IS31FL3800

Smart Integrated Matrix LED Driver with Touch Key Controller

GENERAL DESCRIPTION

IS31FL3800 is an ultra-low power, fully integrated 18x4 matrix LED driver with a touch key controller. It is designed with an easy to use GUI for touch key tuning and GPIO configuration. The application of IS31FL3800 requires the presence of a host MCU with an I2C master, to poll the status and control the LED drivers. Each LED in the matrix can be dimmed individually with 8-bit PWM data and 8-bit DC scaling (Color Calibration) data. This allows 256 steps of linear PWM dimming and 256 steps of adjustable DC current level. Additionally, each LED's open/short state can be detected. The host MCU can poll for the open/short information stored in the Open/Short Registers.

An eleven-channel capacitive touch controller is integrated with on-chip calibration logic which continuously monitors the environment and automatically adjusts the threshold levels to prevent false triggers.

An on-chip I²C slave controller with 400kHz capability and programmable slave addresses serves as the communication port for the host MCU. An interrupt, INTB, can be configured so it is generated when a trigger event (touched or released) occurs. Trigger or clear condition can be configured by setting the interrupt register.

IS31FL3800 is available in RoHS compliant package QFN-60 (7mm×7mm). It operates from 2.7V to 5.5V over the temperature range of -40°C to +105°C.

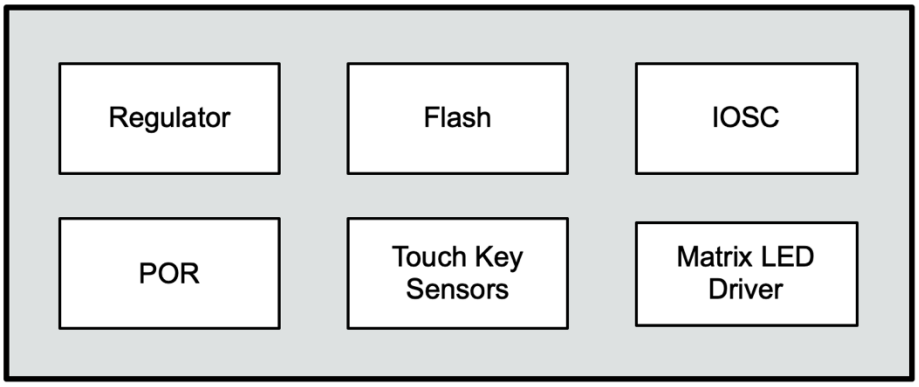
FEATURES

- Matrix LED Driver
  - 18 current sinks
  - 2.7 to 5.5V LED driver supply (VCC)
  - Support 18×n (n=1~4) LED matrix configurations
  - Individual 256 PWM control steps
  - Individual 256 DC current steps
  - Global 256 current steps
  - Programmable H/L logic: 1.4V/0.4V, 2.4V/0.6V
  - 29kHz PWM frequency
  - State lookup registers
  - Individual open and short error detect function
  - 180 degree phase delay operation to reduce power noise
- Capacitive Touch Sensor
  - Capacitive touch controller with readable key value through shared GPIO
  - Individual sensitivity threshold setting for each touch key
  - Optional multiple-key function
  - Press and hold function
  - Automatic calibration
  - Individual key calibration
  - Interrupt output with auto-clear and repeating
  - Auto sleep mode for extremely low power
  - Key wake up from sleep mode
- 400kHz fast-mode I²C interface
- Operating temperature between -40°C ~ +105°C
- QFN-60 package

APPLICATIONS

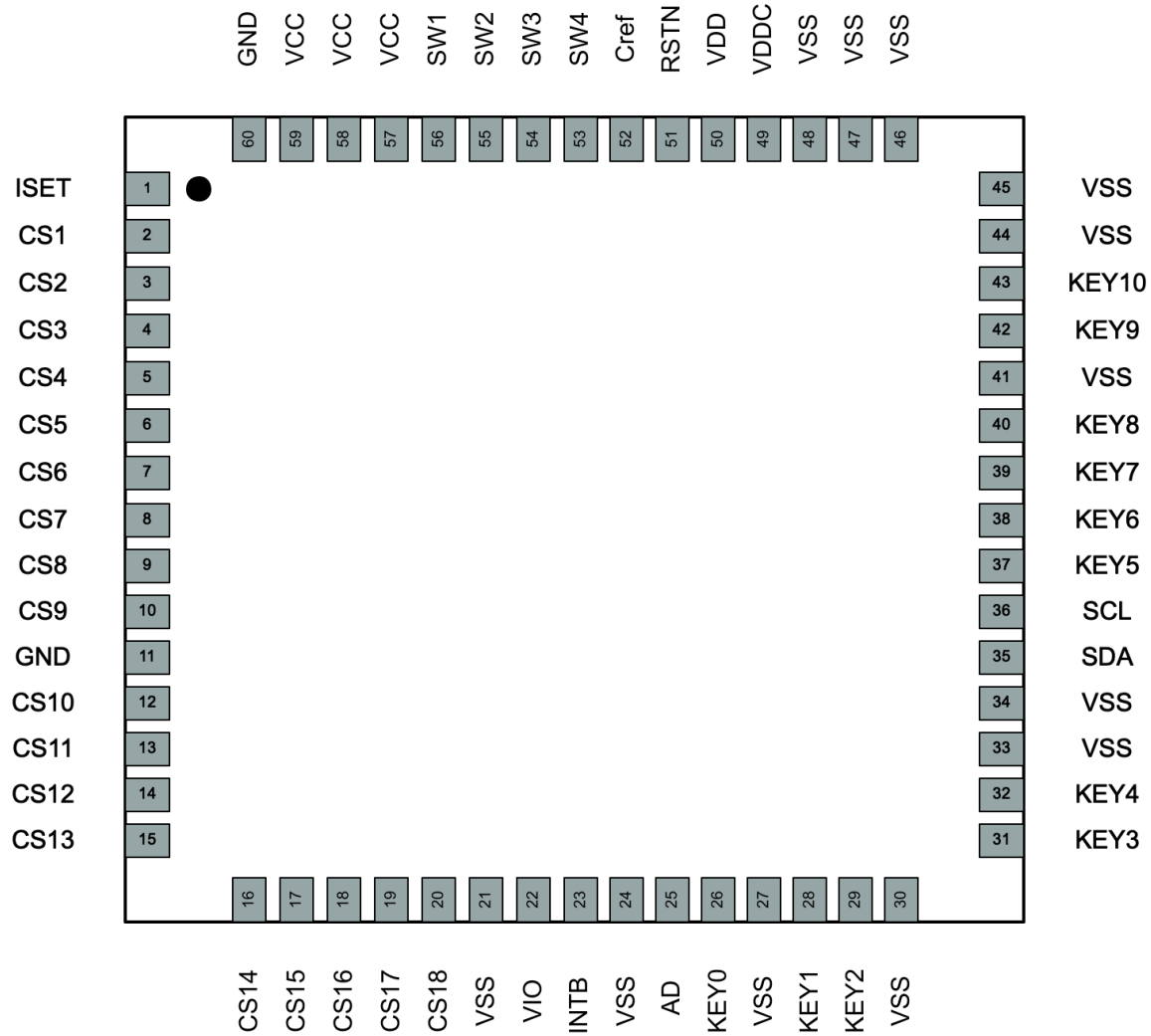
- Home appliance touch control keys
- Industrial applications
- Gaming devices
- IoT devices

BLOCK DIAGRAM



Block Diagram of IS31FL3800

PACKAGE TYPE



PIN CONFIGURATION

No.	Pin	Description
1	ISET	An external resistor to ground is required for setting the LED current
2-10, 12-20	CS1-CS18	Current sinks for LED matrix
11,60,21,24,27,30,33,34 ,41,44,45,46,47,48	VSS	Ground connection
22, 50	VDD	Power supply. Typical decoupling capacitors of 0.1uF and 10uF should be connected between VDD and VSS
23	INTB	Interrupt output, active low.
25	AD	I2C address setting.
26,28,29,31,32,37,38,39 ,40,42,43	KEY0-KEY10	Input sense channel 0 -10. Can be programmed as GPIOs.
35	SDA	I2C data, need to pull up with 4.7K resistor
36	SCL	I2C clock, need to pull up with 4.7K resistor
49	VDDC	Internal regulator output around 1.8V. Typical decoupling capacitors of 0.1uF and 10uF should be connected between VDDC and VSS
51	RSTN	Low active. A resistor to VDD and a capacitor to VSS are typically connected. RSTN is pulled low when LVR occurs. The threshold of RSTN is set at 0.3VDD. RSTN is also used for special test mode and writer mode entry.
52	C_{REF}	External capacitor must be connected for touch key controller.
53-56	SW1-SW4	Power SW.
57-59	VCC	Supply of LED power switch.

ORDERING INFORMATION

Industrial Range: -40°C to +105°C

Order Part No.	Package	QTY
IS31FL3800-QFLS3-TR	QFN-60, Lead-free	2500

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TYPICAL APPLICATION CIRCUIT (QFN-60)

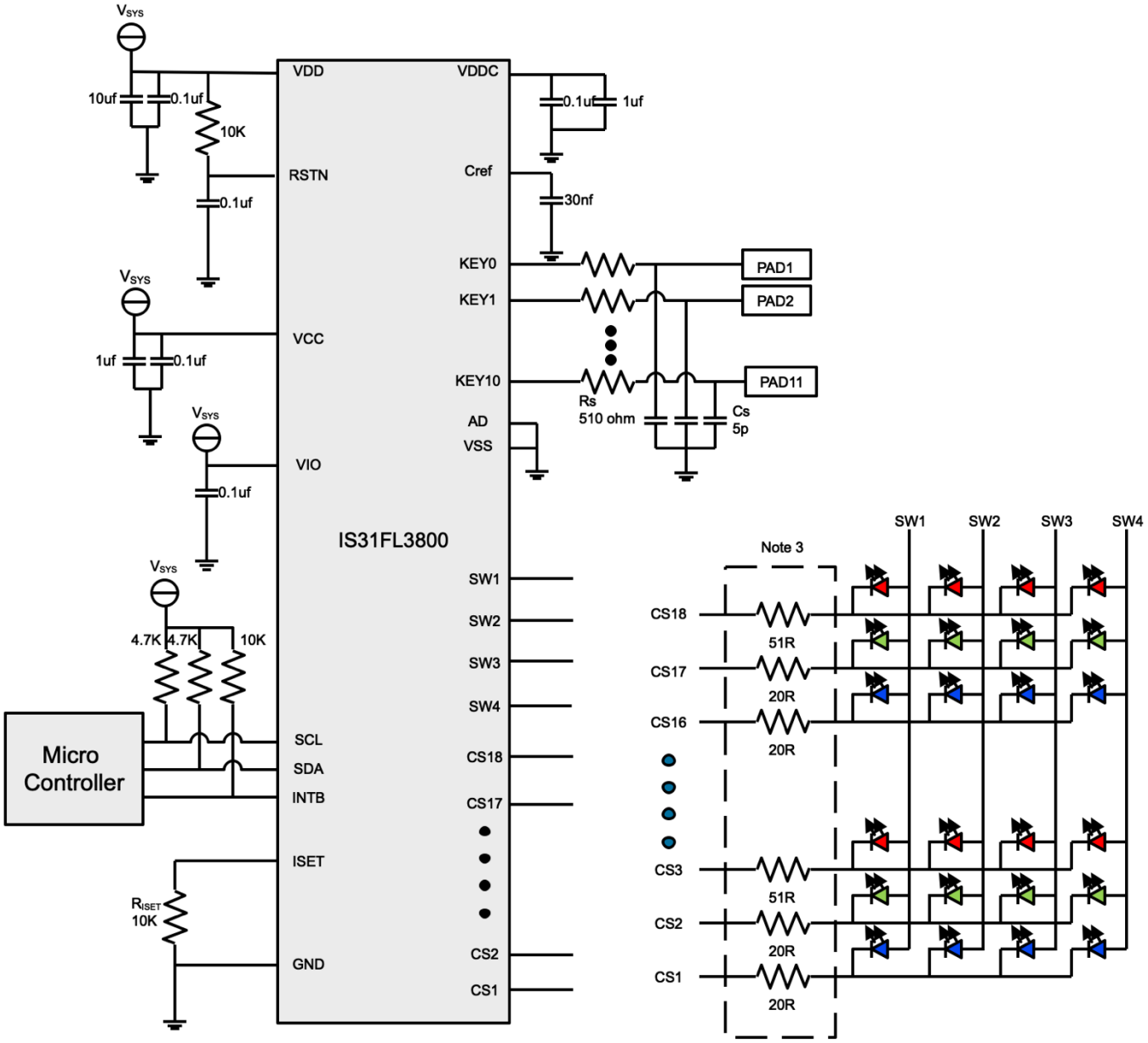


Figure 1 Typical Application Circuit (QFN-60)

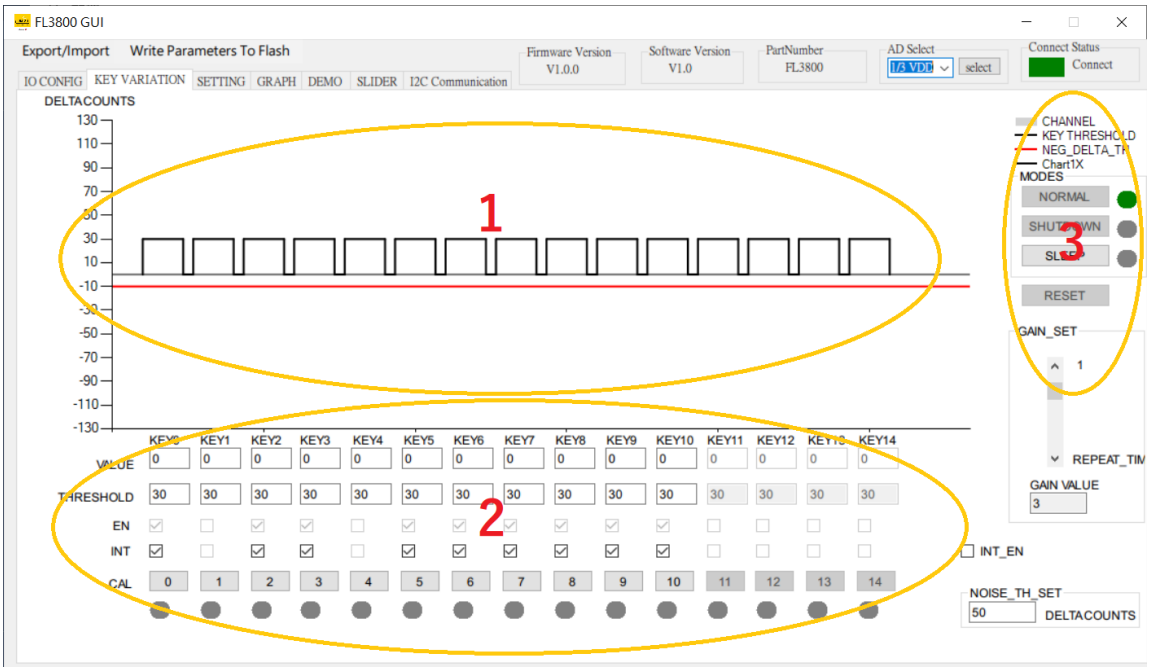
Note 1: The chip should be placed far away from the noise points in order to prevent the EMI.
Note 2: The R_S and C_S should place as close to the chip as possible to reduce EMI.
Note 3: The 20R or 51R resistors between LED and the chip are only for thermal reduction. For mono red LED, if Vcc=3.3V, these resistors are not required.

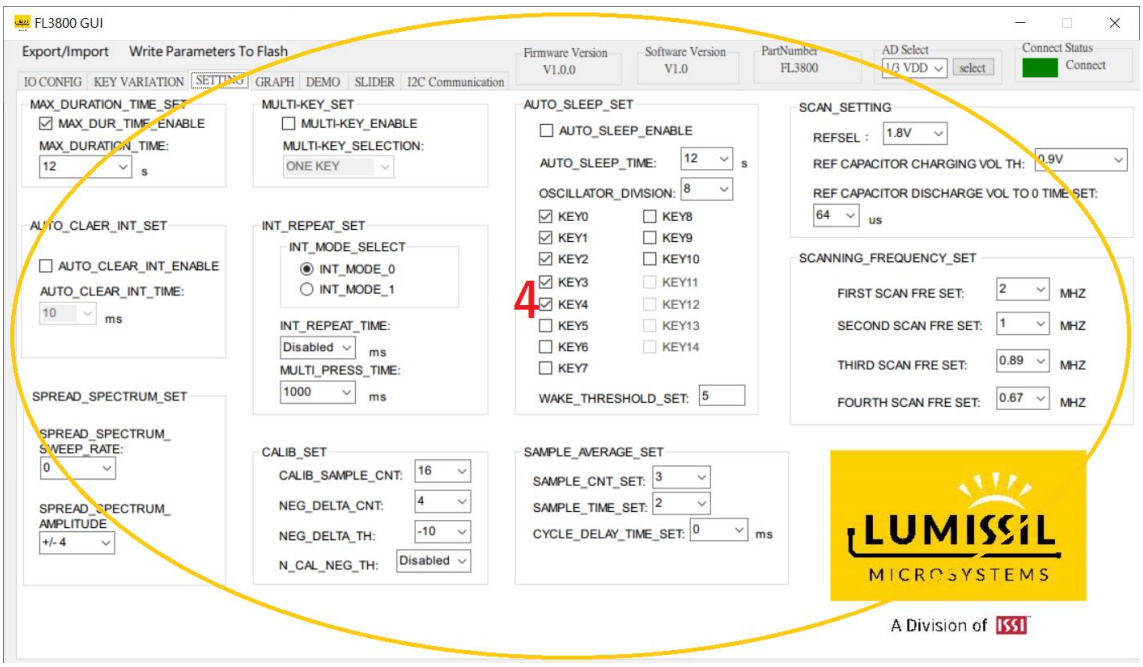
1. DETAILED DESCRIPTION

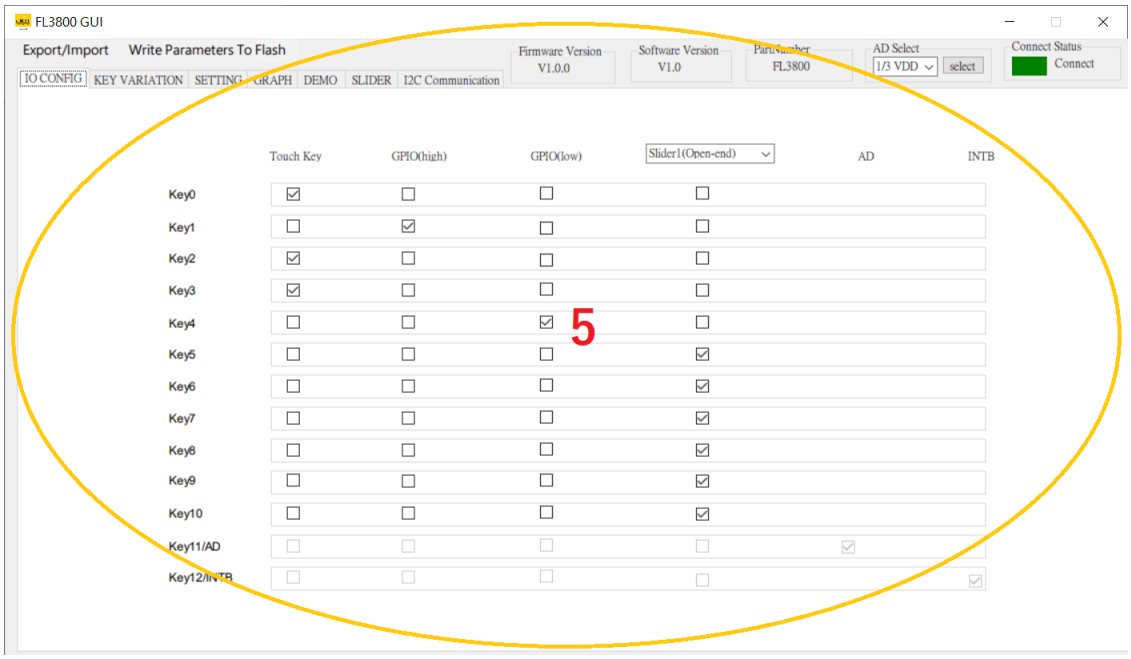
1.1 IS31FL3800 GUI

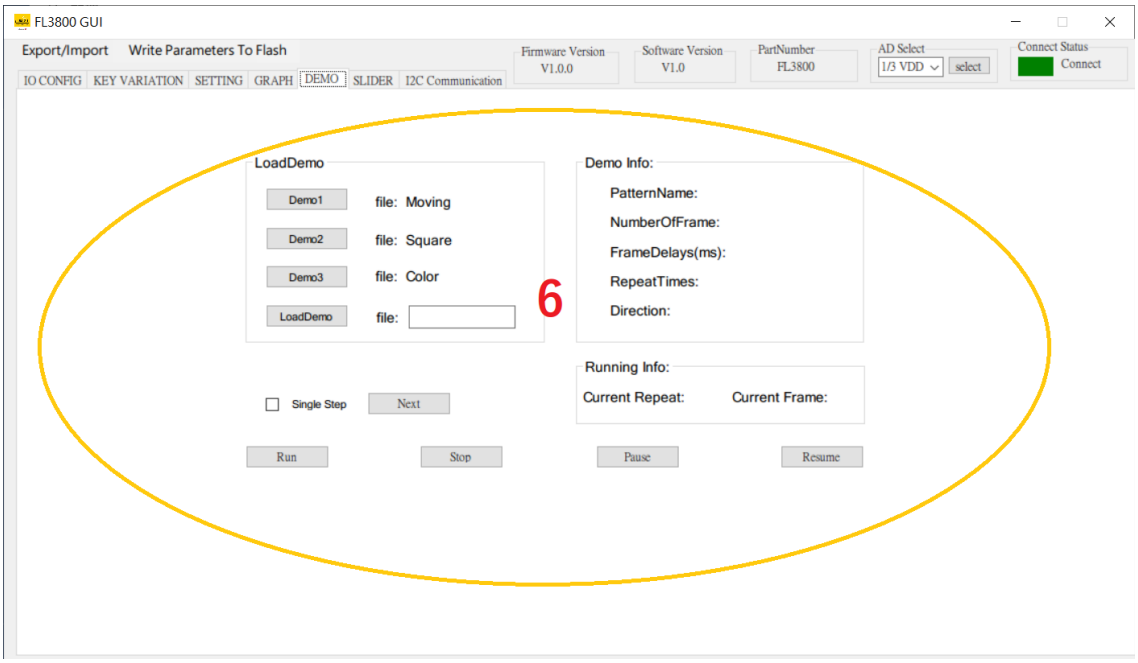
IS31FL3800 GUI is a windows-based Integrated Design Environment (IDE). User can use it to develop touch key applications without firmware coding. With the GUI user can design the touch key system easily. With the GUI you can:

1. Monitor the Key value
2. Set touch threshold and enable keys
3. Switch the operating modes
4. Tune System parameters
5. Set LED and GPIO parameters
6. LED demo
7. Set Slider Electrodes






FL3800 GUI
Export/Import
Write Parameters To Flash
Firmware Version
V1.0.0
Software Version
V1.0
PartNumber
FL3800
AD Select
1/3 VDD
select
Connect Status
Connect
IO CONFIG
KEY VARIATION
SETTING
GRAPH
DEMO
SLIDER
I2C Communication
Touch Key
GPIO(high)
GPIO(low)
Slider1(Open-end)
AD
INTB
Key0
Key1
Key2
Key3
Key4
Key5
Key6
Key7
Key8
Key9
Key10
Key11/AD
Key12/INTB
5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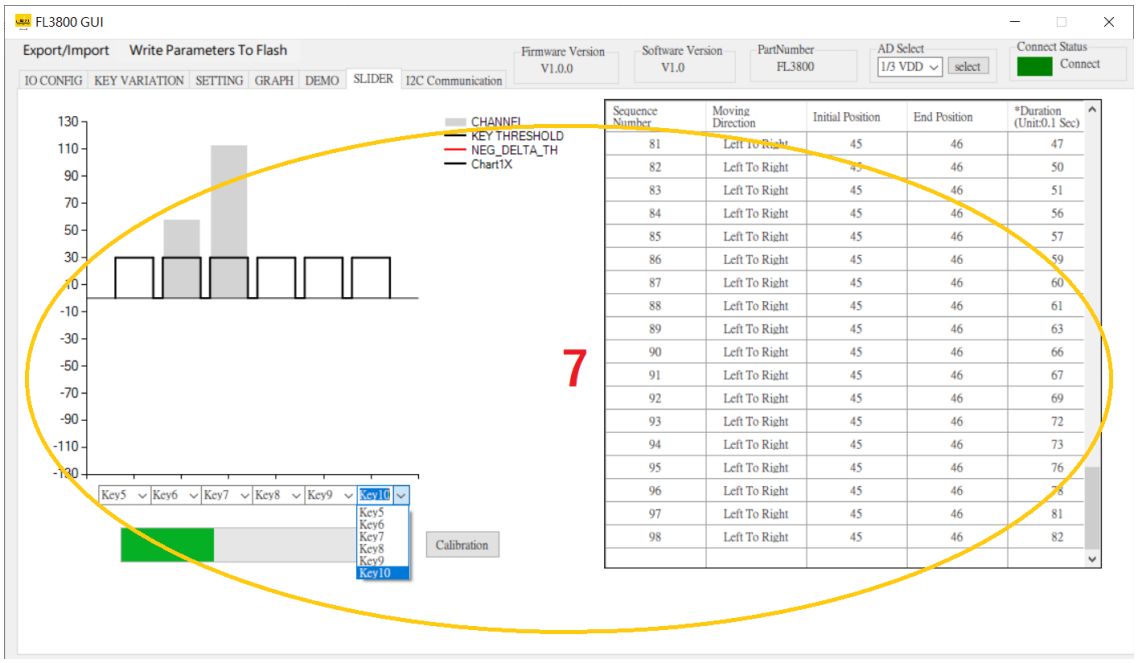
GRAPH
DEMO
SLIDER
I2C Communication
LoadDemo
Demo1
file: Moving
Demo2
file: Square
Demo3
file: Color
LoadDemo
file:
6
Demo Info:
PatternName:
NumberOfFrame:
FrameDelays(ms):
RepeatTimes:
Direction:
Running Info:
Current Repeat:
Current Frame:
Single Step
Next
Run
Stop
Pause
Resume



Please refer to the User's Guide for other details.

ABSOLUTE MAXIMUM RATINGS

Supply voltage, VCC (for LED driving)	-0.3V ~ +6.0V
Supply voltage, VDD	+5.5V
Voltage at any input pin	-0.3V ~ V_{CC}+0.3V
Maximum junction temperature, T_{JMAX}	+150°C
Storage temperature range, T_{STG}	-65°C ~ +150°C
Operating temperature range, T_A=T_J	-40°C ~ +105°C
Junction Package thermal resistance, junction to ambient (4 layer standard test PCB based on JESD 51-2A), θ_{JA}	35°C/W
ESD (HBM) ESD (CDM)	±2kV ±750V

Note 4: Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

1.2 ELECTRICAL CHARACTERISTICS

T_A = 25°C, V_{DD} = 2.7V ~ 5.5V, unless otherwise noted. Typical value are T_A = 25°C, V_{DD} = 5V.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V_{DD}	Supply voltage		2.7		5.5	V
V_{CC}	Supply voltage		2.7		5.5	V
I_{OUT}	Maximum constant current of CSy	R_{ISET} =10kΩ, GCC=0xFF SL=0xFF		34.5		mA
$I_{DD,}$ stop	Quiescent power supply current	V_{DD} = 5.5V		2.5		mA
Electrical Characteristics (LED Driver)						
I_{LED}	Average current on each LED I_{LED} = $I_{OUT(PEAK)}$/Duty(4.14)	R_{ISET} =10kΩ, GCC=0xFF SL=0xFF		8.33		mA
V_{HR}	Current switch headroom voltage SWx	I_{SWITCH}=612mA R_{ISET} =10kΩ, GCC=0xFF, SL=0xFF		450		mV
	Current sink headroom voltage CSy	I_{SINK}=34mA, R_{ISET} =10kΩ, GCC=0xFF, SL=0xFF		250		
t_{SCAN}	Period of scanning			33		µs
t_{NOL1}	Non-overlap blanking time during scan, the SWx and CSy are all off during this time			0.83		µs
t_{NOL2}	Delay total time for CS1 to CS 18, during this time, the SWx is on but CSy is not all turned on	(Note 5)		0.3		µs
Electrical Characteristics (Touch Key)						
ΔC_S	Normal detectable capacitance			40		pF
tscan, TK	Period of scanning for 11 Touch Key channels			55		mS

1.3 I2C SWITCHING CHARACTERISTICS (Note 5)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
f_{SCL}	Serial-Clock frequency				400	kHz
t_{BUF}	Bus free time between a STOP and a START condition		1.3			μs
$t_{HD, STA}$	Hold time (repeated) START condition		0.6			μs
$t_{SU, STA}$	Repeated START condition setup time		0.6			μs
$t_{SU, STO}$	STOP condition setup time		0.6			μs
$t_{HD, DAT}$	Data hold time				0.9	μs
$t_{SU, DAT}$	Data setup time		100			ns
t_{LOW}	SCL clock low period		1.3			μs
t_{HIGH}	SCL clock high period		0.7			μs
t_R	Rise time of both SDA and SCL signals, receiving	(Note 6)		20+0.1C_b	300	ns
t_F	Fall time of both SDA and SCL signals, receiving	(Note 6)		20+0.1C_b	300	Ns
I_{OL}	Low level sink current			10		mA
V_{IH}	Logic “0” input voltage	VDD = 5.5V	1.4			V
V_{IL}	Logic “0” input voltage	VDD = 2.7V			0.4	V

Note 5: Guaranteed by design.
Note 6: Cb = total capacitance of one bus line in pF. ISINK ≤ 6mA. tR and tF measured between 0.3 × VDD and 0.7 × VDD.

1.4 I2C INTERFACE

IS31FL3800 uses a serial bus, which conforms to the I2C protocol, to control the chip’s functions with two wires: SCL and SDA. IS31FL3800 has a 7-bit slave address (A7:A1), followed by the R/W bit, A0. Set A0 to “0” for a write command and set A0 to “1” for a read command. The value of bits A1 and A2 are determined by the connection of the AD pin, to GND, 1/3 VDD, 2/3VDD, and VDD.

The complete slave address is:

Bit	A7:A3	A2:A1	A0
Value	01111	AD	1/0

AD connected to GND, AD = 00;

AD connected to 1/3VDD, AD = 01;

AD connected to 2/3VDD = 10;

AD connected to VDD = 11;

AD pin can also be configured as a Touch Key channel. When then AD pin is used for a Touch Key channel, A2: A1 = 00.
The SCL and SDA are open-drain IO so an external pull-up resistor (typically 4.7kΩ) is required. The maximum clock frequency specified by the I2C standard is 400kHz. In this discussion, the master is the host microcontroller and the slave is IS31FL3800.
The timing diagram for the I2C is shown in Figure 2. When there is no interface activity, both the SDA and SCL should be held high.
The “START” signal is generated by lowering the SDA signal while the SCL signal is high. The start signal will alert all devices attached to the I2C bus to check the incoming address against their own chip address.
The 8-bit chip address is sent next, most significant bit first. Each address bit must be stable while the SCL level is high.
After the last bit of the chip address is sent, the master checks for IS31FL3800’s acknowledge. The master releases the SDA line which gets pulled to high (through a pull-up resistor). Then the master sends an SCL pulse. If

IS31FL3800 has received the address correctly, it holds the SDA line low during the SCL pulse. If the SDA line is not low, the master should send a “STOP” signal (discussed later) and abort the transfer.
Following acknowledge of IS31FL3800, the header byte is sent, most significant bit first. IS31FL3800 must generate another acknowledge indicating that the header has been received.
Following acknowledge of IS31FL3800, the commands or register address byte is sent, most significant bit first. IS31FL3800 must generate another acknowledge indicating that the register address has been received.
Then 8-bit of data byte are sent next, most significant bit first. Each data bit should be valid while the SCL level is stable high. After the data byte is sent, IS31FL3800 must generate another acknowledge to indicate that the data was received.
The “STOP” signal ends the transfer. To signal “STOP”, the SDA signal goes high while the SCL signal is high.

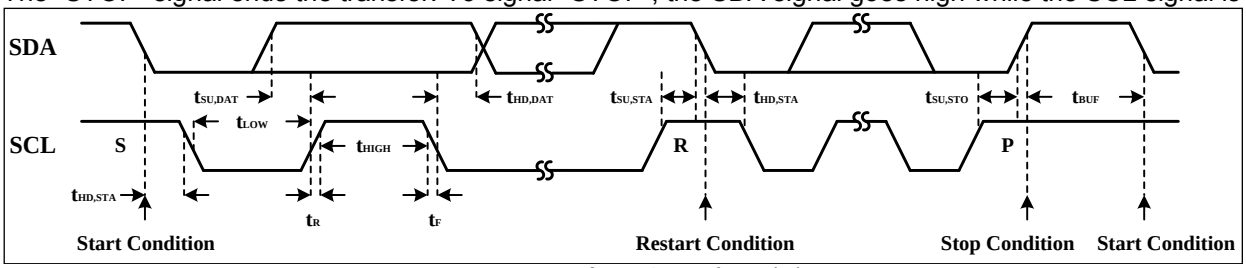


Figure 2 Interface Timing

1.5 READING PORT REGISTERS

To read the device data, the bus master must first send to IS31FL3800’s address with the R/$\overline{W}$ bit set to “0”, followed by the header byte. The address of the register of interest is then specified. After a restart, the bus master must then send to IS31FL3800’s address with the R/$\overline{W}$ bit set to “1”. Data from the register defined by the command byte is then sent from IS31FL3800 to the master.

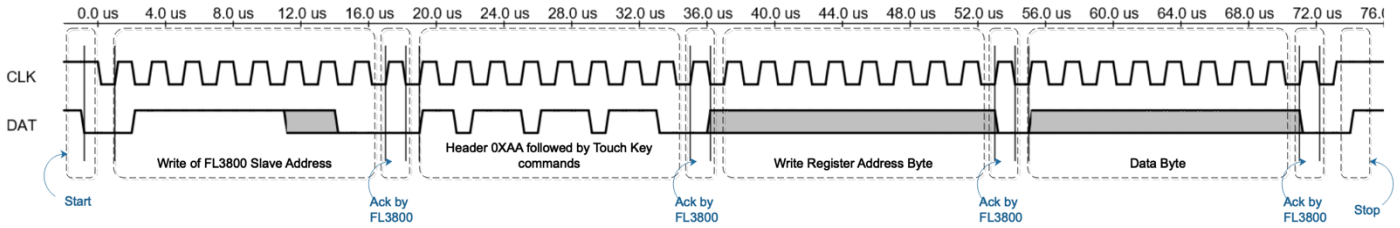
1.6 I2C Command Format

In the I2C bus, some devices are masters, and they have to generate the bus clock and initiate communication. To select the IS31FL3800 device, they must choose the right slave address and follow it by a header. If the header is 55h, the commands and data that follows are for the matrix LED driver. If the header is AAh, the commands and data that follows are for the Touch Key controller. If the header is A5h, IS31FL3800 will immediately save the current data in the registers. Saved data will become the default value of IS31FL3800. Commands are always ended by a stop signal.

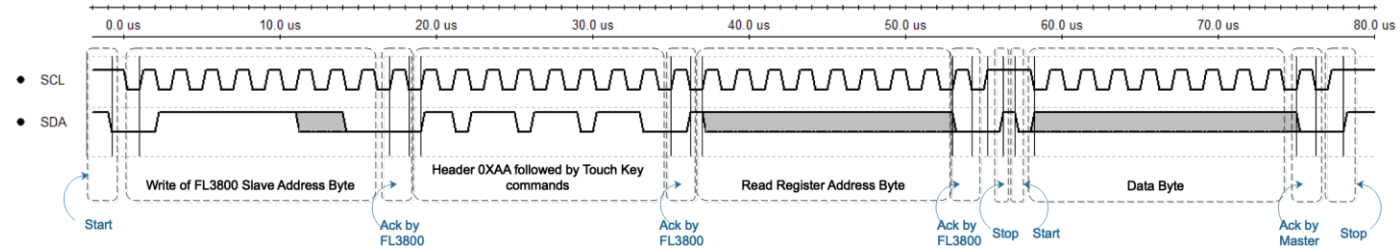
First byte	Second byte	Other bytes	Ending
Slave address	Header		
	55h	Matrix LED Commands and data	Stop signal
			SCL High
			SDA Rising edge
	AAh	Touch Key Commands and data	Stop signal
	A5h	A special header is no following bytes. It is used for saving parameters	Stop signal

Bit	A7:A3	A2:A1	A0
Value	01111	AD	1/0

Two examples for the I2C Command are as follows:
The waveforms of Touch Key Commands for Write data.



The waveforms of Touch Key Commands for Read data.



1.7 Matrix LED Operation

Command Register Definition

Address	Name	Function	Table	R/W	Default
FEh	Command Register Write Lock	To unlock Command Register	-	W	0000 0000
FDh	Command Register	Available Page 0 to Page 1 registers	-	W	xxxx xxxx

REGISTER CONTROL