Net Weight of one Carton	1.24±5%
4	Per Carton Set (4 Boxes, 40,000 pcs)	9.68±5%

DM11C-SSOP Package and Weight（6 Boxes Set）

SSOP16 - 150 - 0.635

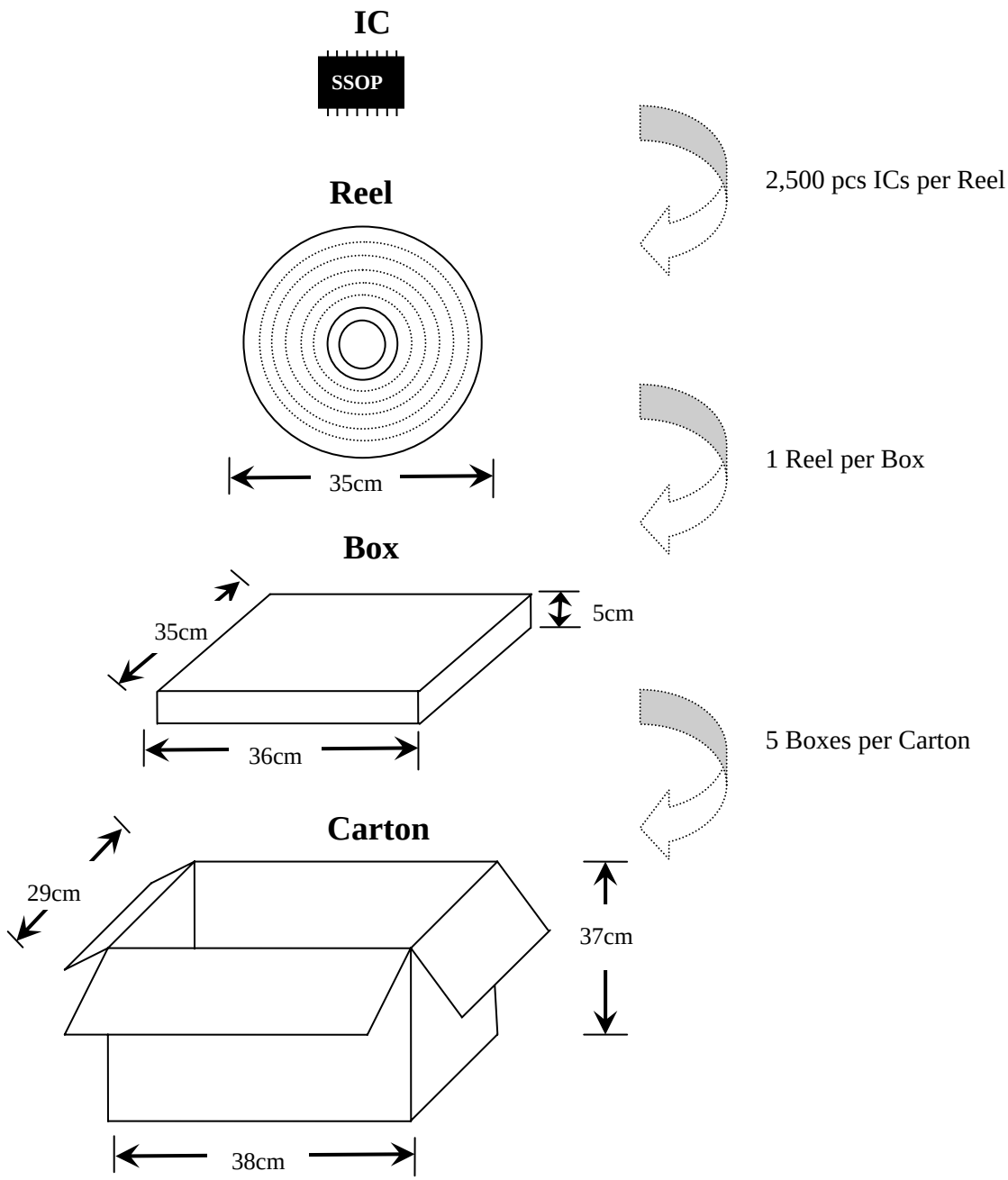


Weight

Item	Description	Weight (Kg)
1	100 pcs DM11C-SSOP per Tube	0.0171±5%
2	Net Weight of one Box	0.40±5%
3	Net Weight of one Carton	1.44±5%
4	Per Carton Set (6 Boxes, 60,000 pcs)	14.1±5%

DM11C-SSOP Package and Weight

SSOP16 - 150 - 0.635



Weight

Item	Description	Weight (Kg)
1	2,500 pcs DM11C-SSOP per Reel	0.86±5%
2	Net Weight of one Box	0.24±5%
3	Net Weight of one Carton	0.90±5%
4	Per Carton Set (5 Boxes, 12,500 pcs)	6.4±5%

Product Ordering Information

Part Number	Package Type	Number / Weight (typ.)	
		Tube / Tray	Reel (Box included)
DM11C-DIP	DIP16-300-2.54	30pcs / Tube 0.06kg ± 5%	—
DM11C-SOP	SOP16-150-1.25	50pcs / Tube 0.0175kg ± 5%	2,500pcs / Reel 1.1kg ± 5%
DM11C-SSOP	SSOP16-150-0.635	100pcs / Tube 0.0171 kg± 5%	2,500pcs / Reel 0.86kg ± 5%

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