TU8FA0109

TERACHIPS, Inc.

General Description

TU8FA0109 is a LED controller chip and it includes 16ch constant current driving circuit. So this chip is suitable for LED Video display, LED Sign Board and LED decorative lighting application.

Customer can set constant current level, which is applicable LED intensity for their application, within 5mA ~ 60mA by connecting external resistor to the REF pin.
Also this chip includes 256 step brightness controller and it can use 256 level global dimming control or Gray Scale control.

Besides this LED controller chips adopt our own Network controller technology, ELINTM, This network controller is very powerful and effective method for forming LED driver serial network chain and it can handle maximum 35Mbps data transfer rate.
In addition, this network controller include various network command set and register set which are very helpful for composing serial network chain effectively and easily.

Basically two signal lines (SCLKI, SDATI) are enough to make network chain and data transfer. So it's very helpful and cost saving way to make LED module and network chain. And then, we also adopt latch enable pin (LATCH).
Customer can enable or disable this latch enable by network command and if customer enabling this pin, then uploading time of PWM data will be synchronized with signal which is enforced by latch enable pin. This method is very good way to remove incident image as like LED Video display application.

The thermal detector trigger system reset if the chip junction temperature over around 150℃ and release system reset if operating temperature falls below around 90℃ to prevent thermal damage to the LED driver chip. Also customer can enable or disable thermal detection function by network command set.

With LED open detection, TU8FA0109 can detect LED open status by respectively without extra component. If LED open detection network command are applied to SDATI pin, then this command are propagate to each LED driver IC and check the LED open status individually. After individual chip finish to check LED open status, it transfer LED open status through network chain (feed back loop). So customer can verify which ID and which channel of LED are open.

The Key Features of TU8FA0109

- Analog Part

* 7.3Mhz Internal RC Oscillator
* Maximum Synchronous Clock : 35Mhz
* Power On Reset and Low Voltage Detector
* Internal Thermal Detector and Shutdown
    * Shutdown > 150℃ , Release < 90℃
* 60mA Constant Current Driver (REF = 20KΩ)
    * Current Fine Tuning can be executed by external resistors. (REF pin)
* Constant Current Accuracy
    * Between Channels : ± 1.5% (typ), ± 3% (max)
    * Between Chips : ± 6% (max)
* Support Up to 27V LED Power
* LED Open Detection to detect LED errors for each channel
* 256 Level Global Brightness Control (Analog Dimming control)
* Communication Line Observer Reset (Watch Dog Function)

- Control Part

* Max 40 Mbps Enhanced Local Interconnect Network (ELIN ™)
    * Software selectable data bandwidth (8bit or 12bit)
    * Need 4 wires (H_VDD, VSS, SCLKI, SDATI) to form network
    * Support Total 65536 devices for one serial Network.
* 12bit x 16 Advanced Pulse Width Modulator (APWM ™) to improve refresh rate and reducing Flicker noise.
* Staggered LED output to reduce EMI noise and power fluctuation during data change
* Built in buffer for data to next driver

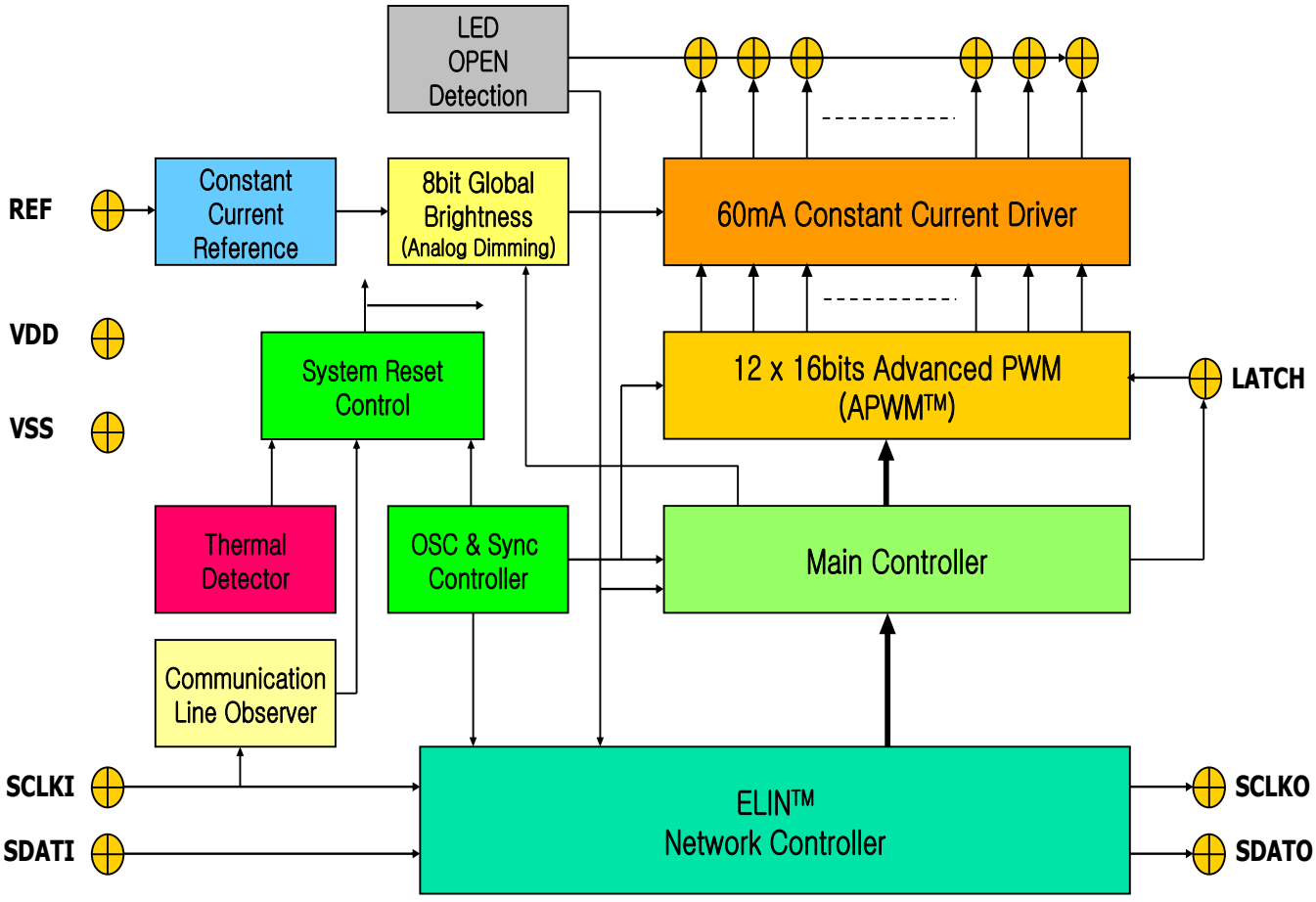
- Package

* 24SSOP

- Major Application

* LED Decorative Lighting
* Outdoor/Indoor LED Video
* Message Display

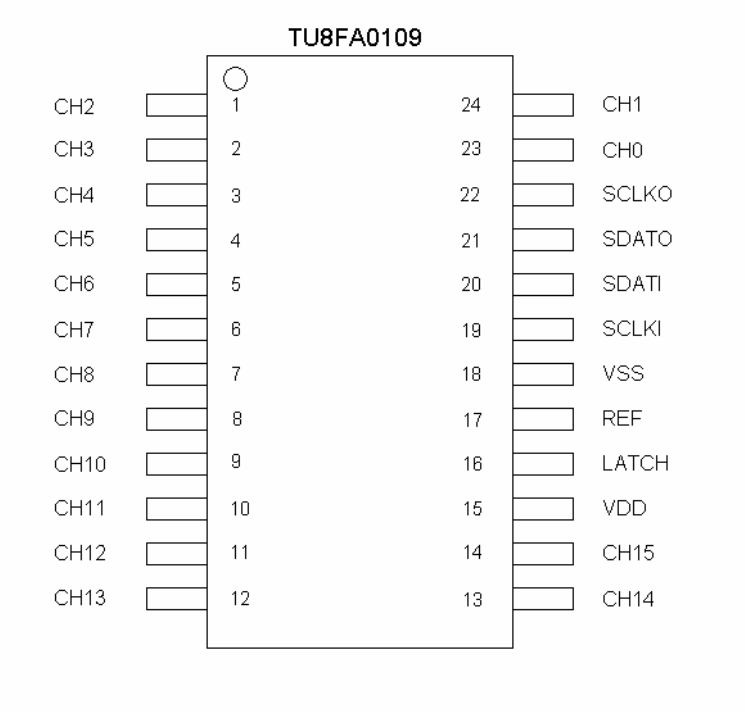
Block Diagram



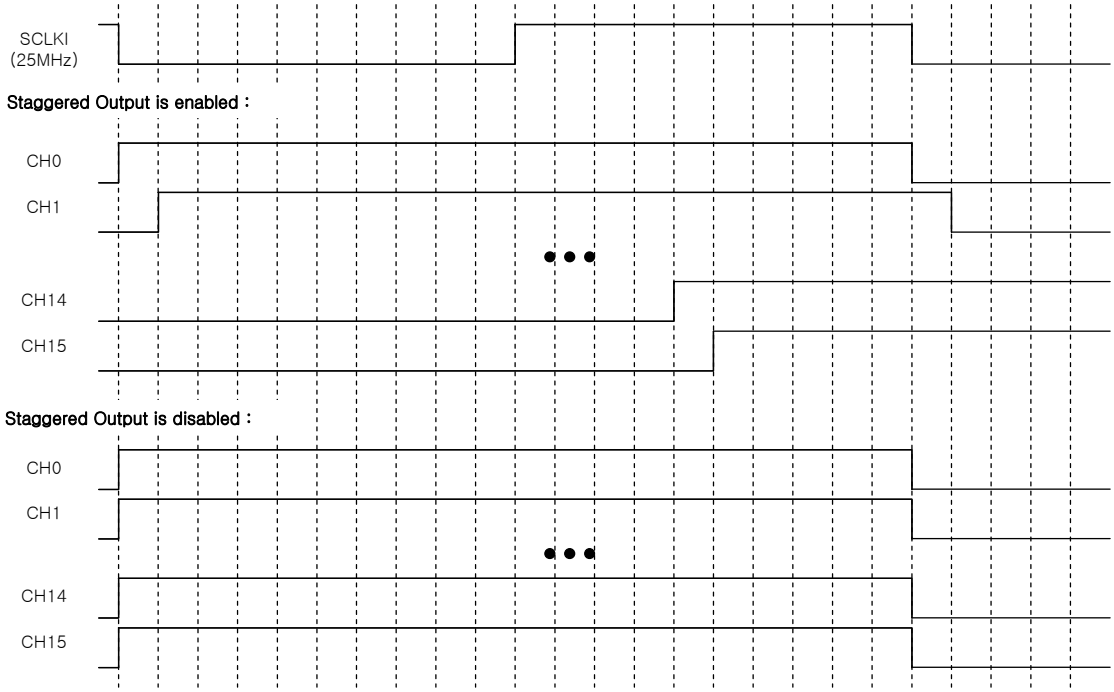
Pin Descriptions

Pin Number (24 PIN)	Name	Type	Description
1	CH2	Analog	Constant Current Driver CH2
2	CH3	Analog	Constant Current Driver CH3
3	CH4	Analog	Constant Current Driver CH4
4	CH5	Analog	Constant Current Driver CH5
5	CH6	Analog	Constant Current Driver CH6
6	CH7	Analog	Constant Current Driver CH7
7	CH8	Analog	Constant Current Driver CH8
8	CH9	Analog	Constant Current Driver CH9
9	CH10	Analog	Constant Current Driver CH10
10	CH11	Analog	Constant Current Driver CH11
11	CH12	Analog	Constant Current Driver CH12
12	CH13	Analog	Constant Current Driver CH13
13	CH14	Analog	Constant Current Driver CH14
14	CH15	Analog	Constant Current Driver CH15
15	VDD	Power	System Supply Voltage (3.3V ~ 5V)
16	LATCH	Input (PD)	Load Color Data into PWM
17	REF	Analog	External Resister Terminal for Constant Current Setting
18	VSS	Power	System Ground Power
19	SCLKI	Input (PU)	Serial Clock Input
20	SDATI	Input (PU)	Serial Data Input
21	SDATO	Output	Serial Data out
22	SCLKO	Output	Serial Clock out
23	CH0	Analog	Constant Current Driver CH0
24	CH1	Analog	Constant Current Driver CH1

Package Pin Drawing



Staggered Output control



TU8FA0109 has a built in delayed output control mechanism. LED output ports exist a graduated 1clock delay time among CH0 ~ CH15 by which the output ports will be turn on at a different time so that the instant current from the power line will be lowered.
User can enable or disable this staggered output function by register (PWMCON[7]) setting, using network command as like WRA, WRS.
Above Figure show the function of staggered output.

Constant Current Driver

TU8FA0109 support 60mA constant current driver. This driver are made with very stable analog circuit so theirs are very low current variation between channel by channel (± 3%) and chip by chip (± 6%)
The current characteristics of output are flat so the output current can be constant regardless of variation LED forward voltage (V_F).
This can be guarantee stable LED brightness as user's application.
Below figure is constant current characteristics of this device and user can refer this figure 1).

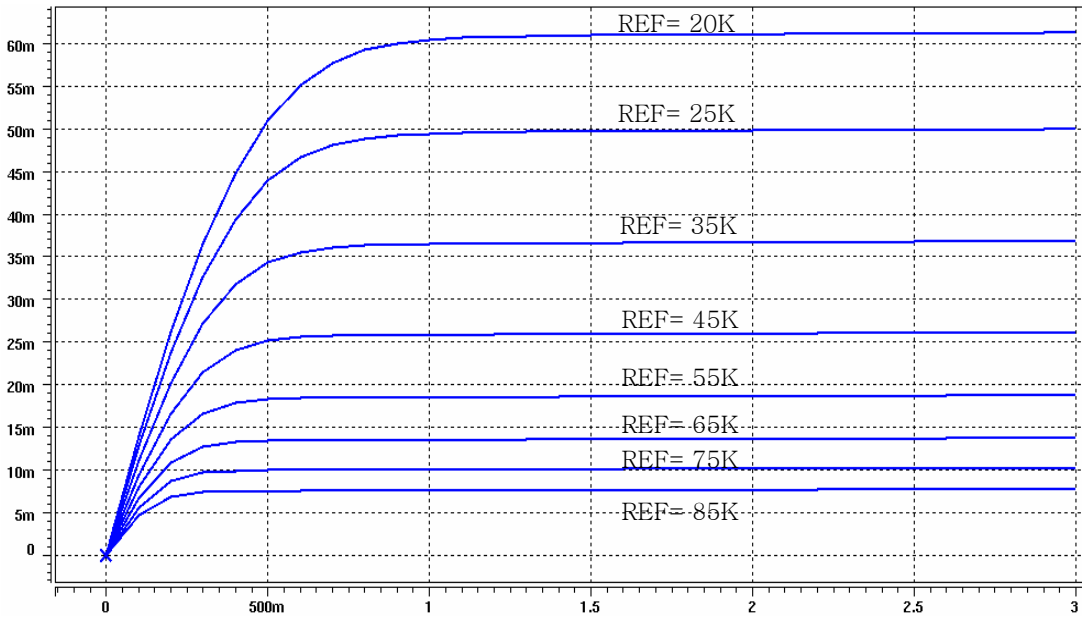


Fig 1) I_{OUT} vs V_{OUT} of TU8FA0109 at various Reference resistor values

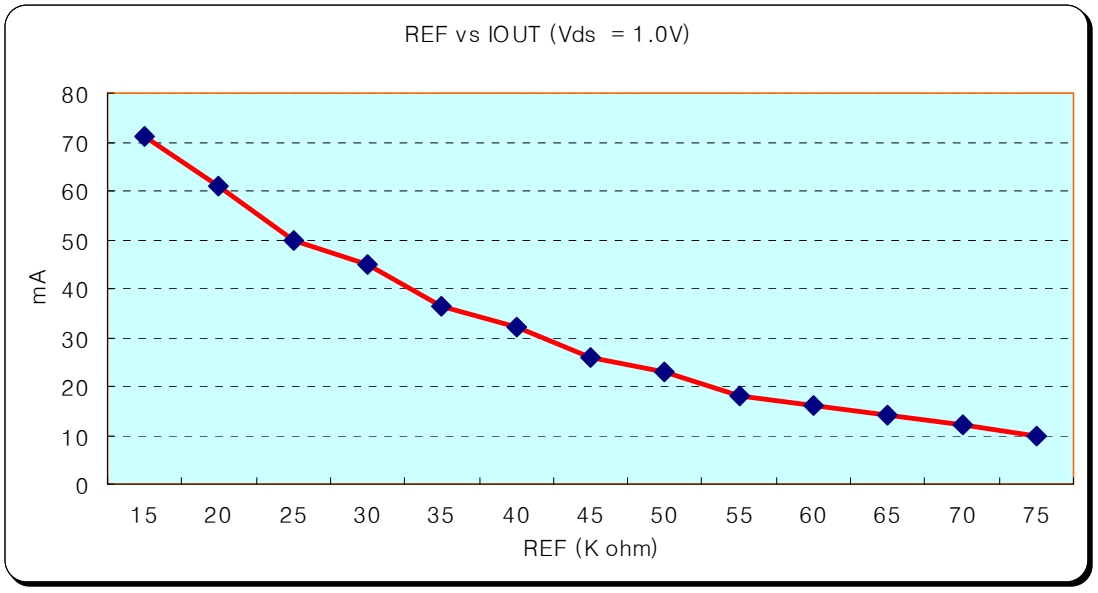


Fig 2) REF vs I_{OUT}

Setting Output Current

The Maximum current is set by external resistors (REF).
Once set, the maximum current remains constant regardless of the LED voltage variation, temperature or other parameter that could affect LED current.
The relationship between I_{OUT} and external resistor is shown in the above figure 2)
Also the output current can be roughly calculated from below equation.

- $I_{OUT} \fallingdotseq (V_{REF} \times 1000) / (REF)$
- $V_{REF} = 1.21V$
- Where V_{REF} is internal Bandgap reference voltage and REF is external Resistor to set maximum constant current

Global Brightness Control (Analog Dimming)

The global brightness control function can adjust global current of each LED channel.
The output current can be adjust in 256 step from ((1/256) * 100) % to 100% of maximum setting current. The following equation can calculate the global brightness current roughly.

- Iglobal $\fallingdotseq$ (BRIGHT[7:0] + 1) / 256 * Imax

Where BRIGHT[7:0] is brightness control register value
Imax is maximum LED output current

LED Voltage (Load Voltage)

LED Voltage is a supply source for LED driver and this supply voltage is applied to constant current driver (LED Driving Port) as like below equation.

- $V_{DS} = V_{LED}$ (Load Voltage) – $V_F \times N$ (number of serial LED) – V_{DROP}

The chip will be destroyed if V_{DS} is high to exceed Maximum Package Power

Dissipation (P_D). Preventing chip destruction by power dissipation, it is recommended to use the lowest possible V_{DS} power is applied to chip.

TU8FA0109 is designed to operate with adequate V_{DS} to achieve constant current around 0.7V ~ 1.2V range.

So user should to use voltage reducer as like Zener diode or resistor to reduce the V_{DS} voltage

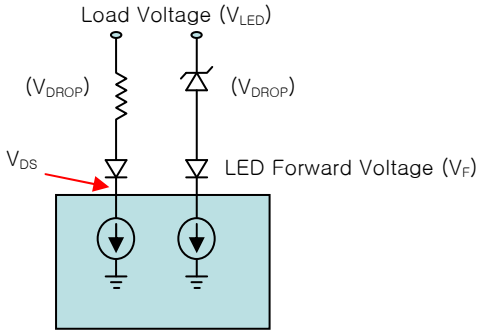


Fig 3) Load Voltage

OPEN CIRCUIT DETECTION

TU8FA0109 has a LED Open Detection circuit and it can detect LED open when loading status are changed by LED open.

When one of the LED becomes open circuit, it can behave as either an infinite resistance or a gradually increasing finite resistance. The TU8FA0109 monitors the current in each channel and if the Drain voltage (V_{DS}) down below the some level (0.3V typical), then it will set the LED Open detection status register “LODRES[15:0]”.

This LED open detector are operated, when setting Open detection master enable register “LODEN[7:0] and Open detection selection register LODSEL[15:0].

This error status can be read out using “RDS” command through the LODRES[15:0] registers.

For open circuit error detection, channel must be on and it will be controlled by setting LODSEL register. But to operate LED open detection, only 1 channel should be on during one time. So only set one channel at a time. (don’t set LODRES bit to “1” simultaneously)

Temperature Detection

The TU8FA0109 is equipped with a Temperature detector to protect thermal damage by overheat. When the Temperature detector reaches the trip temperature (around 150℃), system reset is happened and all channels are shut down. After system reset, the system automatically restart after cooling down (around 90℃).

To operate Thermal detector, customer enable thermal detection register (THERMEN[7:0]) by network command set as like WRA or WRS.

Package Power Dissipation (P_D)

The maximum allowable package power dissipation is determined as :

- $P_D(max) = (T_J - T_A) / R_{JA}$.

  (where T_J max = 150) (R_{JA} : package thermal resistance)

The actual package power dissipation is:

- $P_D(act) =$ (IDD x VDD) + (Iout x VDS x Duty x 16) Duty

where Duty is the PWM duty cycle for each channel.

When calculating power dissipation, the total number of available device outputs is usually used for the worst-case situation (displaying all 16 LEDs at 100% Duty Cycle).

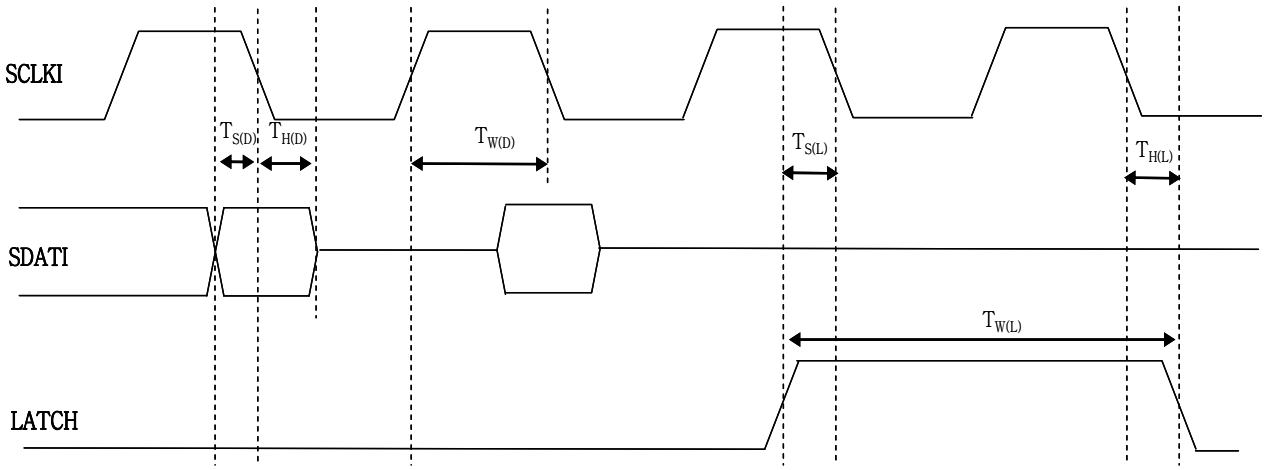
Absolute Maximum Ratings

Parameter	Symbol	Ratings	Unit
Power Supply Voltage	VDD	6.0	V
Operating Temperature	T_A	-40 ~ 85	℃
Storage Temperature	T_S	-55 ~ 150	℃
Junction Temperature	T_J	150	℃
Input Pin Voltage	V_{IN}	-0.3 ~ VDD + 0.3	V
Output Voltage at LED pin	V_{DS}	-0.5 ~ 30	V
Output Current at LED pin	I_{OUT}	90	mA
Clock Frequency (SCLKI)	F_{SCLKI}	35	MHz

DC Electrical Characteristics at T_A=25°C Typical Application, VDD=5V)

Parameter	Sym	Test Condition	Limits			Unit
			Min	Typ	Max	
Supply Voltage	VDD	Operating	3.0	5	5.5	V
Regulation Voltage	VDD1	VDD = 5V	3.0	3.3	3.6	V
Output Voltage	V_{OUT1}	LED Output			27	V
	V_{OUT2}	SDATO, SCLKO	VDD-0.3	VDD	VDD+0.3	V
Output Current	I_{OD}	LED output	5		60	mA
	I_{OH}	SDATO, SCLKO		24		mA
	I_{OL}	SDATO, SCLKO		-24		mA
Input Voltage	V_{IH}	Input Pins	0.7VDD	-	VDD	V
	V_{IL}	Input Pins			0.3VDD	V
Input Leakage	I_{IH}	Input Pins			0.5	uA
	I_{IL}	Input pins			0.5	uA
Output Leakage	I_{OLL1}	LED Output H_VDD=24V			0.5	uA
	I_{OLL2}	SDATO, SCLKO			0.5	uA
Supply Current	I_{DD1}	VDD=5V, REF=20K		10	TBD	mA
Output Current Skew (Channel To Channel)	I_{OS1}	REF=50K, IOUT= 20mA V_{DS}=1.0V	-3		+3	%
Output Current Skew (Chip to Chip)	I_{OS2}	REF=50K, IOUT=20mA V_{DS}=1.0V	-6		+6	%
Output Voltage vs Output Current regulation	%dVds	REF=50K, IOUT=20mA VDS = 1.0V ~ 3.0V		±0.1	±0.3	%/V
LED open detection Trip voltage	Lodt			0.3	0.4	V
Internal Oscillation Clock	F_{OSC}	VDD = 12V		7.3		Mhz
Thermal temperature	Ttd	Junction temperature		150		℃

AC Electrical Characteristics at TA=25°C Typical Application, VDD=3.3V)

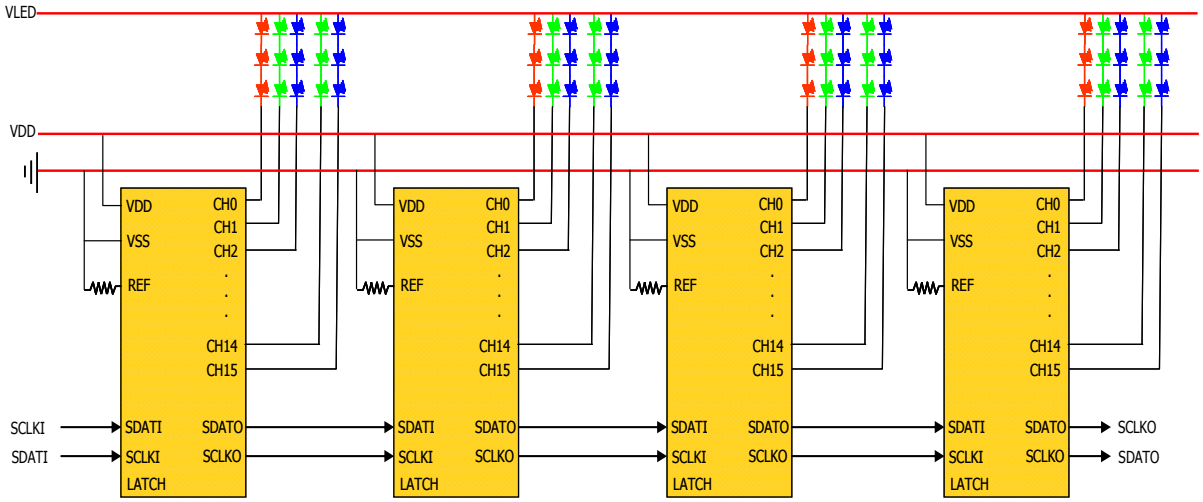


AC Timing Diagram

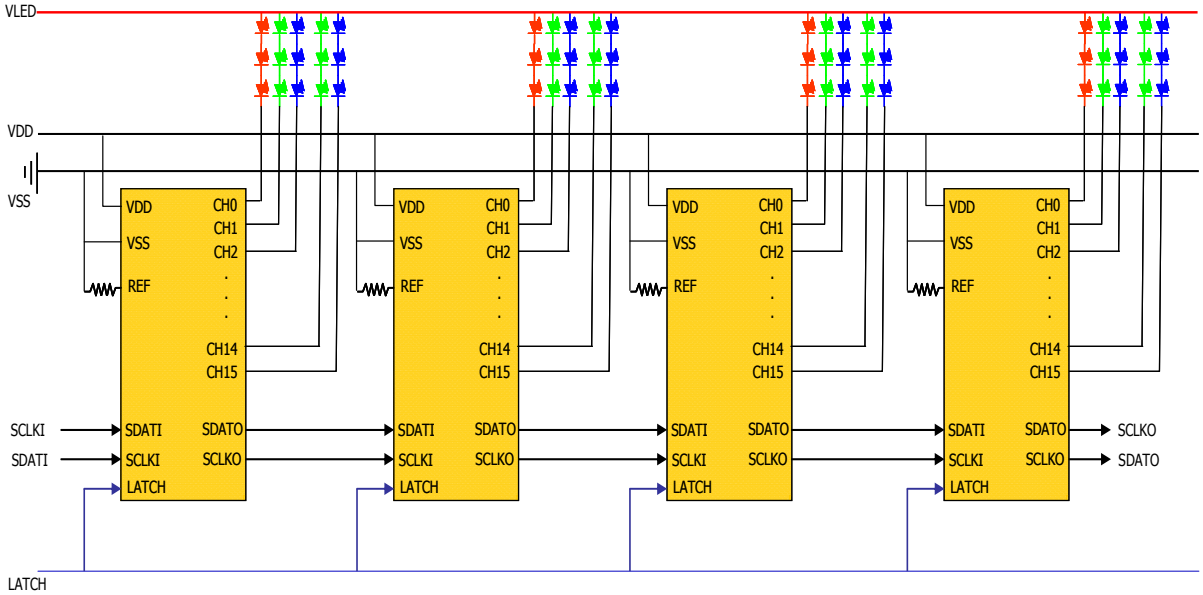
Parameter	Symbol		Min	Typ	Max	
Set Up Time for SDATI	$T_{S(D)}$	VDD = 5.	3			ns
Hold Time for SDATI	$T_{H(D)}$	V_{IH} = VDD.	3			ns
Setup Time for Latch	$T_{S(L)}$	V_{IL} = VSS	3			ns
Hold Time for Latch	$T_{H)L)}$	C_L=10pF	3			ns
Pulse Width	$T_{W(D)}$		14.3			ns
Duration for Latch	$T_{W(L)}$		2			SCLKI

Chip Application Diagram

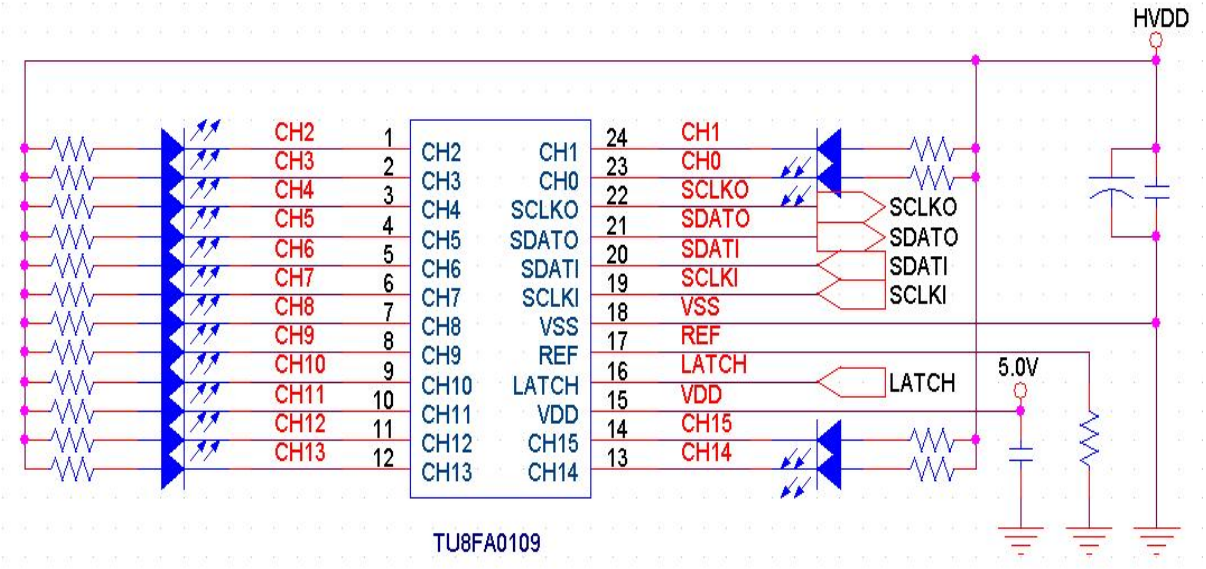
1) Latch Pin Disable



2) Latch Pin Enable



Chip Application Note



Package Dimension

Dimensions in milimeters/inches