

TU8FA0309AA



**TERACHIPS, Inc.**

## General Description

The TU8FA0309AA is a single networking color LED driver designed for LED decorative lighting and LED sign. Three channel constant current circuitry with current value set by three external resistors and Internal RC oscillator, 12bit PWM and Power On Reset, built in buffers for data to next driver and device controller are integrated into the chip. And then, it include wide range internal voltage regulator. So don't need to compose external voltage regulator to supply 3.3V device system power.

This LED driver includes RC oscillator, therefore only 3 lines (External High Voltage (H\_VDD), Ground (VSS) and Serial Data (SDATI)) are needed to connect between cluster and network line (Asynchronous Mode). This feature can reduce network lines.

This color LED drivers are connected cascade method via transmission line, which transmit data as like image or Text among cluster. So above feature can reduce network connection overhead and easy to make connection line.

In addition, this LED driver supports Synchronous Mode to enhance data transmission speed. In this Synchronous Mode, one more line is needed to receive synchronous clock (SCLKI). Therefore customer can choose Asynchronous or Synchronous Mode for their application by connecting MOD pin to VSS or VDD levels.

This TU8FA0309AA device is pin compatible with TU8FA0408AA device.

## The Key Features of TU8FA0309AA

### - Analog Part

- \* 7.3Mhz Internal RC Oscillator
- \* Maximum Synchronous Clock : 25Mhz (only used for Synchronous Mode)
- \* Power On Reset and Low Voltage Detector
- \* Wide range Internal Voltage Regulator (4V ~ 17V to 3.3V Regulation)
- \* 60mA Constant Current Driver (REF = 18K $\Omega$ )
  - \* Current Fine Tuning can be executed by external resistors.
- \* Constant Current Accuracy
  - \* Between Channels :  $\pm 1.5\%$  (typ),  $\pm 3\%$  (max)
  - \* Between Chips :  $\pm 6\%$  (max)
- \* Support Up to 27V LED Power
- \* LED Open Detection to detect LED errors for each channel. (R,G,B)

**- Control Part**

- \* Device Controller
- \* 420 Kbps Enhanced Local Interconnect Network (ELIN™(Mini), Asynchronous Mode)
  - \* Don't need external Sync clock
  - \* Only need 3 wires (H\_VDD, VSS, SDATI) to form network
  - \* Maximum distance between two clusters is 1M
  - \* It can compose up to 512 devices for one serial Network
- \* Max 25 Mbps Enhanced Local Interconnect Network (ELIN™(Mini), Synch Mode)
  - \* Need 4 wires (H\_VDD, VSS, SCLKI, SDATI) to form network
  - \* It can compose up to 512 devices for one serial Network.
- \* 12bit Advanced Pulse Width Modulator (APWM™) to improve refresh rate and reduce Flicker noise.
- \* Staggered LED output to reduce EMI noise and power fluctuation during data change
- \* Built in buffer for data to next driver

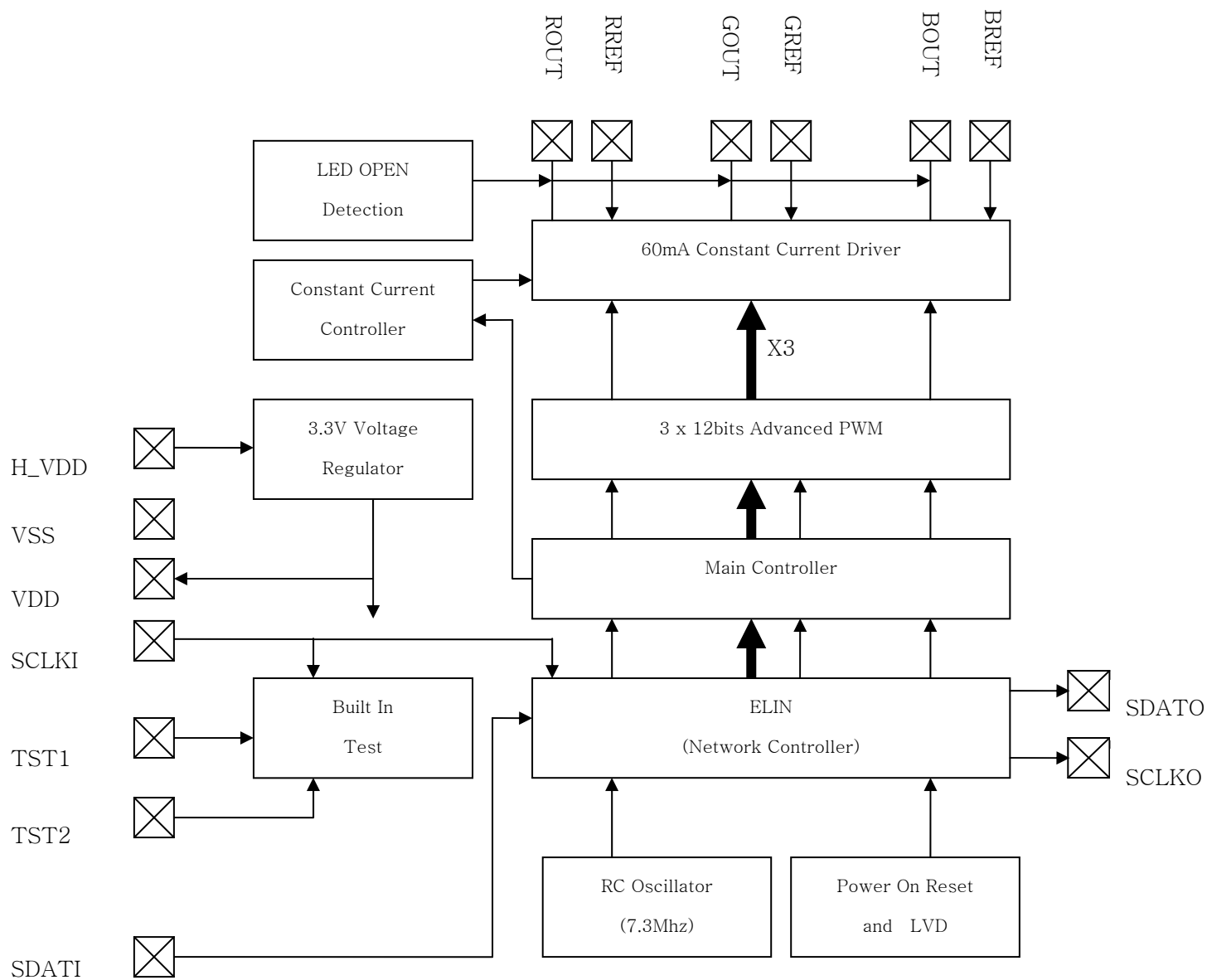
**- Package**

- \* 20SSOP

**- Major Application**

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

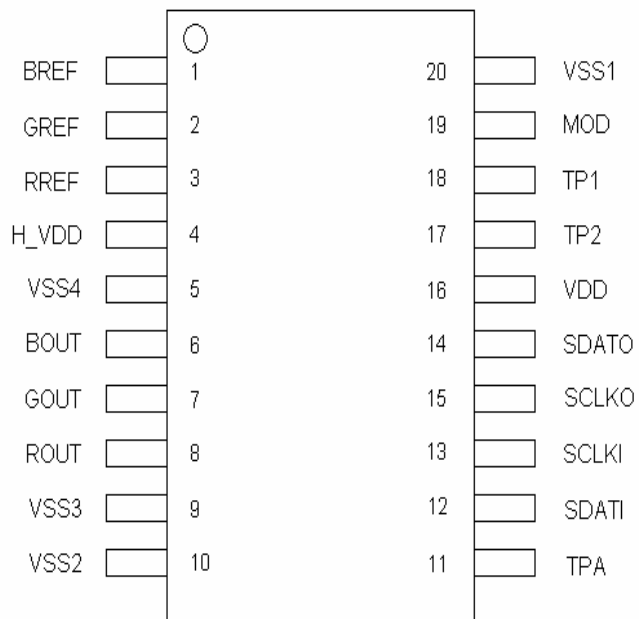
### Block Diagram



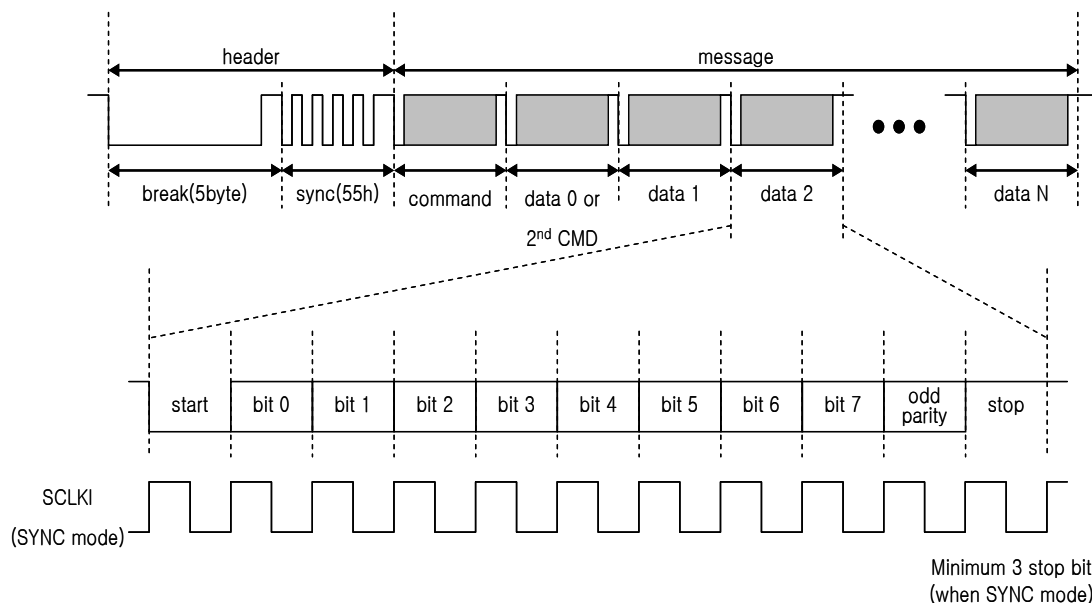
## Pin Descriptions

Pin Number (20 PIN)	Name	Type	Description
1	BREF	Analog	External Resister Terminal for Blue LED Current setting
2	GREF	Analog	External Resister Terminal for Green LED Current setting
3	RREF	Analog	External Resister Terminal for Red LED Current setting
4	H_VDD	Power	System Supply Voltage
5	VSS4	Power	System Ground 4
6	BOUT	Analog	Constant Current Output for Blue LED
7	GOUT	Analog	Constant Current Output for Green LED
8	ROUT	Analog	Constant Current Output for Red LED
9	VSS3	Power	System Ground 3
10	VSS2	Power	System Ground 2
11	TPA	Analog	Test Point for Analog
12	SDATI	Input (PU)	Serial Data Input
13	SCLKI	Input (PU)	Serial Clock Input (SYNC Mode only)
14	SCLKO	Output	Serial Clock Output (SYNC Mode only)
15	SDATO	Output	Serial Data Output
16	VDD	Analog	Regulated Power
17	TP2	Input (PD)	Test Point 2
18	TP1	Input (PD)	Test Point 1
19	MOD	Input (PD)	Mode Selection (1/0=SYNC/ASYN)
20	VSS1	Power	System Ground 1

### Package Pin Drawing



- The Structure Of Protocol



- **command**
  - F1h : RSU
  - F2h : RSL
  - F3h : GSU
  - F4h : GSL
  - F5h : BSU
  - F6h : BSL
  - F7h : WSU

- **command**
  - FBh : CIA (except 16 channel)
  - FCh : RDS
  - FDh : APS (2<sup>nd</sup> CMD=F0h)
  - CLK (2<sup>nd</sup> CMD=3Ch)
  - CAA (2<sup>nd</sup> CMD=C3h)
  - DC1 (2<sup>nd</sup> CMD=A5h)
  - DC2 (2<sup>nd</sup> CMD=5Ah) (16 channel only)
  - FFh : IDS

### Constant Current Driver

TU8FA0309AA 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 ( $\pm 3\%$ ) and chip by chip ( $\pm 6\%$ )

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 characteristic of this device and user can refer this figure.

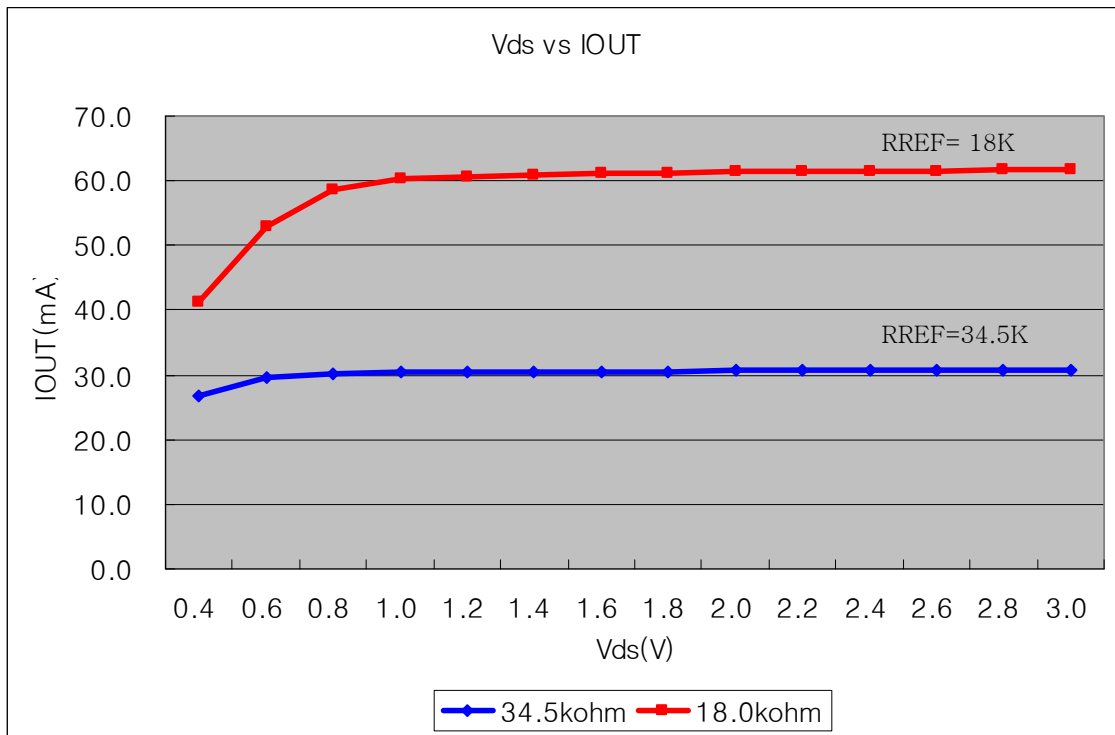


Fig 1)  $I_{OUT}$  vs  $V_{OUT}$  of TU8FA0309AA at various Reference resistor values



## Setting Output Current

The Maximum current is set by external resistors (RREF, GREF, BREF) respectively. 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 (R,G,B REF) is shown in the following figure

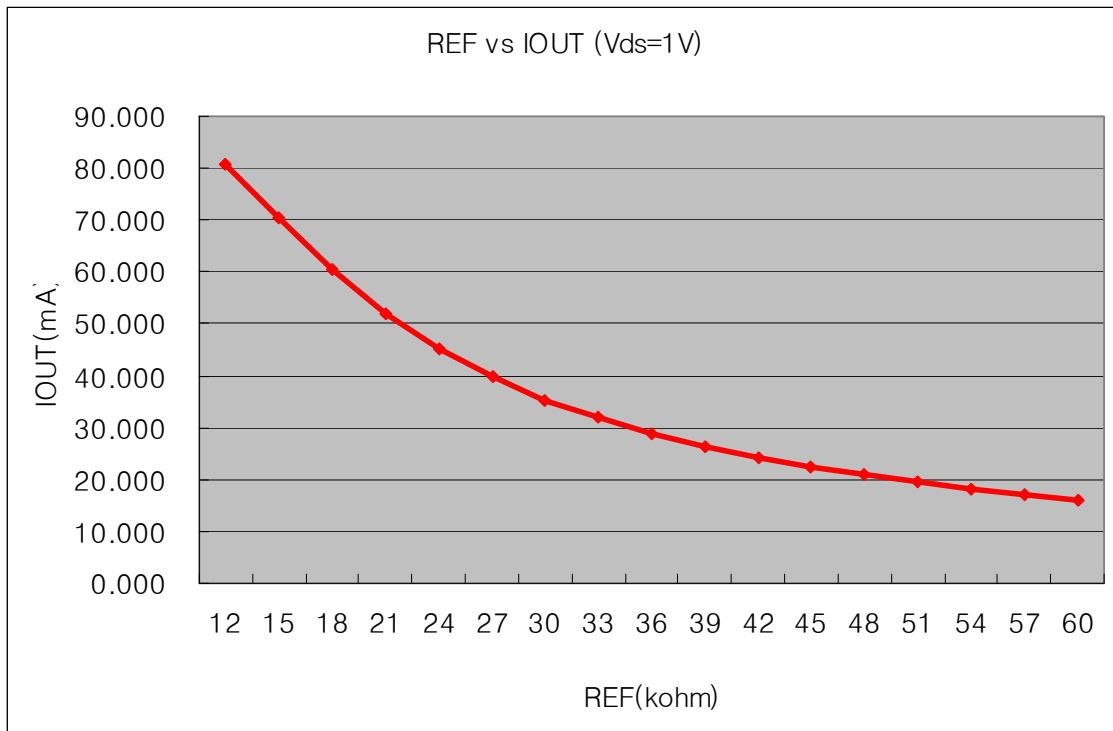


Fig 2) R,G,B REF vs I<sub>OUT</sub>

Also the output current can be calculated from below equation.

- $I_{OUT} = (V_{REF} \times 900) / (R,G,B \text{ Ref})$
- $V_{REF} = 1.21V$
- Where  $V_{REF}$  is internal Bandgap reference voltage and R,G,B Ref is external Resistor to set maximum constant 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.

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

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 are applied to chip.

TU8FA0309AA 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

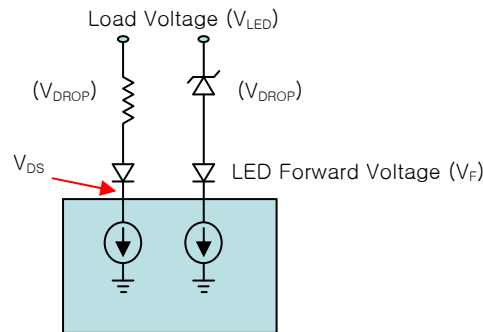


Fig 3) Load Voltage

## OPEN CIRCUIT DETECTION

TU8FA0309AA has a LED Open Detection circuit and it can detect LED open when loading status is 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 TU8FA0309AA 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 “STATUS[2:0]”.

This LED open detector are operated, when Open detection enable command “DC1” is applied.

If “DC1” command set dedicated LED channel to “1”, then LED channel is connected and If “DC1” command reset LED channel, then the LED Open status is saved to status Register.

User can read this LED Open status register using “RDS” command.

## Package Power Dissipation (P<sub>D</sub>)

The maximum allowable package power dissipation is determined as :

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

(where T<sub>J</sub> max = 150) (R<sub>JA</sub> : package thermal resistance)

The actual package power dissipation is:

$$- P_D(\text{act}) = \text{Duty R} \times V_{DSR} \times I_{OUT-R} \\ + \text{Duty G} \times V_{DSG} \times I_{OUT-G} \\ + \text{Duty B} \times V_{DSB} \times I_{OUT-B} + V_{IN} \times I_{IN} .$$

where Duty R,G, B is the PWM duty cycle for each R,G,B channel , and V<sub>DS</sub> R,G,B is the LED output voltage for each R,G,B channel. And then, I<sub>OUT-R</sub>, I<sub>OUT-G</sub>, I<sub>OUT-B</sub> are the LED output current which value is fixed by external resistor (RREF, GREG, BREF). When calculating power dissipation, the total number of available device outputs is usually used for the worst-case situation (displaying all 3 LEDs at 100% Duty Cycle).

## Absolute Maximum Ratings

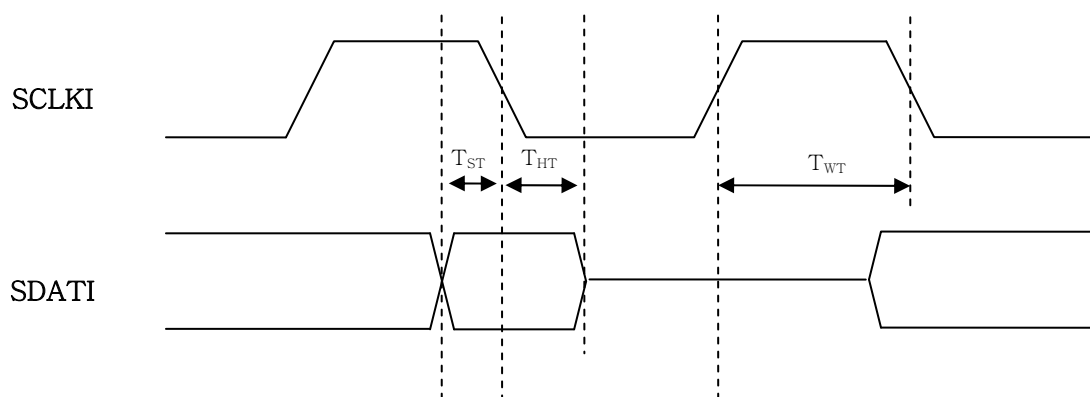
Parameter	Symbol	Ratings	Unit
Power Supply Voltage	VDD	17	V
Operating Temperature	T <sub>A</sub>	-40 ~ 85	°C
Storage Temperature	T <sub>S</sub>	-55 ~ 150	°C
Junction Temperature	T <sub>J</sub>	150	°C
Input Pin Voltage	V <sub>IN</sub>	-0.3 ~ VDD + 0.3	V
Output Voltage at LED pin	V <sub>DS</sub>	-0.5 ~ 30	V
Output Current at LED pin	I <sub>OUT</sub>	90	mA
Clock Frequency (SCLKI)	F <sub>SCLKI</sub>	25	MHz

DC Electrical Characteristics at  $T_A=25^{\circ}\text{C}$  Typical Application,  $V_{DD}=3.3\text{V}$ 

Parameter	Sym	Test Condition	Limits			Unit
			Min	Typ	Max	
Supply Voltage	H_VDD	Operating	4	12	17	V
Regulation Voltage	VDD1	H_VDD=12V	3.0	3.3	3.6	V
Output Voltage	V <sub>OUT1</sub>	LED Output			27	V
	V <sub>OUT2</sub>	SDATO, SCLKO	VDD-0.3	VDD	VDD+ 0.3	V
Output Current	I <sub>OD</sub>	LED output	5		60	mA
	I <sub>OH</sub>	SDATO, SCLKO		24		mA
	I <sub>OL</sub>	SDATO, SCLKO		-24		mA
Input Voltage	V <sub>IH</sub>	Input Pins	2.4	VDD	VDD+ 0.3	V
	V <sub>IL</sub>	Input Pins			1	V
Input Leakage	I <sub>IH</sub>	Input Pins			0.5	uA
	I <sub>IL</sub>	Input pins			0.5	uA
Output Leakage	I <sub>OLL1</sub>	LED Output H_VDD=12V			0.5	uA
	I <sub>OLL2</sub>	SDATO, SCLKO			0.5	uA
Supply Current	I <sub>DD</sub>	H_VDD=12V, REF=18K SCLKI = 10Mhz		10	TBD	mA
Output Current Skew (Channel To Channel)	I <sub>OS1</sub>	REF=18K V <sub>DS</sub> =1.0V	-3		+ 3	%
Output Current Skew (Chip to Chip)	I <sub>OS2</sub>	REF=18K V <sub>DS</sub> =1.0V	-6		+ 6	%
Internal Oscillation Clock	F <sub>OSC</sub>	H_VDD= 12V		7.3		Mhz

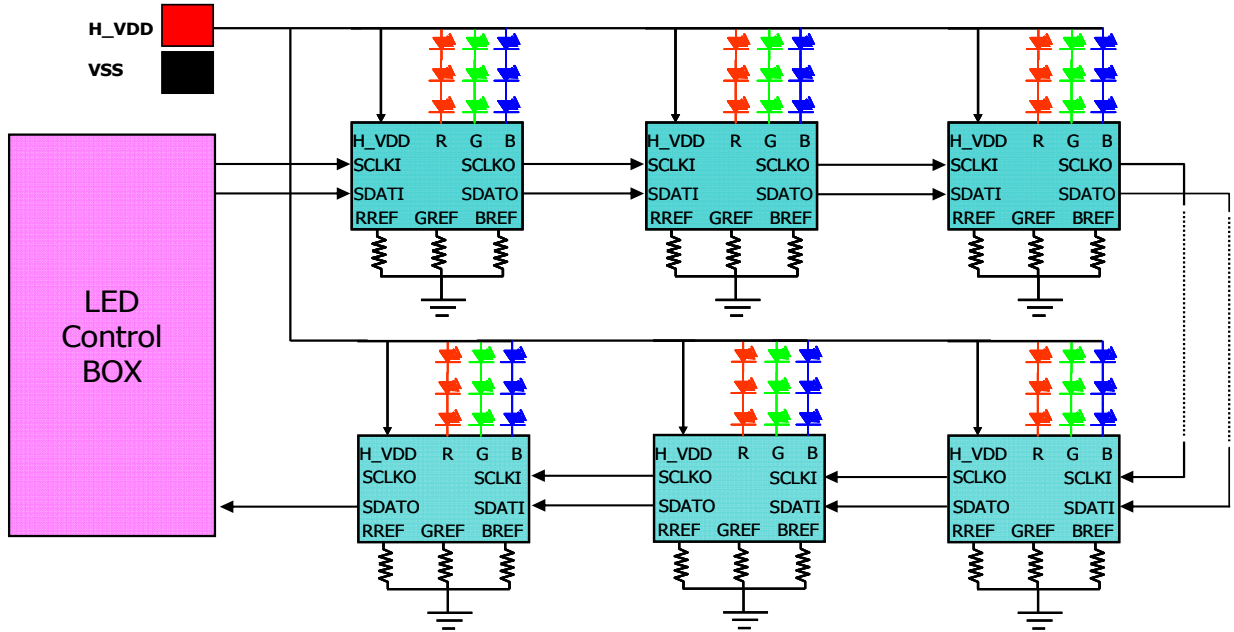
AC Electrical Characteristics at TA=25°C Typical Application, VDD=3.3V)

Parameter	Sym	Test Condition	Limits			Unit
			Min	Typ	Max	
Set Up Time	T <sub>ST</sub>	VDD = 3.3V.	3			ns
Hold Time	T <sub>HT</sub>	V <sub>IH</sub> = VDD.	3			ns
Pulse Width	T <sub>WT</sub>	V <sub>IL</sub> = VSS	20			ns
		C <sub>L</sub> =10pF				

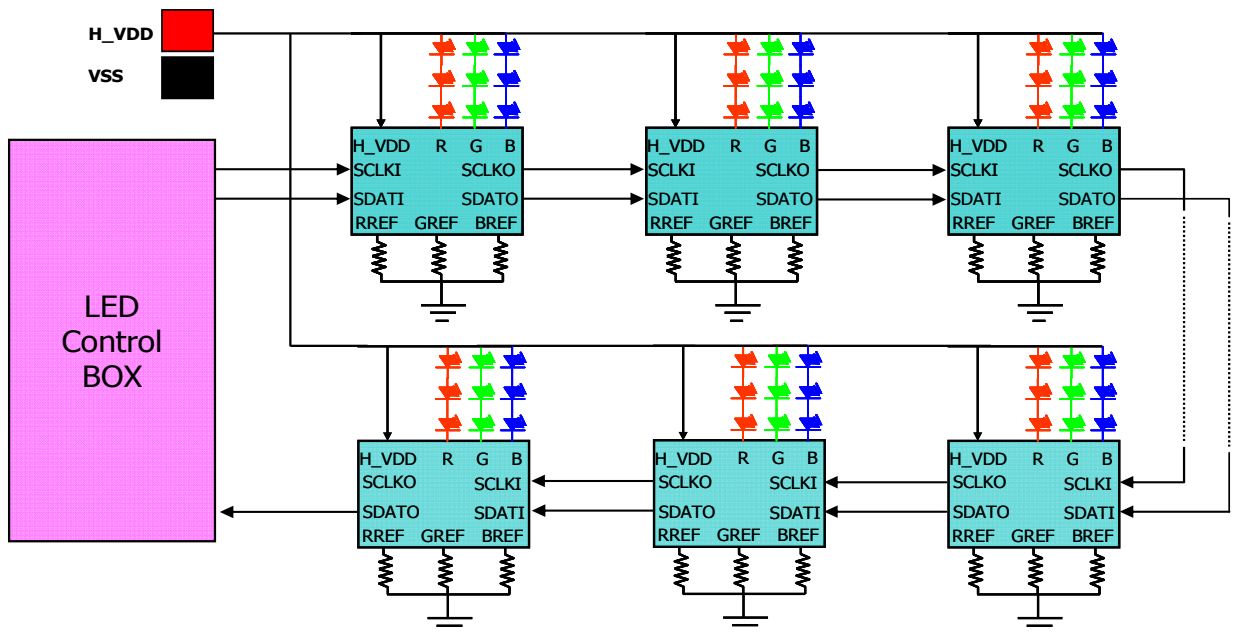


AC Timing Diagram

### Typical Application Diagram

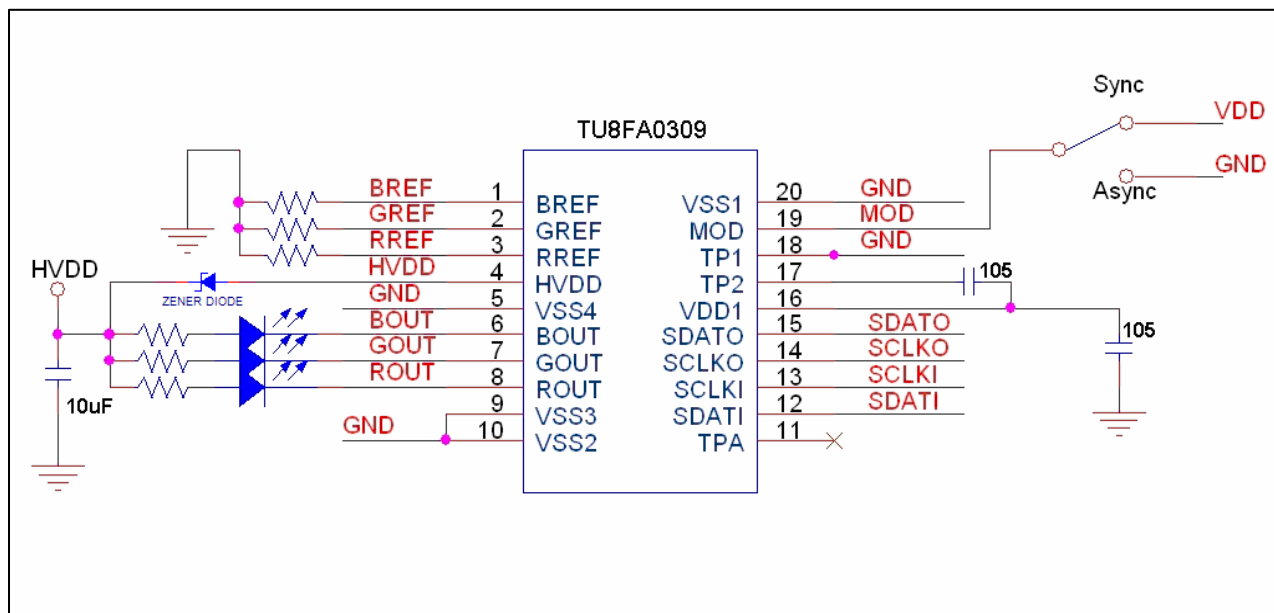


Application Example for Asynchronous mode



Application Example for Synchronous mode

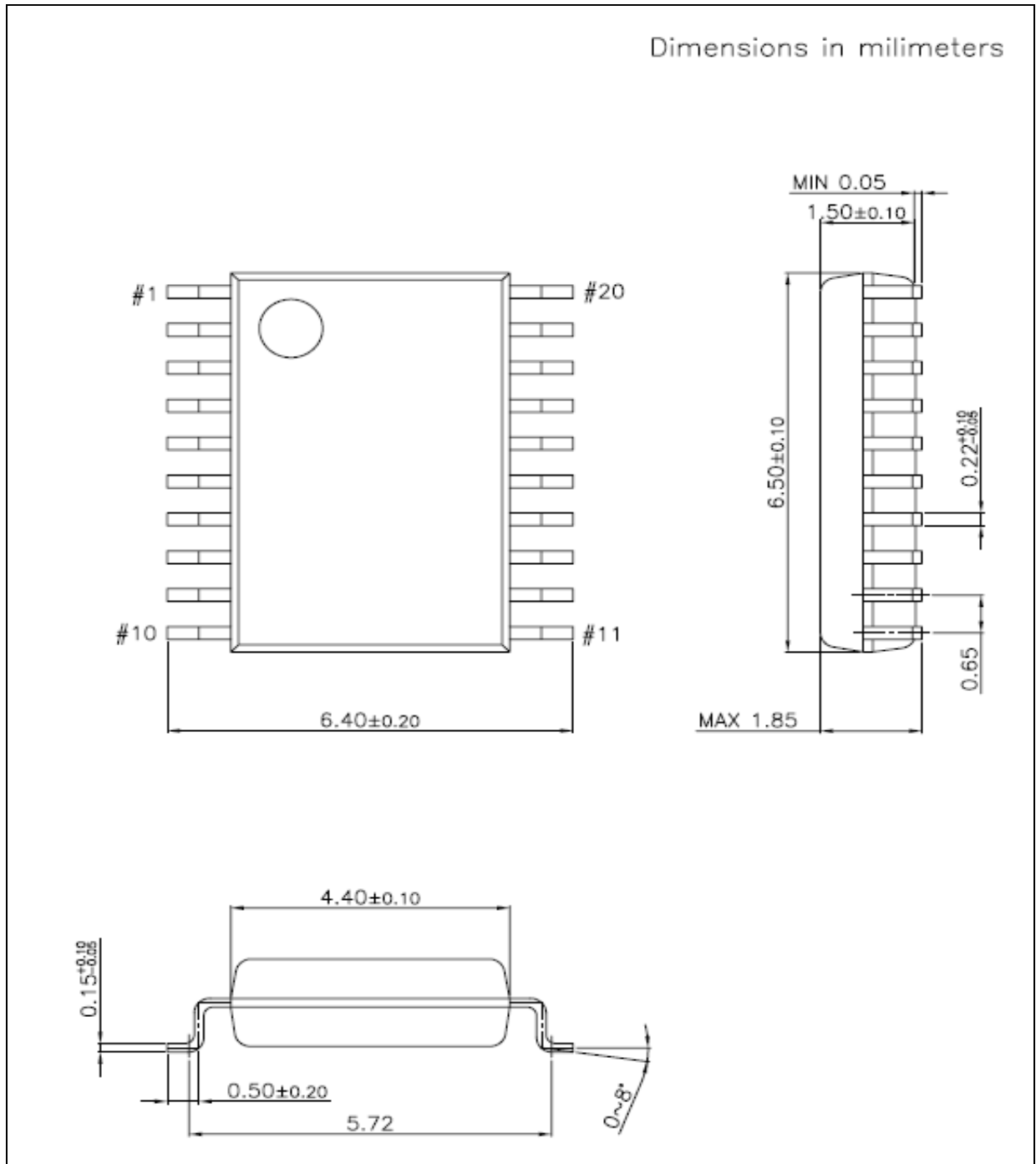
### Chip Application Note



*Note1: Tie SCLKI pin to VDD Level when it use Asynchronous mode*

*Note2: Select the Zener Diode breakdown voltage to adjust the output voltage between 3.3 ~ 5V.*

### Package Dimension



- 20SSOP -