SK5220 FlexMatrix™ Keyboard Controller
Ultra-Low Power, User-Programmable SMBus I2C Keyboard Scanner with external PS/2, PWM Backlight, 9 LEDs Control, Firmware Field Upgradable

FEATURES

- SMBus v1.1 (or I2C) interface
- PEC CRC enabled communication
- Bootloader for firmware field upgrade
- One external PS/2 interface to PS/2 device such as mouse, touchpad, pointing stick
- 9 LEDs
- 1 PWM backlight brightness control
- 8 x 16 matrix keyboard scan
- Advanced ghost key detection algorithm to maximize the key combination without additional diodes
- PS/2 command relay support
- Built-in oscillator and digital circuit. No external crystal is needed
- LQFP 48 pin package: 7x7mm 1.6 Max (LxWxH)
- Low power consumption: 0.3uA (no key pressed)
- Operation voltage range: 2.2 to 5.5V
- Industrial temperature range: -40°C to +85°C
- Custom versions available in small and large quantities

APPLICATION

- Notebook/Netbook PCs
- Tablet PCs
- Tablet/Mobile Phone docking station
- Instruments
- I/O Expander
- Wireless keyboards

ORDEING INFORMATION

SK5220-LP LQFP 48-pin, 0.5mm pitch, (7x7mm 1.6 MAX), Pb-Free, RoHS Complaint
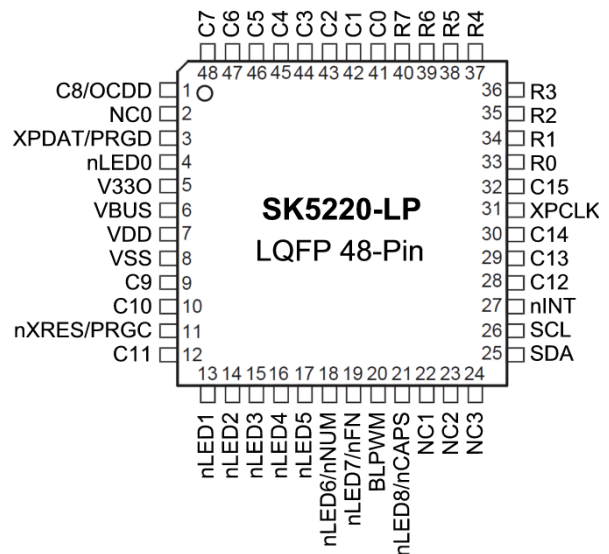
DESCRIPTION

The SK5220 is an ultra-low power (0.3uA) SMBus I2C interface keyboard encoder with 1 PWM backlight and 9 LEDs control. It's the best choice for customized keyboard design for battery powered tablet / laptop / docking station / Instrument. The SK5220 deploys Sprintek FlexMatrix™ technology for users to upgrade firmware in the field.

The SK5220 scans and encodes an 8-row by 16-column matrix. The key press events are translated to keyboard event report.

The SK5220 provides command-controlled PWM for backlight LED PWM brightness control.

The SK5220 provides an external PS/2 port that supports hot plug and hot swap of PS/2 devices such as touchpad, pointing stick, mouse including wheel mice. The host can send commands via SK5220 PS/2 command relay feature to the external PS/2 device to change default settings.

PIN ASSIGNMENTS

FUNCTION BLOCK DIAGRAM
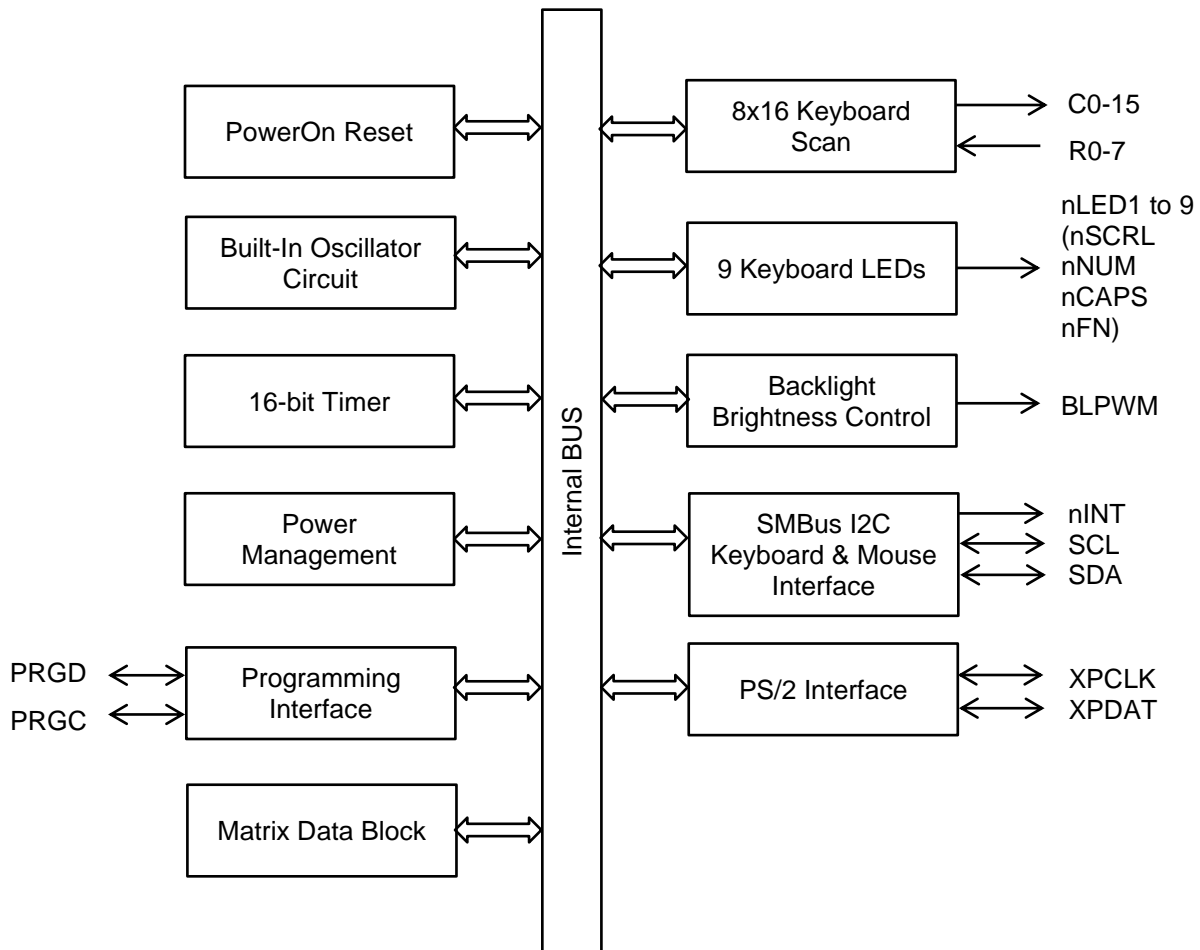
PIN DEFINITION

Pin No	Type	Name	Description
1	IO	C8	Column line 8 for scan matrix
2	NA	NC0	NC pin
3	IO	XPDAT/PRGD	External PS/2 data line / programming data line
4	O	nLED0	General LED0
5	P	V33O	Reserved
6	P	VBUS	Power supply
7	P	VDD	Power supply
8	P	VSS	Ground connection
9 – 10	IO	C9 – C10	Column lines 9, 10 for scan matrix
11	I	nXRES / PRGC	External reset: low active / programming clock line
12	IO	C11	Column line 11 for scan matrix
13 – 14	O	nLED1 - 5	General LED1 to LED2
15	O	nLED3	General LED3
16	O	nLED4	General LED4
17	O	nLED5	General LED5
18	O	nLED6 / nNUM	General LED6 / Num lock LED
19	O	nLED7 / nFN	General LED7 / Fn lock LED
20	O	BLPWM	Backlight control PWM
21	O	nLED8 / nCAPS	General LED8 / Caps lock LED
22 – 24	NA	NC1 – NC3	NC pins
25	IO	SDA	I2C slave data line
26	IO	SCL	I2C slave clock line
27	O	nINT	I2C slave interrupt line
28 – 30	IO	C12 – C14	Column lines 12 to 14 for scan matrix
31	IO	XPCLK	External PS/2 clock line
32	IO	C15	Column line 15 for scan matrix
33 – 40	I	R0 – R7	Row lines 0 to 7 for scan matrix with internal pull-up resistor
41 – 48	IO	C0 – C7	Column lines 0 to 7 for scan matrix

LENGENG I = Input, O = Output, IO = Input/Output, P = Power

FUNCTION BLOCK DESCRIPTION

The SK5220 consists functionally of several major sections (see the block diagram on the previous page). These include power on reset, oscillator circuit, 16-bit timer, power management, programming interface, keyboard scan, keyboard LEDs, backlight brightness control, matrix data block, SMBus I2C keyboard and Mouse interface, external PS/2 interface. All sections communicate with each other and operate concurrently.

Keyboard Scan

The SK5220 scans a keyboard organized as an 8 row by 16 column matrix for a maximum of 128 keys. Smaller size matrixes can be accommodated by leaving unused pins open. The IC provides internal pull-ups for the row input pins. When active, the encoder selects each column line (C0-C15); for each column selected, it reads the row data lines (R0-R7). A key closure is detected as a zero in the corresponding position of the matrix.

Each key found pressed is de-bounced for a period of 24 ms. Once the key is verified, the corresponding key code(s) are loaded into the transmit buffer.

In any scanned contact switch matrix, whenever three keys defining a rectangle on the switch matrix are pressed at the same time, a fourth key positioned on the fourth corner of the rectangle is sensed as being pressed. This is known as the "ghost" or "phantom" key problem.

Although the problem cannot be totally eliminated without using external hardware, there are methods to neutralize its negative effects for most practical applications. Keys that are intended to be used in combinations should be placed in the same row or column of the matrix, whenever possible. Shift keys (Shift, Alt, Ctrl, Window, Fn) should not reside in the same row (or column) as any other keys. The SK5220 has built-in mechanisms to detect and reject "ghost" keys.
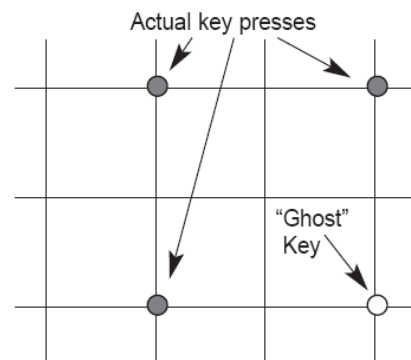
Keyboard LEDs

The SK5220 provides 9 pins to directly drive general LED indicators which can be controlled via commands.

SMBus I2C Interface

The SK5220 follows proprietary SMBus protocols to report keyboard and mouse events. See details in document "*Sprintek SMBus Keyboard Controller Communication Protocol*".

nINT pin is low assertion to indicate that the SK5220 has events to report.

Power Management

The SK5220 automatically enter low power mode when no key is pressed.

Backlight Brightness Control

The 10-bit PWM output controls the brightness of backlight circuit. The PWM clock is sourced from 12MHz clock, and the parameters such as period, positive width are programmable.

Power On Reset Circuit

The SK5220 has built-in power on reset circuit with simple external RC components.

Oscillator Circuit

The SK5220 has built-in oscillator circuit and no external crystal or resonator is needed.

16-bit Timer

The 16-bit timer provides the timing control for I2C communication, keyboard scan and sleep timer wakeup.

External PS/2 Port

The SK5220 provides an external PS/2 port that supports hot plug and hot swap of PS/2 devices including touchpad, pointing stick mouse. The host can send any PS/2 commands to control the external PS/2 device settings via the SK5220's PS/2 command relay feature.

Matrix Data Block

The SK5220 provides an on-chip data block to store configuration data.

Programming Interface

The programming interface is reserved for Sprintek to programming new firmware. **PRGC and PRGD pins are recommended to be connected to a 6 pin header in the schematic.** The header needn't be populated in the final assembly. Three test points are preferred if 6 pin header is not allowed due to space reason.

SMBus COMMAND PROTOCOL

SMBus Slave Device Address

The 7-bit address of the device is shown as below 0x39. After combined with R/W bit, the 8-bit address is 0x72 for I2C write operation, 0x73 for I2C read operation.

SMBus Based Low Level Communication

The Controller follows SMBus protocol with PEC always enabled.

Table – Host to SMBus keyboard controller I2C Packet Formats

SMBus Protocol	
Write Byte	| S | Address | W | {A} | Command | {A} | Data Byte | {A} | PEC | {A} | P |
Read Byte	| S | Address | W | {A} | Command | {A} | S | Address | R | {A} | {Data Byte} | A | {PEC} | nA | P |
Write Word	| S | Address | W | {A} | Command | {A} | Data Low | {A} | Data High | {A} | PEC | {A} | P |
Read Word	| S | Address | W | {A} | Command | {A} | S | Address | R | {A} | {Data Low} | A | {Data High} | A | {PEC} | nA | P |
Block Read	| S | Address | W | {A} | Command | {A} | S | Address | R | {A} | {Byte Count} | A | {Byte 0} | A | {Byte 1} | A | ... | {Byte N} | A | {PEC} | nA | P |
Block Write	| S | Address | W | {A} | Command | {A} | Byte Count | {A} | Byte 0 | {A} | Byte 1 | {A} | … | Byte N | {A} | PEC | {A} | P |

Legend: S = Start, P = Stop, A = Ack, nA = NAck, W=Write (0), R=Read (1)
Items in { } are sent from the slave (Keyboard controller) to the master (Host controller).

Events

Event Format

The device can notify the host when certain events happen. The device will assert nINT line first; then wait for the host send "Read Events" command to query what events happens. Each event is led by an event identification byte, then followed by zero or more data bytes.

Event Table

Event Name	Event Code	Description
EVENT_KEYSTROKE	0x00	Keyboard event. Followed by one-byte keyboard status. See keyboard event table.
EVENT_RESET_COMPLETE	0x04	Sent when POR
EVENT_FWU_STATUS	0x06	Event generated by SMBus bootloader. See further in FWU status table.
EVENT_BACKLIT_OFF	0x07	When backlit is turned off when backlit timeouts.
EVENT_PROD_INFO_STATUS	0x08	Not supported
EVENT_PS2_STD_MOUSE	0x12	PS/2 standard mouse report. It's followed by 3-byte PS/2 mouse report. See the PS/2 standard mouse report table.
EVENT_PS2_WHEEL_MOUSE	0x13	PS/2 3 button wheel mouse report. It's followed by 4-byte PS/2 mouse report. See the PS/2 3 button wheel mouse report table.
EVENT_PS2_5BTN_MOUSE	0x14	PS/2 5 button wheel mouse report. It's followed by 4-byte PS/2 mouse report. See the PS/2 5 button wheel mouse report table.
EVENT_CHECKSUM	0x15	Followed by 3-byte data. Byte0: verification status Byte1: Checksum low byte Byte2: Checksum high byte
EVENT_PS2_RELAY_COMPLETE	0x16	
EVENT_BUFFER_EMPTY	0xFF	When no event is in the even buffer, it's sent.

Keyboard Event Format (Event ID 0)

Keyboard events are represented in single byte that indicates the row and column of the key that changed state.

Event ID 0	Keyboard Event Format
Bits	**Description**
7	**Key Press/Release** 1=Key was pressed, 0=Key was released
4:6	**Keyboard Matrix Row** Key scan input number (0-7)
3:0	**Keyboard Matrix Column** Key scan output number (0-15 depending on number of columns used)

PS/2 Standard Mouse Event Format (Event ID 0x12)

Byte	D7	D6	D5	D4	D3	D2	D1	D0	Comment
1	Yover	Xover	Ysign	Xsign	Tag	M	R	L	X/Y overflows and signs, buttons
2	X7	X6	X5	X4	X3	X2	X1	X0	X data byte
3	Y7	Y6	Y5	Y4	Y3	Y2	Y1	Y0	Y data byte

PS/2 3 button Wheel Mouse Event Format (Event ID 0x13)

Byte	D7	D6	D5	D4	D3	D2	D1	D0	Comment
1	0	0	Ysign	Xsign	1	M	R	L	X/Y signs and R/L/M buttons
2	X7	X6	X5	X4	X3	X2	X1	X0	X data byte
3	Y7	Y6	Y5	Y4	Y3	Y2	Y1	Y0	Y data byte
4	Z7	Z6	Z5	Z4	Z3	Z2	Z1	Z0	Z/wheel data byte

PS/2 5 button Wheel Mouse Event Format (Event ID 0x14)

Byte	D7	D6	D5	D4	D3	D2	D1	D0	Comment
1	0	0	Ysign	Xsign	1	M	R	L	X/Y signs and L/R/M buttons
2	X7	X6	X5	X4	X3	X2	X1	X0	X data byte
3	Y7	Y6	Y5	Y4	Y3	Y2	Y1	Y0	Y data byte
4	0	0	B5	B4	Z3	Z2	Z1	Z0	Z/wheel data and buttons 4 and 5

List of Commands Of Application Code

Command 0x82 – Read Events
Command 0xC0 – Reset Device
Command 0xC1 – Get Device Information
Command 0xC2 – Calculate Application Code Checksum
Command 0x90 – FWU Init
Command 0x83 – Set LEDs
Command 0x8C – Reset Backlit Timer
Command 0x94 – Set Backlit Timeout
Command 0x95 – Toggle Backlit AutoOn
Command 0xC5 – Set Backlit Period and Duty
Command 0xC6 – Relay PS/2 Command

KEYBOARD MATRIX DESIGN
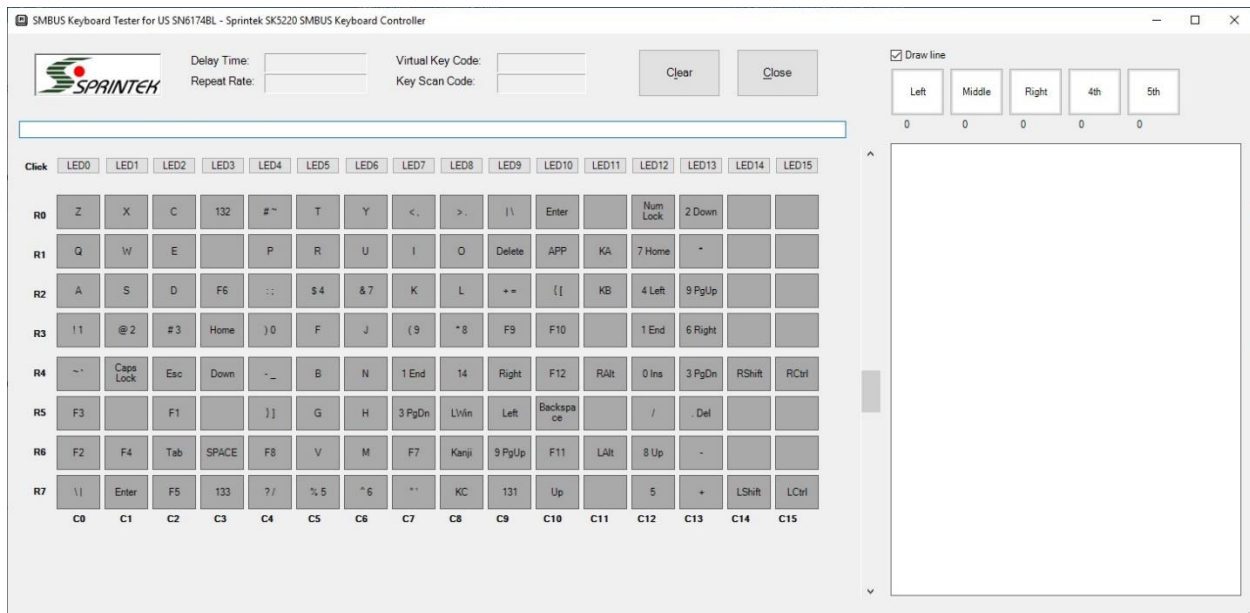
Design Keyboard Matrix

Please refer to Microsoft Windows Platform Design Notes "Keyboard Scan Code Specification" to get more information.

Test Keyboard Matrix

Sprintek offers a keyboard test tool to verify your keyboard design. The FlexMatrix Tester software can be downloaded from the download page on the Sprintek web site
http://sprintek.com/support/Downloads.aspx

Here is the screen snapshot of FlexMatrix Tester software.

DEFAULT KEYBOARD MATRIX

The SK5220 reports keyboard location (row, column) to the host, so no matrix scan code mapping table is needed. The tables shall be defined at the host controller. The scan code table can be seen in the following section "*HID Usage Tables 1.2*" from www.usb.org.

SCHEMATIC OF REFERENCE DESIGN
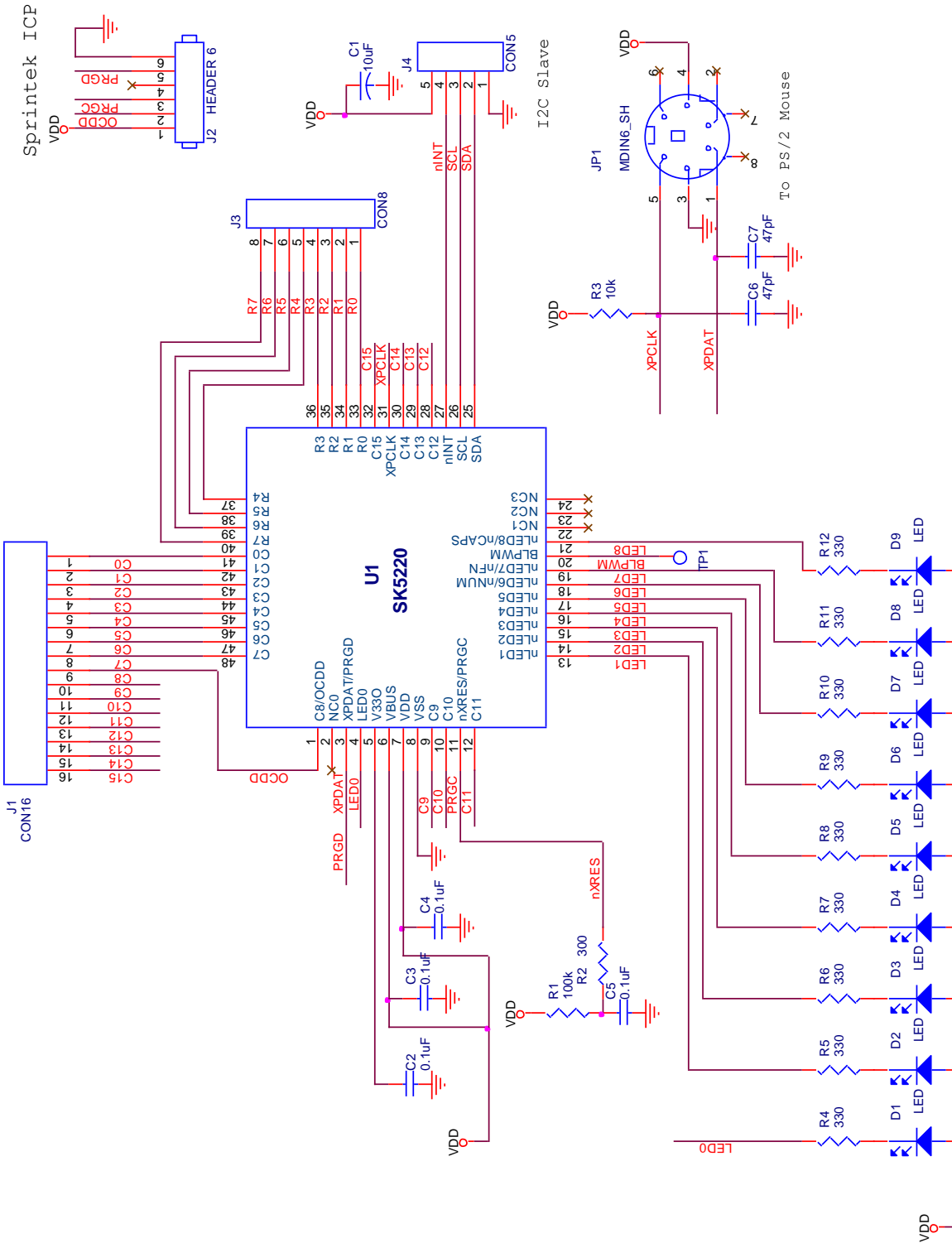
ELECTRONICS SPECIFICATIOIN

Absolute Maximum Ratings

Symbol	Description	Min	Typ	Max	Units	Notes
TSTG	Storage Temperature	-50	25	+125	ºC	
VDD	Supply Voltage on Relative to VSS	-0.3	-	+6.0	V	
VIO	DC Input Voltage	VSS-0.3	-	VDD+0.3	V	
IMTO	Maximum Current into all pins in total	-100	-	+150	mA	

Operating Temperature

Symbol	Description	Min	Typ	Max	Units	Notes
TOP	Operating Temperature	-40	-	+85	ºC	

DC Electrical Characteristics

Symbol	Description	Min	Typ	Max	Units	Notes
VDD	Supply Voltage	2.21	-	5.5	V	
IDD	Supply Current when no key is pressed		0.3	2	uA	5V
			0.1	1	uA	3.3V
IDDK	Supply Current when one key is pressed		1.5		mA	5V
			0.75		mA	3.3V
LVR	Low voltage reset	1.995	2.1	2.205	V	
RPU	Pull-up Resistor	10	30	50	kΩ	5V
		20	60	100	kΩ	3.3V

GPIO Electrical Characteristics

Symbol	Description	Min	Typ	Max	Units	Notes
VIL	Input Low Level	-	-	0.2VDD	V	
VIH	Input High Level	0.8VDD	-	-	V	
BLFPWM	Backlight PWM frequency		357		Hz	

I2C Slave Electrical Characteristics

Symbol	Description	Min	Typ	Max	Units	Notes
BI2C	I2C baud rate	-	-	400k	Hz	

PACKAGING INFORMATION

SK5220-LP Drawing
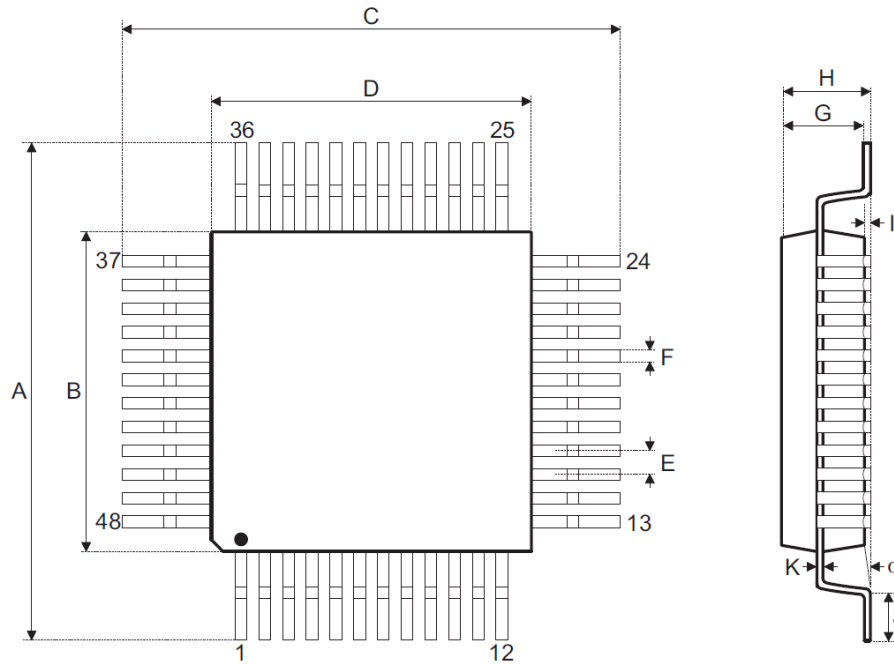
Symbol	Dimensions in mm		
	Min.	**Nom.**	**Max.**
A	-	9.00BSC	-
B	-	7.00BSC	-
C	-	9.00BSC	-
D	-	7.00BSC	-
E	-	0.50BSC	-
F	0.17	0.22	0.27
G	1.35	1.40	1.45
H	-	-	1.60
I	0.05	-	0.15
J	0.45	0.60	0.75
K	0.09	-	0.20
α	0 °	-	7 °

SK5220-LP 48-pin (7x7mm 1.6 MAX) LQFP

SALE AND SERVICE INFORMATION

To obtain information about Sprintek Corporation or FlexMatrix keyboard controller family sales and technical support, reference the following information.

Sprintek Corporation
4969 Corral St.
Simi Valley, CA 93063, USA
Web Site: http://www.sprintek.com

REVISION HISTORY

Revision	Issue Date	Description
1.00	June 21, 2018	Initial release
1.01	September 25, 2018	Added bootloader support for SK5220 v1.02
1.02	April 30, 2019	Updated interface with SMBus
1.03	May 18, 2023	Reformat the document