# DM13A

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## *16-bit Constant Current LED Driver*

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# DM13A

## 16-bit Constant Current LED Driver

### General Description

DM13A 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.

### Features

- Constant-current outputs: 3mA to 60mA adjustable by one external resistor
- Maximum output voltage: 17V
- Maximum clock frequency: 25MHz
- Power supply voltage: 3.3V to 5V
- In-rush current control
- Bit-to-bit skew : ± 3 %  Chip-to-chip skew : ± 6 %
- Package and pin assignment compatible to conventional LED drivers (ST2221C, DM134/5/6)

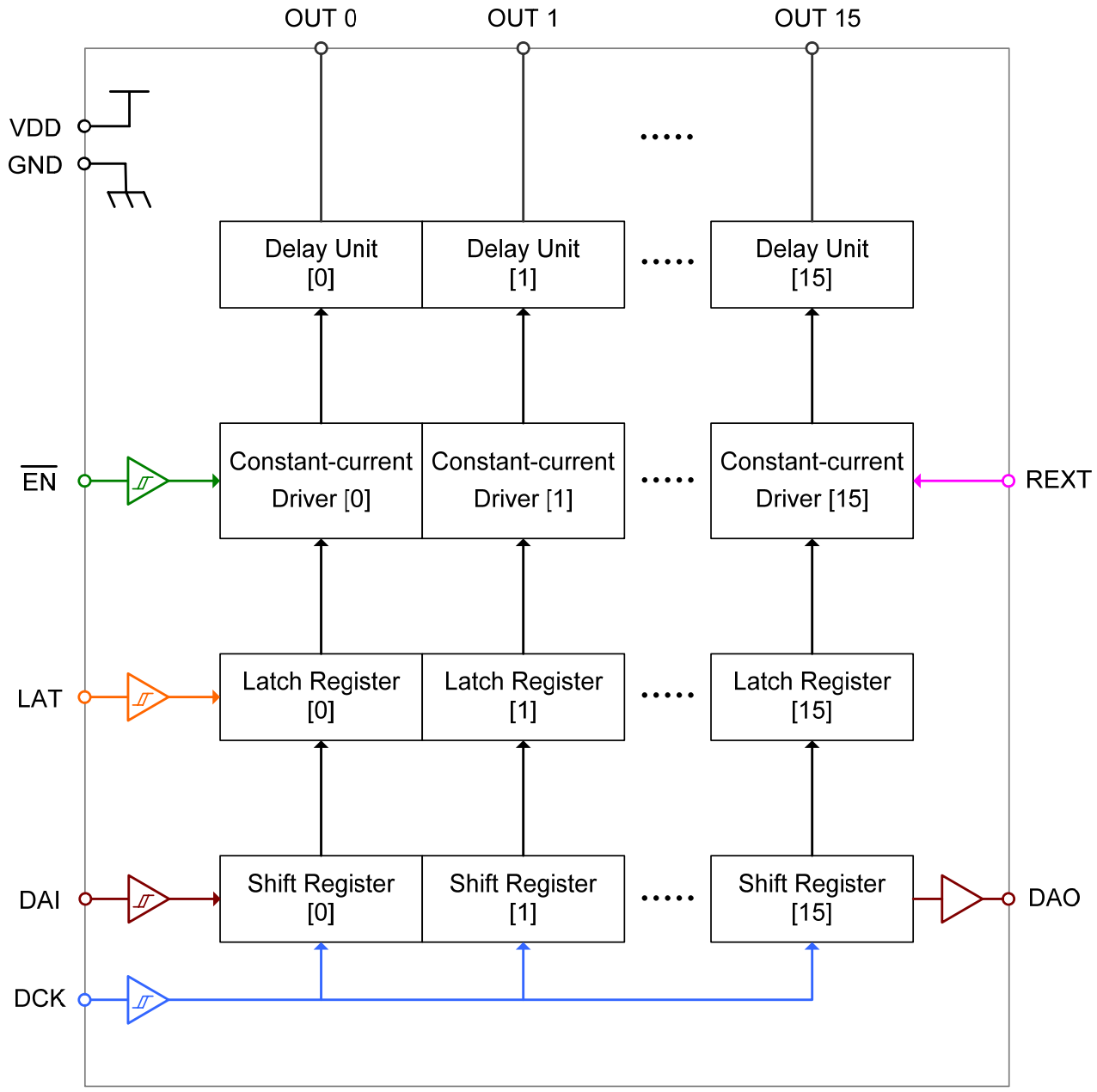
### Applications

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

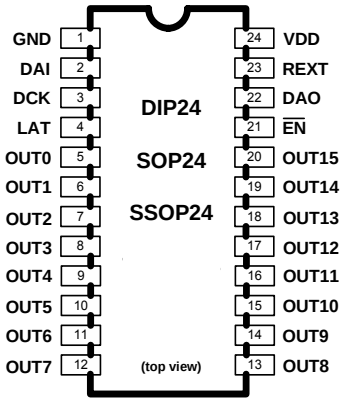
### Package Types

- PDIP24, SOP24, SOP24B, SSOP24

## Block Diagram



## Pin Connection

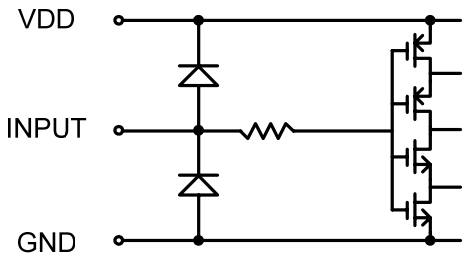



## Pin Description

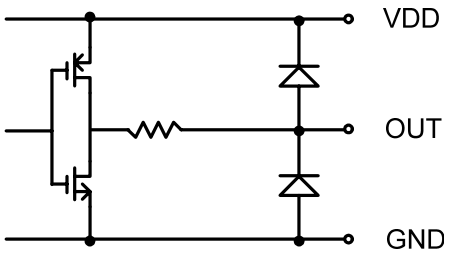
| PIN No. | PIN NAME | FUNCTION |
|---|---|---|
| DIP24/SOP24/SSOP24: 1 | GND | Ground terminal. |
| DIP24/SOP24/SSOP24: 2 | DAI | Serial data input terminal. |
| DIP24/SOP24/SSOP24: 3 | DCK | Synchronous clock input terminal for serial data transfer. Data is sampled at the rising edge of DCK. |
| DIP24/SOP24/SSOP24: 4 | LAT | Input terminal of data strobe. Data on shift register goes through at the high level of LAT (level trigger). Otherwise, data is latched. |
| DIP24/SOP24/SSOP24: 5~20 | OUT0~15 | Sink constant-current outputs (open-drain). |
| DIP24/SOP24/SSOP24: 21 | $\overline{EN}$ | Output enable terminal:<br>**'H'** for all outputs are turned off ,<br>**'L'** for all outputs are active. |
| DIP24/SOP24/SSOP24: 22 | DAO | Serial data output terminal. |
| DIP24/SOP24/SSOP24: 23 | REXT | External resistors connected between REXT and GND for output current value setting. |
| DIP24/SOP24/SSOP24: 24 | VDD | Supply voltage terminal. |

# Equivalent Circuit of Inputs and Outputs

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




## 2. DAO terminals



## Maximum Ratings[*1] (Ta=25°C, 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 |
| Input Clock Frequency | FDCK | 25 | MHz |
| GND Terminal Current | IGND | 1500 | mA |
| Power Dissipation (4 layer PCB) | PD | 1.90 ( PDIP24 : Ta=25°C) | W |
| | | 1.20 ( SOP24 : Ta=25°C) | |
| | | TBD( SOP24B : Ta=25°C) | |
| | | 1.05 ( SSOP24 : Ta=25°C) | |
| Thermal Resistance | Rth(j-a) | 50.0 (PDIP24 ) | °C/W |
| | | TBD ( SOP24B) | |
| | | 79.2 (SOP24 ) | |
| | | 90.2 (SSOP24 ) | |
| 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 | — | 3.3 | 5.0 | 5.5 | V |
| Output Voltage | VOUT | Driver On[*2] | 1.0 | — | 0.5VDD | V |
| Output Voltage | VOUT | Driver Off[*3] | — | — | 17 | |
| Output Current | IO | OUTn | 5 | — | 60 | mA |
| | IOH | VOH = VDD – 0.2 V | — | — | +1.2 | |
| | IOL | VOL = 0.2 V | — | — | −1.4 | |
| Input Voltage | VIH | VDD = 3.3 V ~ 5.5V | 0.8VDD | — | VDD | V |
| | VIL | | 0.0 | — | 0.2VDD | |
| Input Clock Frequency | FDCK | Single Chip Operation | — | — | 25 | MHz |
| LAT Pulse Width | tw LAT | VDD = 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 | — | — | |

[*1] Stress beyond those listed under “Maximum Ratings” may cause permanent damage to the device. These are stress ratings only; it’s not implied functional operation condition. Exposure to “Maximum Ratings” conditions for extended periods may affect device reliability and life time.
[*2] Notice that the power dissipation is limited to its package and ambient temperature.
[*3] The driver output voltage including any overshoot stress has to be compliant with the maximum voltage (17V).

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

| CHARACTERISTIC | SYMBOL | CONDITION | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| Input Voltage "H" Level | VIH | CMOS logic level | 0.8VDD | — | VDD | V |
| Input Voltage "L" Level | VIL | CMOS logics2 level | GND | — | 0.2VDD | |
| Output Leakage Current | IOL | VOH = 17 V | — | — | ±1.0 | uA |
| Output Voltage (DAO) | VOL | IOL = 1.5 mA | — | — | 0.2 | V |
| | VOH | IOH= 1.4 mA | VDD-0.2 | — | — | |
| Output Current Skew (Channel-to-Channel) *1 | IOL1 | VOUT = 1.0 V Rrext = 2.2KΩ | — | — | ±3 | % |
| Output Current Skew (Chip-to-Chip) *2 | IOL2 | | — | — | ±6 | % |
| Output Voltage Regulation | % / VOUT | Rrext = 2.2KΩ VOUT = 1 V ~ 3 V | — | ±0.1 | ±0.5 | % / V |
| Supply Voltage Regulation | % / VDD | Rrext = 2.2 KΩ | — | ±1 | ±4 | |
| Supply Current *3 | $I_{DD(off)}$ | power on all pins are open unless VDD and GND | — | 3 | 4 | mA |
| | $I_{DD(off)}$ | input signal is static Rrext = 2.9 KΩ all outputs turn off | — | 5 | 6 | |
| | $I_{DD(on)}$ | input signal is static Rrext = 2.9 KΩ all outputs turn on | — | 5 | 6 | |
| | $I_{DD(off)}$ | input signal is static Rrext = 1.05K Ω all outputs turn off | — | 9 | 10 | |
| | $I_{DD(on)}$ | input signal is static Rrext = 1.05K Ω all outputs turn on | — | 9 | 10 | |

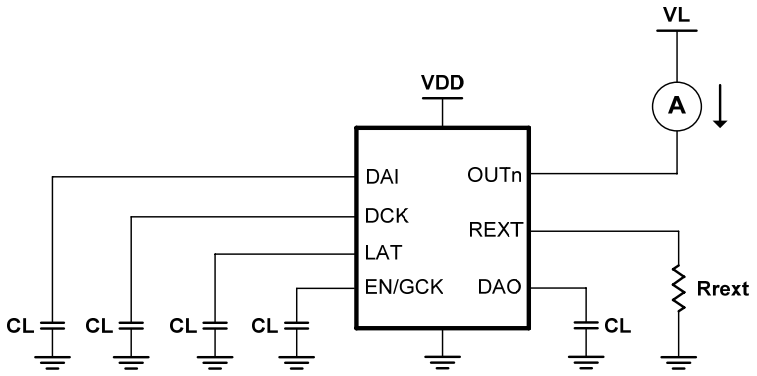
*1 Channel-to-channel skew is defined as the ratio between (any Iout – average Iout) and average Iout, where average Iout = (Imax + Imin) / 2.
*2 Chip-to-Chip skew is defined as the range into which any output current of any IC falls.
*3 IO excluded.

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

| CHARACTERISTIC | | SYMBOL | CONDITION | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|---|
| Propagation Delay ('L' to 'H') | EN-to-OUT0 | tpLH | VIH = VDD<br>VIL = GND<br>Rrext = 2.2KΩ<br>VL = 5.0 V<br>CL*1 = 13 pF | — | 52 | — | ns |
| | LAT-to-OUT0 | | | — | 49 | — | |
| | DCK-to-DAO | | | — | 20 | — | |
| Propagation Delay ('H' to 'L') | EN-to-OUT0 | tpHL | | — | 22 | — | |
| | LAT-to-OUT0 | | | — | 75 | — | |
| | DCK-to-DAO | | | — | 19.5 | — | |
| Output Current Rise Time | | tor | | — | 33.5 | — | |
| Output Current Fall Time | | tof | | — | 6 | — | |
| Output Delay Time ($OUT_{(n)}$-to-$OUT_{(n+1)}$) | | tod | | — | 5 | — | |

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

| CHARACTERISTIC | | SYMBOL | CONDITION | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|---|
| Propagation Delay ('L' to 'H') | EN-to-OUT0 | tpLH | VIH = VDD<br>VIL = GND<br>Rrext = 2.2KΩ<br>VL = 5.0 V<br>CL*1 = 13 pF | — | 51 | — | ns |
| | LAT-to-OUT0 | | | — | 21.5 | — | |
| | DCK-to-DAO | | | — | 12 | — | |
| Propagation Delay ('H' to 'L') | EN-to-OUT0 | tpHL | | — | 23 | — | |
| | LAT-to-OUT0 | | | — | 49 | — | |
| | DCK-to-DAO | | | — | 11.5 | — | |
| Output Current Rise Time | | tor | | — | 35 | — | |
| Output Current Fall Time | | tof | | — | 10 | — | |
| Output Delay Time ($OUT_{(n)}$-to-$OUT_{(n+1)}$) | | tod | | — | 10 | — | |

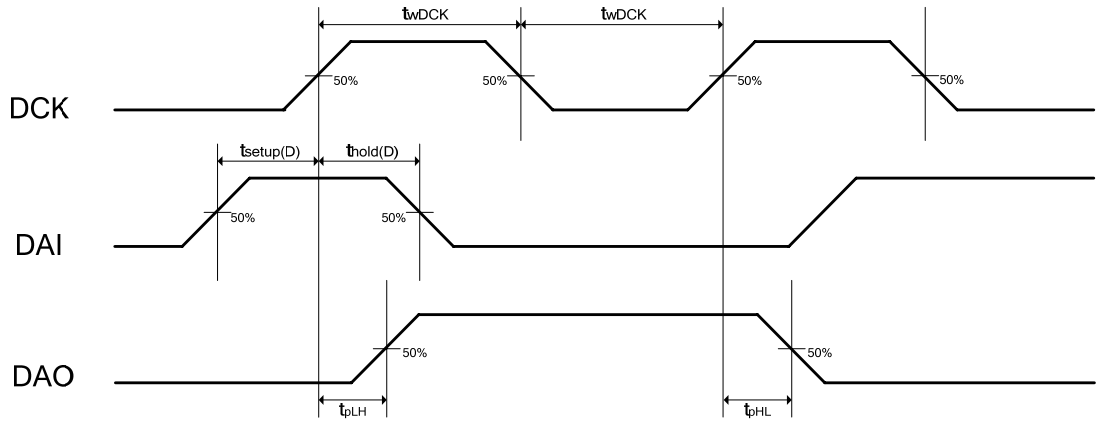



Switching Characteristics Test Circuit

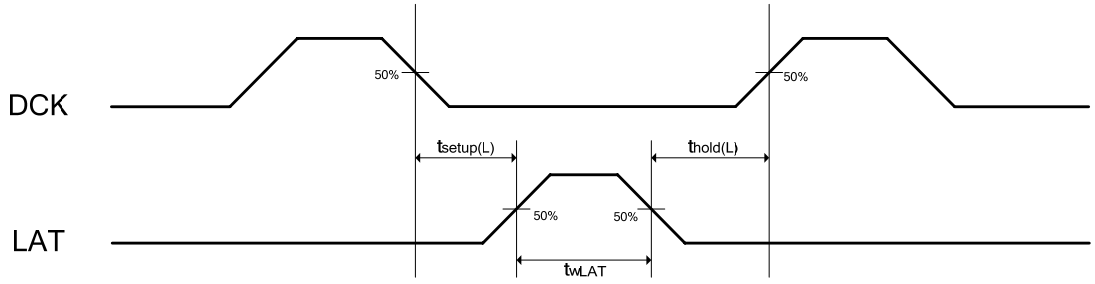
*1 CL means the probe capacitance of oscilloscope.

# Timing Diagram

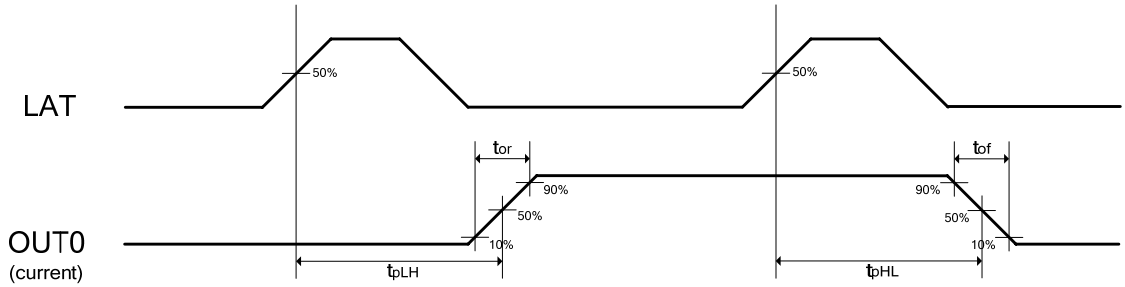
1. DCK-DAI, DAO



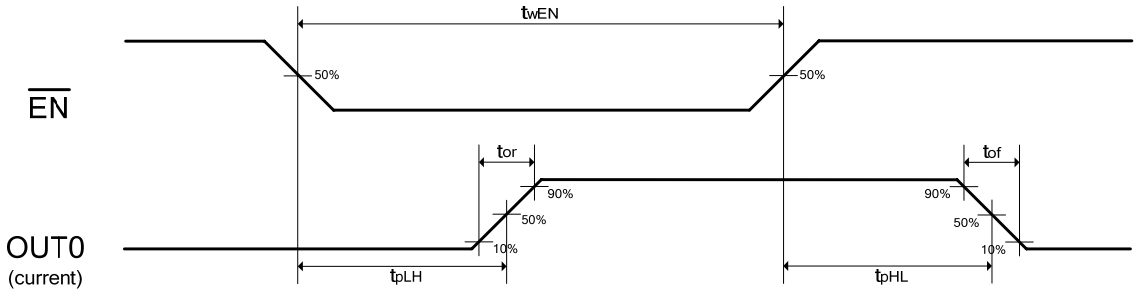

2. DCK-LAT



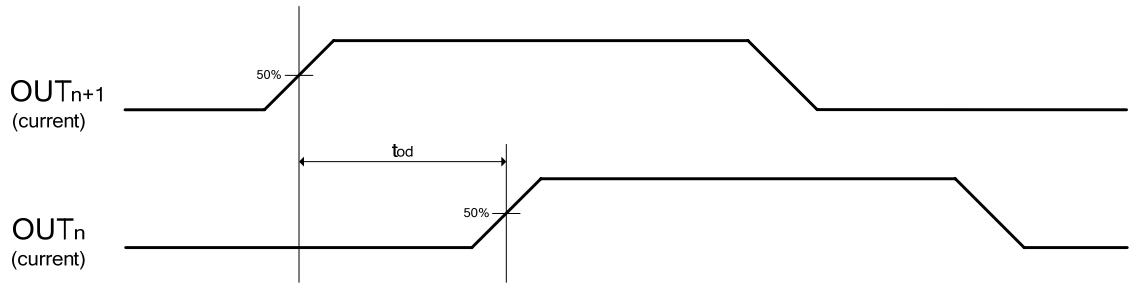

3. LAT-OUT0



4. $\overline{EN}$-OUT0




5. $OUT_{n+1}$-$OUT_n$

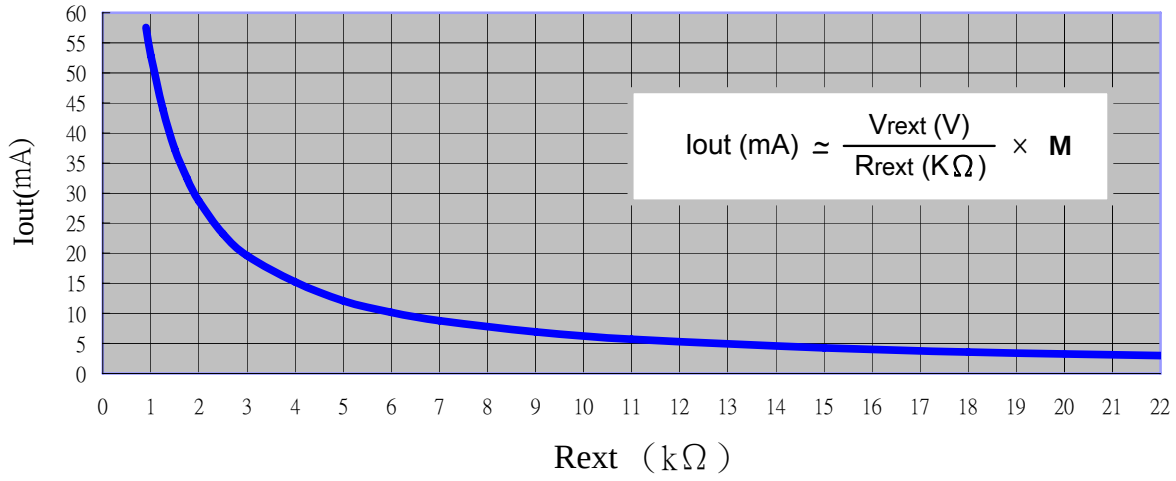


## Constant-Current Output

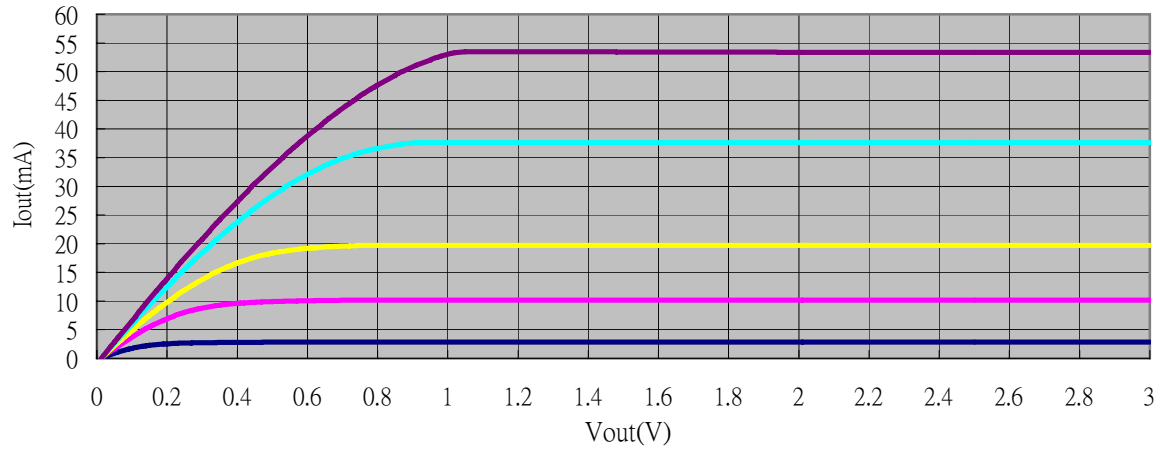
Constant-current value of each output channel is set by an external resistor connected between the REXT pin and GND. Varying the resistor value can adjust the current scale ranging from 3mA to 60mA. The reference voltage of REXT terminal (Vrext) is approximately 1.2V. The output current value is calculated roughly by the following equation:

| Iout(mA) | 3 | 5 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|
| **M** | 55 | 54.1 | 50 | 46.6 | 45 | 43.3 | 41.6 |

Output Current as a Function of Rrext value



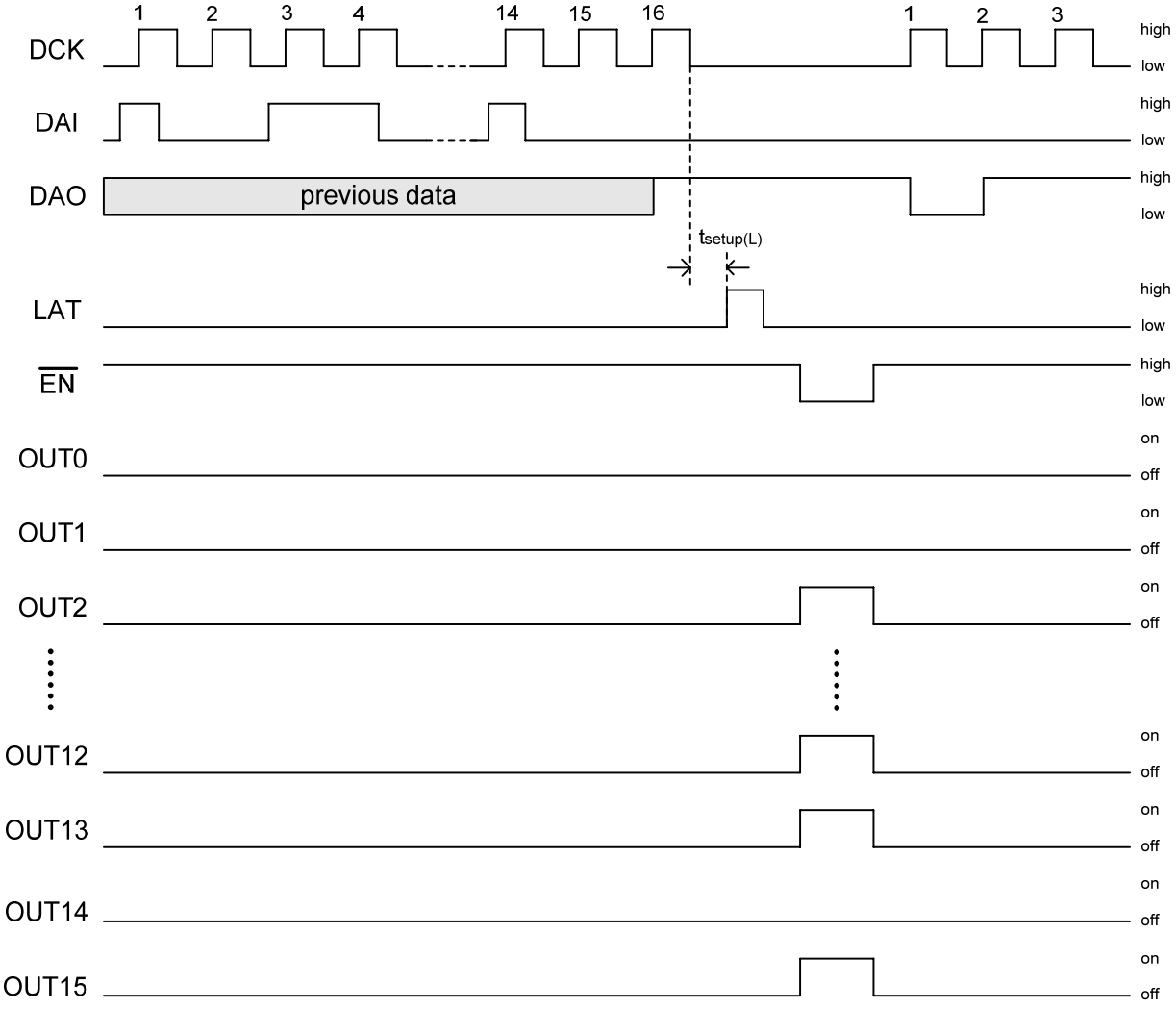

Output Current as a Function of Output Voltage




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 16 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 16 bit latch register when the strobe signal (LAT) is ‘H’ (level trigger); otherwise, the data will be held. 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.

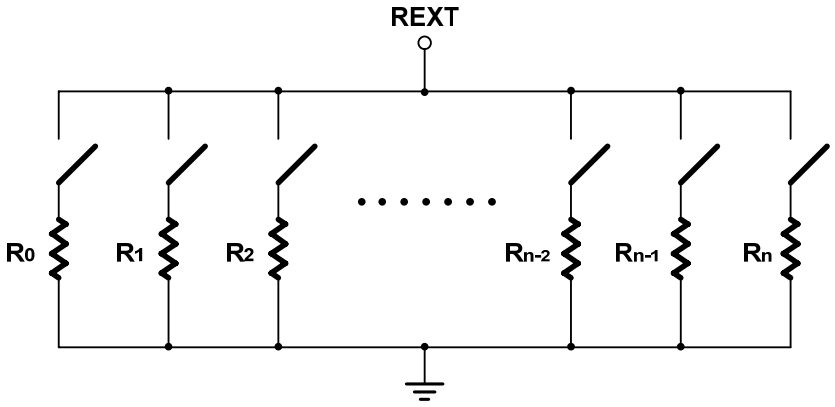


## Outputs Delay

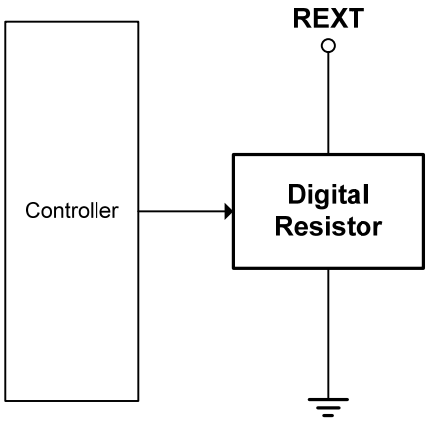
Large in-rush currents will occur when the system activates all the outputs at once. To reduce this effect, DM13A is designed to have a constant unit of delay (around 5ns) between outputs. The delay sequence for every output goes like this: OUT0 (no delay) → OUT15 → OUT1 → OUT14 → OUT2 → OUT13 → OUT3 → OUT12 → OUT4 → OUT11 → OUT5 → OUT10 → OUT6 → OUT9 → OUT7 → OUT8 (the largest delay).

## Global Brightness Control

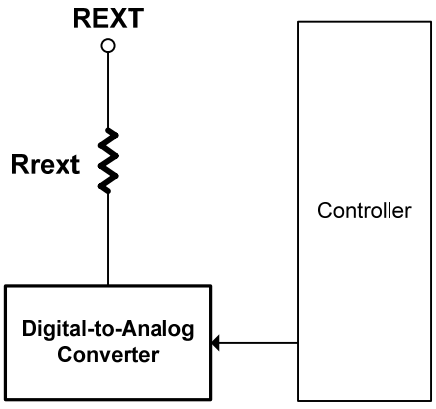
DM13A has no built-in global brightness control feature. In order to obtain a lower resolution of global brightness control effect, two methods could be utilized. One is providing PWM signal synchronized on latch pulse to modulate the output enable terminal ($\overline{EN}$ pin). The other is to adjust 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



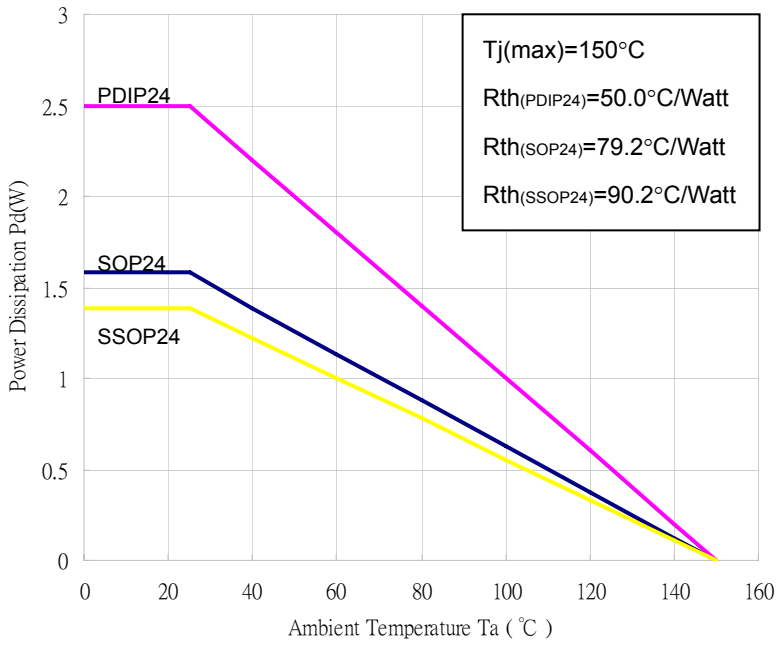

Global Brightness Control
with D/A converter

## 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:

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

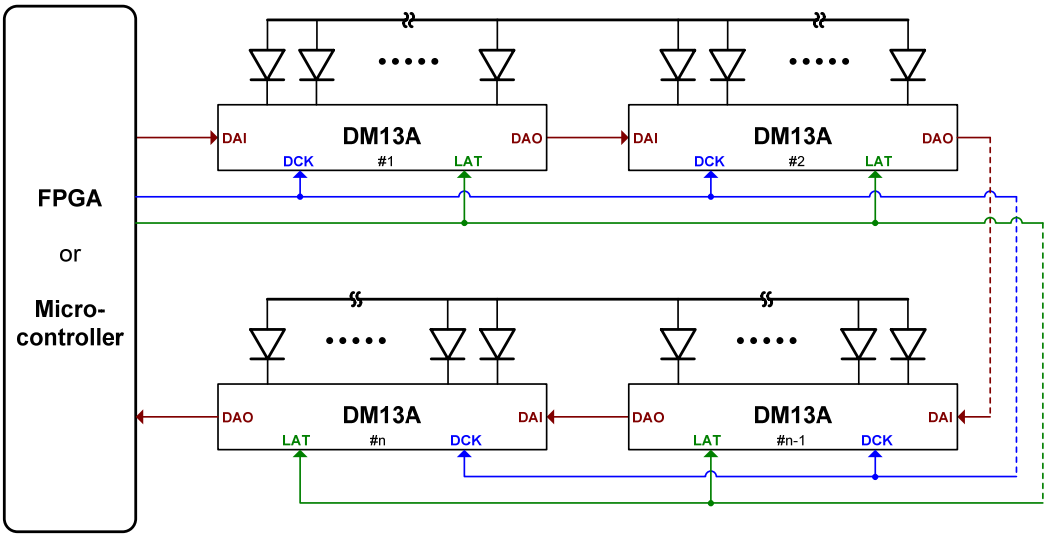
The relationship between power dissipation and operating temperature can be refer to the figure below:



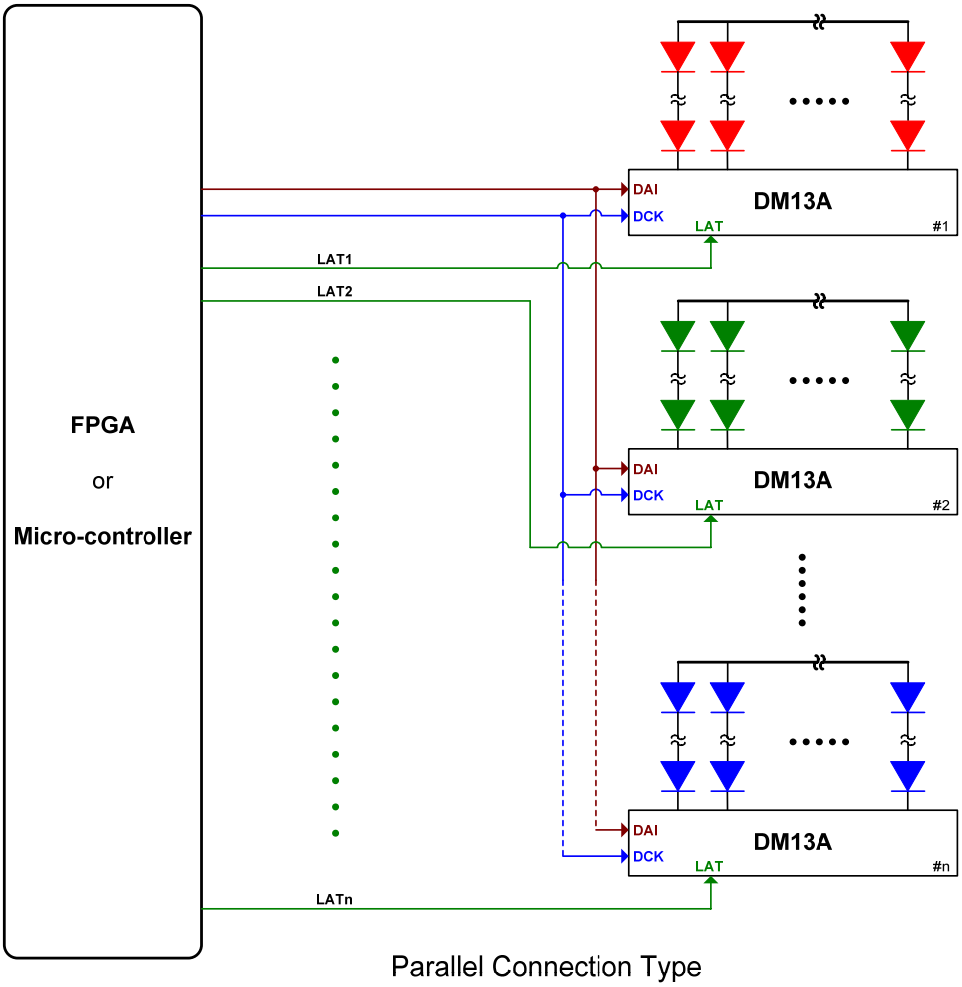

The power consumption of IC can be determined by the following equation and should be less than the maximum allowable power dissipation:

$$Pd(W) = V_{CC}(V) \times I_{DD}(A) + Vout0 \times Iout0 \times Duty0 + \cdots\cdots + Vout15 \times Iout15 \times Duty15 \leq Pd(max)(W)$$

## Typical Application



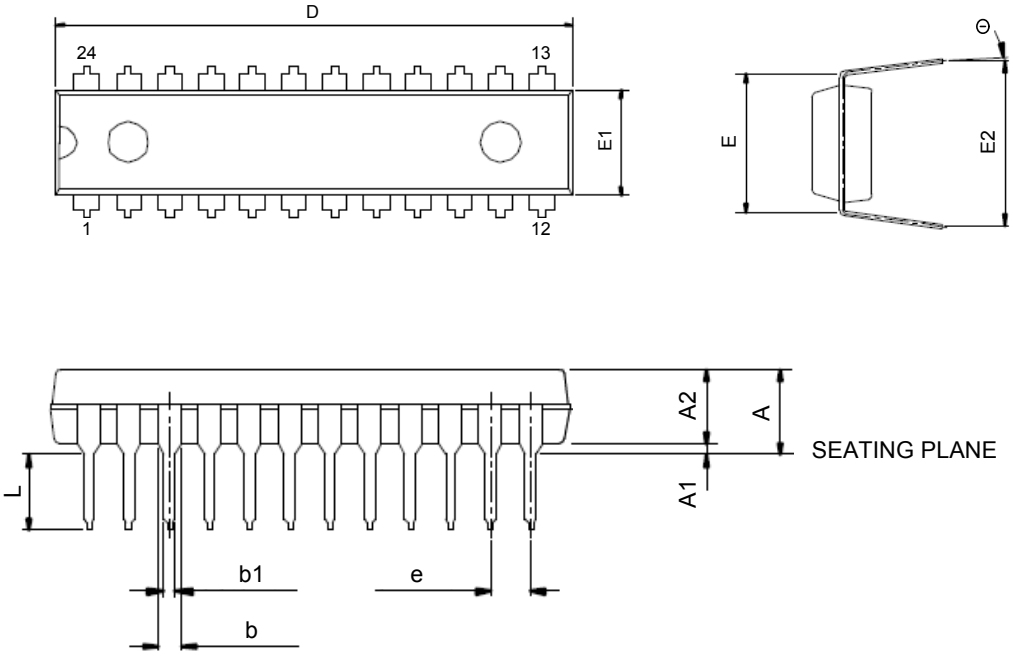

Serial Connection Type




Parallel Connection Type

# Package Outline Dimension

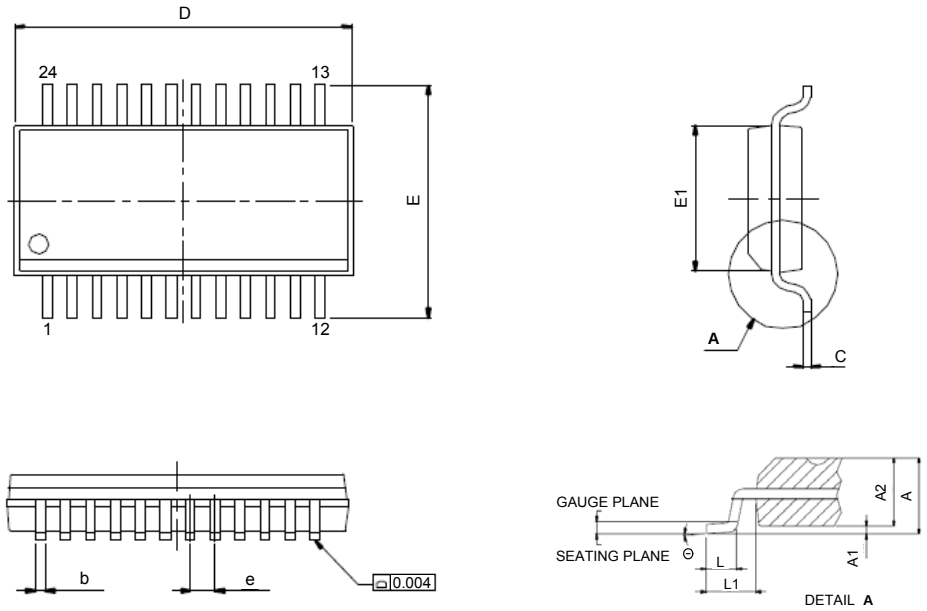
## *PDIP24*




| | DIMENSIONS IN INCH | | DIMENSIONS IN MM | |
|---|---|---|---|---|
| SYMBOLS | MIN. | MAX. | MIN. | MAX. |
| 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° |

# Package Outline Dimension

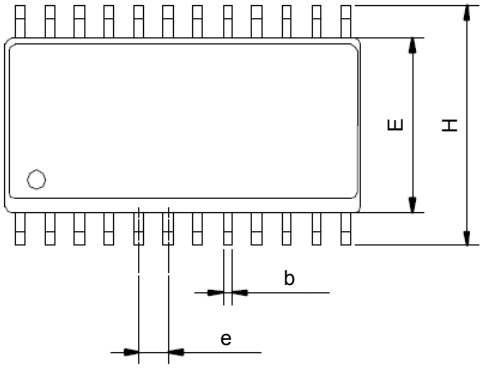
## *SSOP24*

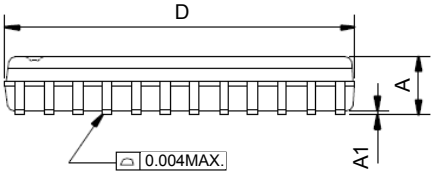


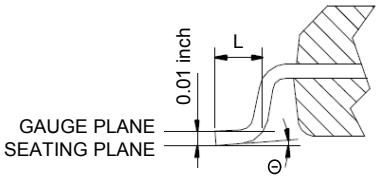

| | DIMENSIONS IN INCH | | DIMENSIONS IN MM | |
|---|---|---|---|---|
| SYMBOLS | MIN. | MAX. | MIN. | MAX. |
| A | 0.053 | 0.069 | 1.346 | 1.753 |
| A1 | 0.004 | 0.010 | 0.102 | 0.254 |
| A2 | - | 0.059 | - | 1.499 |
| b | 0.008 | 0.012 | 0.203 | 0.305 |
| C | 0.007 | 0.010 | 0.178 | 0.254 |
| D | 0.337 | 0.344 | 8.560 | 8.738 |
| E | 0.228 | 0.244 | 5.791 | 6.198 |
| E1 | 0.150 | 0.157 | 3.810 | 3.988 |
| e | 0.025TYP. | | 0.635TYP. | |
| L | 0.016 | 0.050 | 0.406 | 1.270 |
| L1 | 0.041TYP. | | 1.041TYP. | |
| Θ | 0° | 8° | 0° | 8° |

# Package Outline Dimension

## *SOP24*



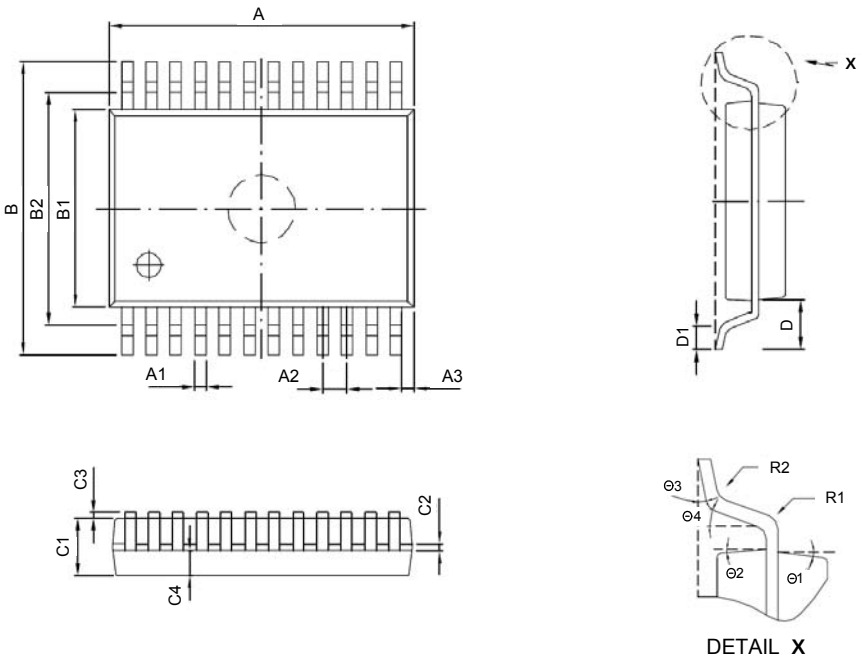




| | DIMENSIONS IN INCH | | DIMENSIONS IN MM | |
|---|---|---|---|---|
| SYMBOLS | MIN. | MAX. | MIN. | MAX. |
| A | 0.093 | 0.104 | 2.362 | 2.642 |
| A1 | 0.004 | 0.012 | 0.102 | 0.305 |
| b | 0.016TYP. | | 0.406TYP. | |
| D | 0.599 | 0.614 | 15.215 | 15.596 |
| E | 0.291 | 0.299 | 7.391 | 7.595 |
| 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° |

# Package Outline Dimension

## *SOP24B*




| | DIMENSIONS IN INCH | | DIMENSIONS IN MM | |
|---|---|---|---|---|
| SYMBOLS | MIN. | MAX. | MIN. | MAX. |
| A | 0.508 | 0.516 | 12.9 | 13.1 |
| A1 | 0.012 | 0.020 | 0.30 | 0.50 |
| A2 | 0.039TYP. | | 1.00TYP. | |
| A3 | 0.031 | | 0.80TYP. | |
| B | 0.299 | 0.323 | 7.60 | 8.20 |
| B1 | 0.232 | 0.240 | 5.90 | 6.10 |
| B2 | 0.300TYP. | | 7.62TYP. | |
| C | - | 0.087 | - | 2.20 |
| C1 | 0.067 | 0.075 | 1.70 | 1.90 |
| C2 | 0.006 | 0.012 | 0.15 | 0.30 |
| C3 | 0.002 | 0.008 | 0.05 | 0.20 |
| C4 | 0.031TYP. | | 0.80TYP. | |
| D | 0.037TYP. | | 0.95TYP. | |
| D1 | 0.013 | 0.029 | 0.33 | 0.73 |
| R1 | 0.008TYP. | | 0.20TYP. | |
| R2 | 0.008TYP. | | 0.20TYP. | |
| Θ1 | 8°TYP | | 8°TYP | |
| Θ2 | 10°TYP | | 10°TYP | |
| Θ3 | 4°TYP | | 4°TYP | |
| Θ4 | 5°TYP | | 5°TYP | |

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.
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