FE1.1s – *Revision B*

USB 2.0 HIGH SPEED 4-PORT HUB CONTROLLER

Data Sheet

INTRODUCTION

The Terminus FE1.1s is an USB 2.0 High Speed 4-port hub controller with special features to support GSMA "*Universal Charging Solution*", (UCS). It is fully compliant to USB-IF "*Universal Serial Bus Specification Revision 2.0*" and "*Battery Charging Specification Revision 1.1/1.2*".

The FE1.1s is a highly integrated, high quality, and high performance solution for USB 2.0 4-port hub. With its tiny footprint and extremely low power consumption, it is the best choice for embedded application as well as standalone hub.

The high quality of FE1.1s is guaranteed by Design-For-Testing with comprehensive scan chains and Built-In-Self-Test modes which could exercise all High, Full, and Low Speed analog front end (AFE) components on the packaging and testing stages.

FE1.1s could be optionally configured to support *Charging Downstream Ports* as defined by USB-IF Battery Charging Specification. With this feature enabled, an USB hub could be easily transformed into a charging station – *USB Charging Hub* for Universal Charging Solution compliant battery based portable devices.

FEATURES

- Fully compliant with Universal Serial Bus Specification Revision 2.0 (USB 2.0);
  - Upstream Facing Port supports High-Speed (480MHz) and Full-Speed (12MHz) modes;
  - 4 Downstream Facing Ports support High-Speed, Full-Speed, and Low-Speed (12MHz) modes;
- Compliant with Universal Charging Solution, and USB Battery Charging Specification 1.1/1.2.
- Integrated USB 2.0 Transceivers;
- Integrated upstream 1.5KΩ pull-up, downstream 15KΩ pull-down, and serial resisters;
- Integrated 5V to 3.3V and 1.8V regulators;
- Integrated Power-On-Reset with power failure detection circuit;
- Integrated 12MHz Oscillator with feedback resister and crystal load capacitors;
- Integrated 12MHz-to-480MHz Phase Lock Loop (PLL);
- Integrated Portable Device detection circuitry for UCS supporting;
- *Single Transaction Translator* (Single TT) –

  - One TT for all downstream ports;
  - The TT could handle 64 periodic Start-Split transactions, 32 periodic Complete-Split transactions, and 6 none-periodic transactions;
- *Ganged Power Control* and *Global Over-Current Detection* support;
- EEPROM configured options –
  - Vendor ID, Product ID, & Device Release Number; and
  - Number of Downstream Ports;
- Automatic re-enumeration when hub switches from self-powered mode to bus-powered mode;
- Board configured comprehensive Port Indicators support:
  - Four *Downstream Port Enabled* indicator LED (Green, one for each port), plus one *Active/Suspend* indicator LED (Red); or
  - One joint Downstream Port Enabled indicator LED (Green, one for all ports), plus one Active/Suspend indicator LED (Red); or
  - One joint Downstream Port Enabled indicator LED (Green, one for all ports), plus one *Charging Request/Portable Device Detection* indicator LED (Blue);
- Board configure support of portable device detection mechanism for Universal Charging Solution on all 4 downstream ports.

ORDER INFORMATION

P/N-Order Code	Description	Package Type	Packing	Minimum Order Quantity
FE1.1s-BSOP28BTR	USB 2.0 4-Port STT Hub Controller	28-pin SSOP (10mm x 4mm)	Tape & Reel	15000
FE1.1s-BSOP28B		28-pin SSOP (10mm x 4mm)	Tube	10000
FE1.1s-BSOP28BC		28-pin SSOP (10mm x 4mm)	Tube	10000
FE1.1s-BSOP28BCTR		28-pin SSOP (10mm x 4mm)	Tape & Reel	15000
FE1.1s-BQFN24B		24-pin WQFN (4mm x 4mm)	Tape & Reel	15000
FE1.1s-BSOP28BCN		28-pin SSOP (10mm x 4mm)	Tube	10000
FE1.1s-BSOP28BCNTR		28-pin SSOP (10mm x 4mm)	Tape & Reel	15000
FE1.1s-BQFN24BCN		24-pin WQFN (4mm x 4mm)	Tape & Reel	15000

BLOCK DIAGRAM

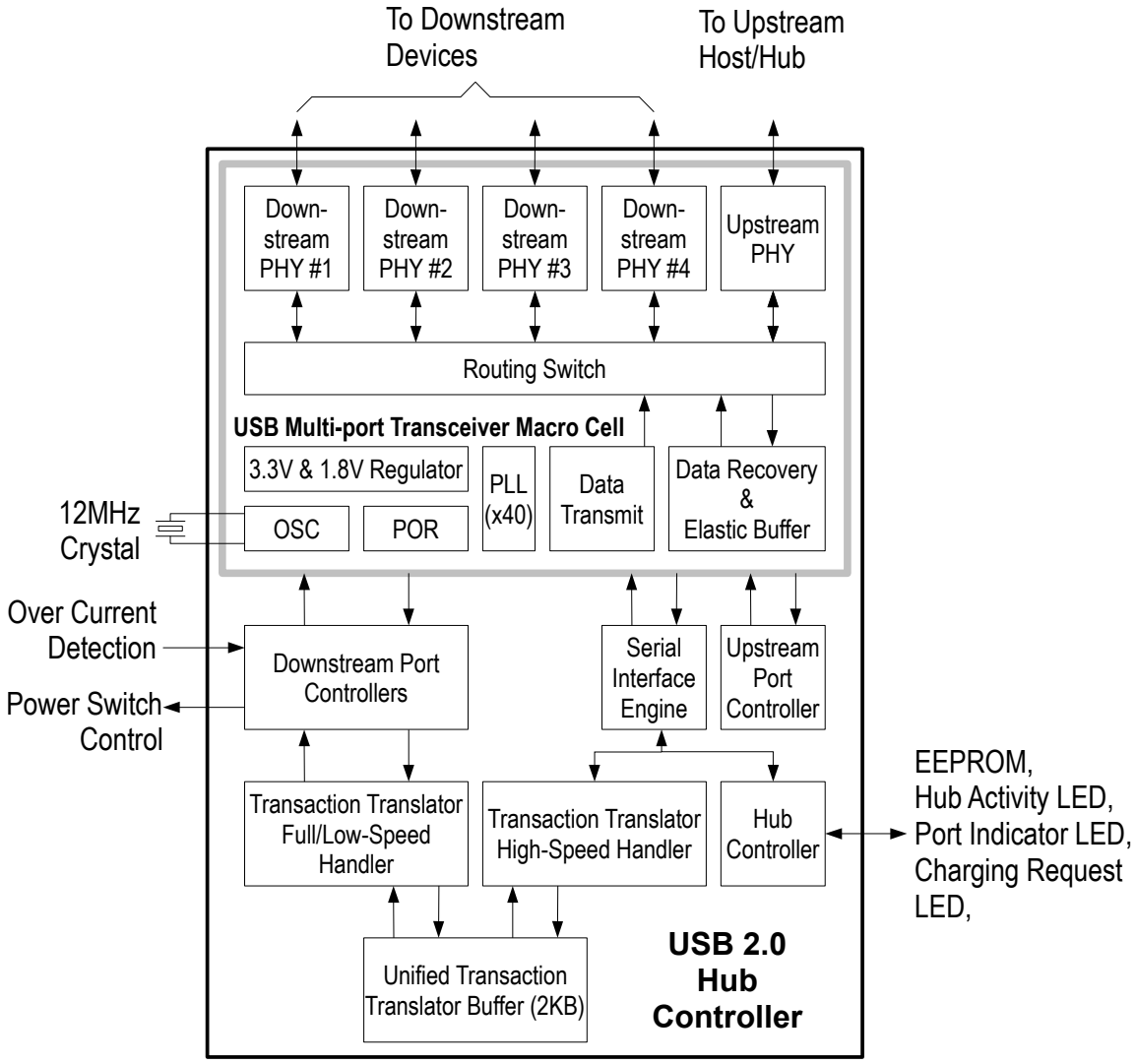


Fig. 1: Block Diagram

PACKAGE I

28-Pin SSOP
(Body Size: 10mm x 4mm, Pitch: 0.64mm)

PIN ASSIGNMENT

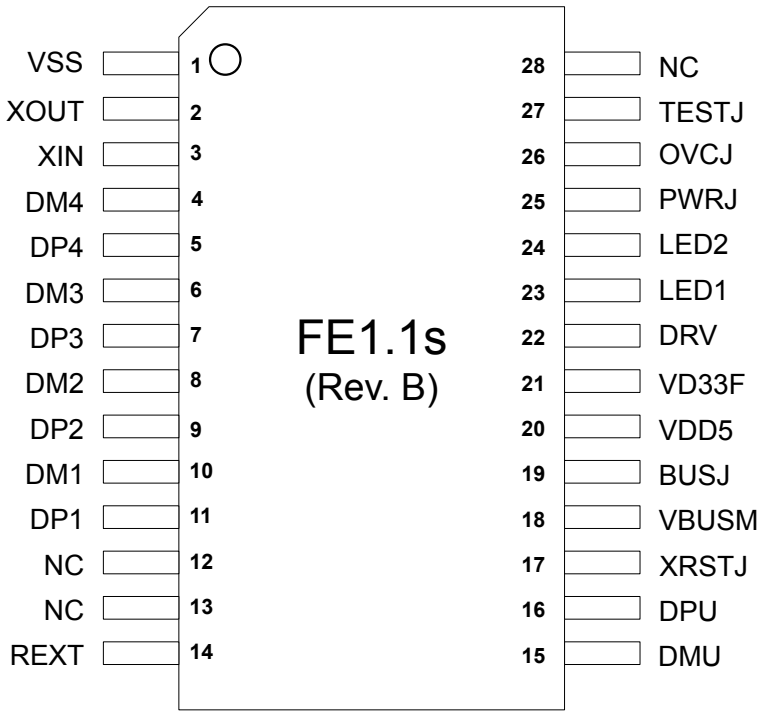


Fig. 2: 28-Pin SSOP Pin Assignment

PACKAGE II

24-Pin WQFN
(Body Size: 4mm x 4mm, Pitch: 0.5mm)
(Exposed Pad: 2.8mm x 2.8mm)

PIN ASSIGNMENT

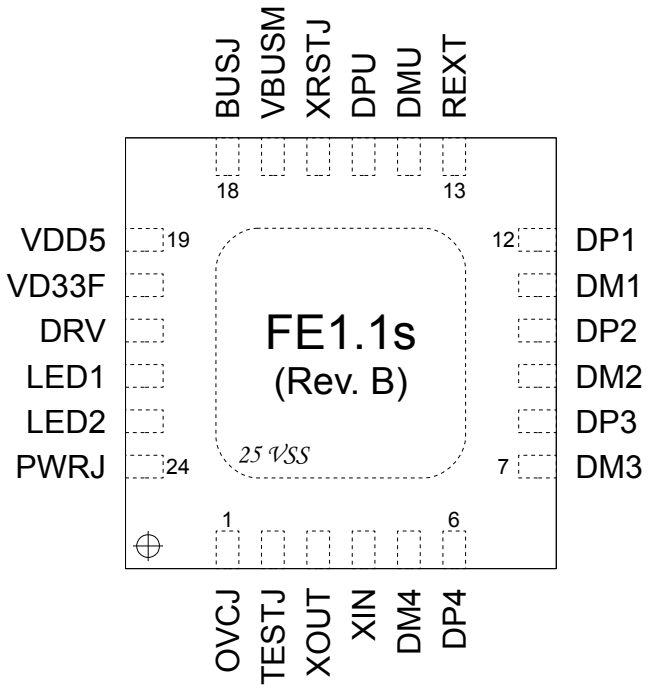


Fig. 3: 24-Pin WQFN Pin Assignment

PIN DESCRIPTION TABLE

Pin Name	Pin No.		Type	Function	Note
	SSOP	QFN			
VSS	1	25	P	Ground (pin 25 of WQFN is the underbelly exposed pad)	
XOUT	2	3	OSC	12MHz Crystal Oscillator output.	1
XIN	3	4	OSC	12MHz Crystal Oscillator input/External 12MHz clock input.	1
DM4	4	5	UTD	The D- pin of the 4th Downstream Facing Port.	
DP4	5	6	UTD	The D+ pin of the 4th Downstream Facing Port.	
DM3	6	7	UTD	The D- pin of the 3rd Downstream Facing Port.	
DP3	7	8	UTD	The D+ pin of the 3rd Downstream Facing Port.	
DM2	8	9	UTD	The D- pin of the 2nd Downstream Facing Port.	
DP2	9	10	UTD	The D+ pin of the 2nd Downstream Facing Port.	
DM1	10	11	UTD	The D- pin of the 1st Downstream Facing Port.	
DP1	11	12	UTD	The D+ pin of the 1st Downstream Facing Port.	
NC	12 28	—	P	These 2 pins were 1.8V power before Revision B. Though backward compatible, it is strongly recommended to be left as *No-Connection* in new designs. They could still be used in this version for testing internal 1.8V level.	
NC	13	—	P	This pin was 3.3V power input before Revision B. It could be either left as *No-Connection* for new design or connected to pin 21 (VD33F) through the PCB board as backward compatible.	
REXT	14	13		External Bias Resister A 2.7KΩ (± 1%) resister should be connected to VSS to provide internal bias reference.	
DMU	15	14	UTU	The D- pin of the Upstream Facing Port.	
DPU	16	15	UTU	The D+ pin of the Upstream Facing Port.	
XRSTJ	17	16	I	External Reset For normal applications, it should be *pull-up to 3.3V*. The internal Power-On-Reset circuit will take care of the reset operation during the chip power-up stage. In case there are system design needs to reset the chip other than power-up stage, it can be done by driving this input low for a minimum pulse of 10 µs.	
VBUSM	18	17	I	Upstream Port Power (V_{BUS}) Monitor This pin monitors the power state of VBUS from upstream facing port. High level indicates that the host is powered up and the hub should function normally. Low level indicates that the host is powered down, and the hub should be in power-down state.	
BUSJ	19	18	I	Bus Power Sense This pin identify the primary power source of the hub. High level indicates the hub is *Self-Powered* and has enough strength to support	

				High-Power devices on its downstream ports. Otherwise, it is *Bus-Powered* and each downstream ports are presumed to supply 100mA of power only.	
VDD5	20	19	P	5V Power Input This is the 5V power input for integrated 5V → 3.3V regulator. However, if external 3.3V source is used, this pin should be *No-Connection*.	
VD33F	21	20	P	3.3V output filter capacitor for embedded 5V → 3.3V regulator, or 3.3V input from external source.	
DRV/ CHRGEN	22	21	I/O24	LED Drive Control/Charging Hub Enable During power-on-reset, this pin is used as Charging Hub Enable. If it is tied to high, the battery charging function will be enabled. Otherwise, it is a normal hub and this pin functions as LED driving control pin.	
LED1/ EESCL	23	22	I/O8	LED Control 1/External EEPROM Clock Port 1 and Port 3 device connected indicator (LED) control; or, when LED2 is tied to high during power-on-reset, it is the joint indicator for all ports. At the same time, it could also be used as the clock (SCL) of external EEPROM.	
LED2/ JLEDEN	24	23	I/O8	LED Control 2/Joint LED Indicator Enable Port 2 and Port 4 device connected indicator (LED) control. During power-on-reset, it is a configuration input for enabling Joint Port Indicator by tying to 3.3V.	
PWRJ	25	24	OD	Power Enable This is an active low, open-drain output signal for controlling power to the downstream devices in *Ganged Power Switching* mode. It is enabled and disabled by the host hub driver to reduce the in-rush current or in response to Over-Current Detection.	
OVCJ	26	1	I	Over Current Sense Active low input from external current monitor indicating over current condition for *Global Over-Current Protection.*	
TESTJ/ EESDA	27	2	OD-PU	Test Mode Enable/External EEPROM Serial Data Active low, open drain signal with internal pull-up resistor. When tied to low during power-on-reset, the chip will be set in test mode. The test mode is for factory test only, for all applications, this pin should be either left as *No-Connection* or connected to the Serial Data/Address (SDA) pin of external 2-wire EEPROM.	

Type Abbreviation –

I: Schmitt Trigger Input, 5V-Tolerant;

I/O8: Input/Output (driving strength: 8mA);

I/O24: Input/Output (driving strength: 24mA);

OD: Output, Open Drain (sink current: 4mA);

OD-PU: 3.3V Input/Output, Open Drain with Internal Pull-Up (sink current: 4mA);

I-PU: 3.3V Input with Internal Pull-Up;

UTD: USB Downstream Facing Port Transceiver (supporting High/Full/Low-Speed);

UTU: USB Upstream Facing Port Transceiver (supporting High/Full-Speed);

OSC: Crystal Oscillator (with integrated feedback resister, and crystal load capacitor);

P: Power/Ground.

Note 1 – Crystal Requirements

- Frequency accuracy: 12MHz ± 50ppm
- Load capacitance: 16pF ~ 20pF

APPLICATION ALTERNATIVES

The *FE1.1s* can be configured through board design options in one of three modes – *Individual Port Active Indicator* mode, *Joint Port Active Indicator* mode, and *USB Charging Hub* mode. Each mode could incorporate an optional external serial EEPROM for customizing *Vendor ID*, *Product ID*, *Device Release Number*, and number of ports. The detailed layout of EEPROM contents is explained in the following section. All these options are implemented through four pins: DRV, LED1, LED2, and TEST.

Individual Port Active Indicator Mode

In this mode, as shown by Fig. 4, FE1.1s supports 5 LED indicators – one green LED for each downstream port, and one red LED for hub active/suspend indication. The green light turns on whenever a device is properly attached to its corresponding port, and turns off when the device is disconnected or failed, or the hub itself being suspended. The red light turns on when the hub is configured by the USB host, and turns off when it is detached or switched into suspend mode. All LED's are optional and could be safely omitted without any side effects. The external EEPROM is optionally hooked on TESTJ and LED1.

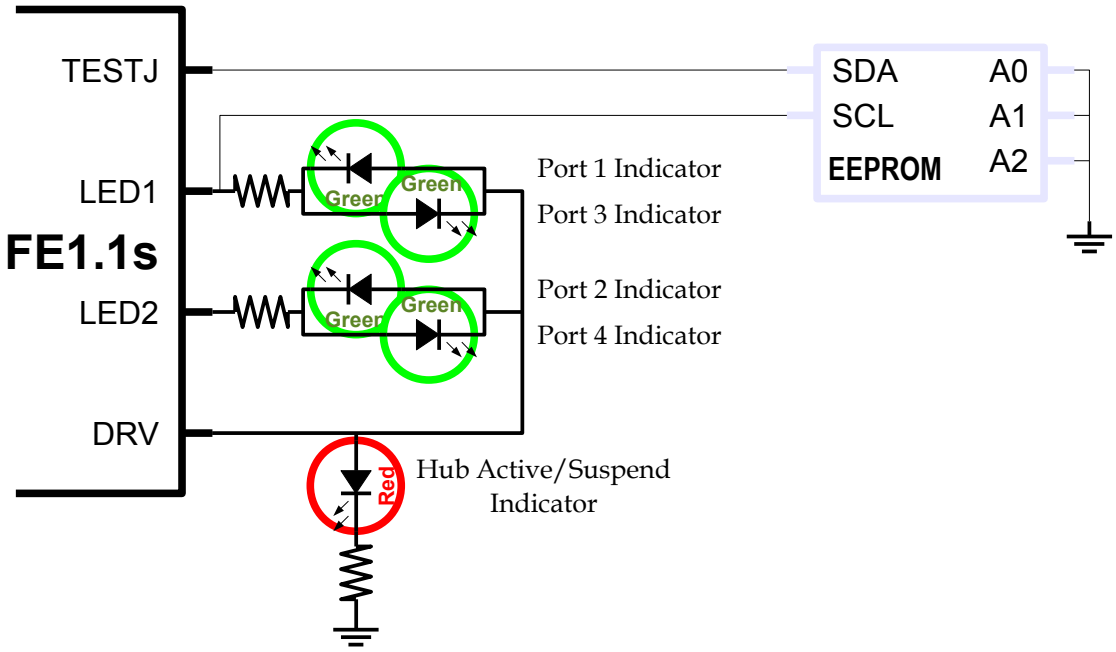


Fig. 4: Individual Port Indicator Configuration

Joint Port Active Indicator Mode

The four downstream port indicators can be summarized into one single LED, as depicted in Fig. 5, by tying LED2 to 3.3V. In this mode, the Joint Port Indicator will turn on whenever there is at least one device attached to any of its downstream ports. The behavior of the Hub Active/Suspend Indicator and the external serial EEPROM are remained the same.

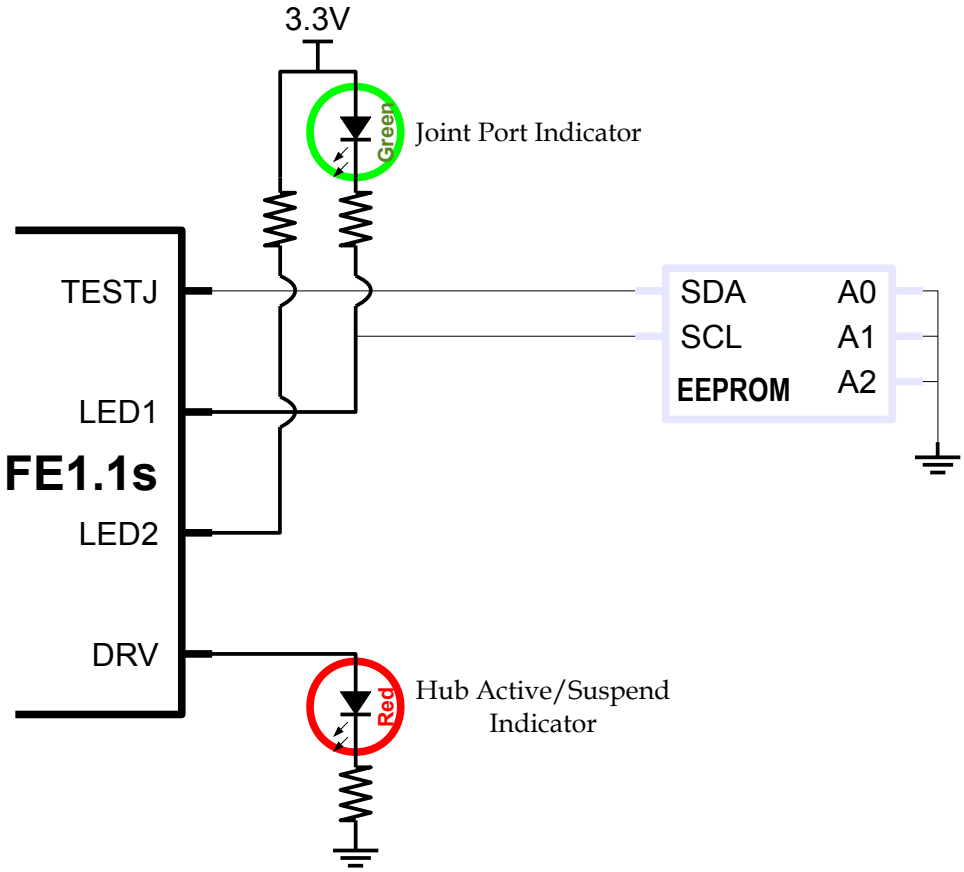


Fig. 5: Joint Port Indicator Configuration

USB Charging Hub Mode

The major changes of FE1.1s *Revision B* from its predecessors are the new capabilities to support GSMA "*Universal Charging Solution*" and USB-IF "*Battery Charging Specification Revision 1.1/1.2*". With the charging support enabled, the FE1.1s will be ready to respond to the charging requests from portable devices no matter whether it is not connected to the host, the host being

powered down, in normal operation, or in suspend. In other words, as long as the hub itself is adequately powered, the charging function is independent to the status of the upstream port or the host controller. Thus make it a full function USB Charging Hub. Figure 6 illustrates how the FE1.1s being configured as USB Charging Hub mode by tying the DRV pin to 3.3V.

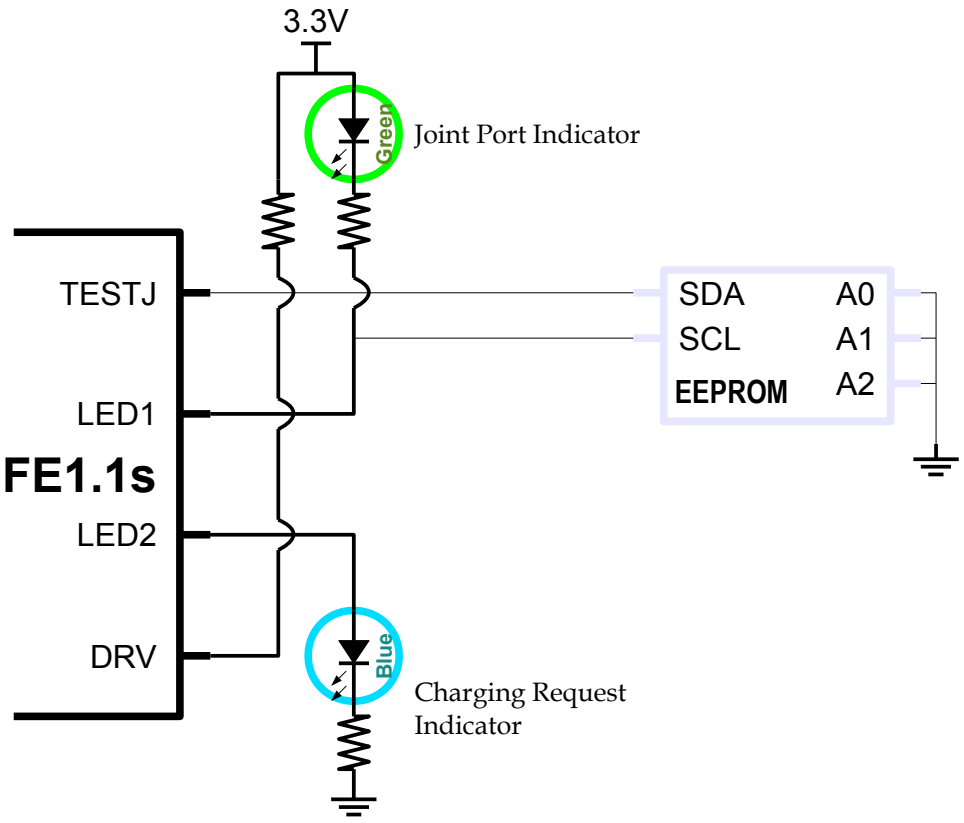


Fig. 6: USB Charging Hub

In this mode, the LED1 is the Joint Port Indicator which turns on whenever there are at least one device connected to any of its downstream ports. And it turns off when all devices has been disconnected, or itself is switched into suspend mode.

The LED2 will be the *Charging Request Indicator* which turns on when Charging Request is detected on any of its downstream ports, or charging request handshake has been completed successfully.

The connect/disconnect status of the portable devices is detected through standard USB procedure.

That is, for Full/Low Speed devices, both D+ and D- of the corresponding downstream port been detected as *Single Ended Zero* (SE0) for more than 2.5 µs. For High Speed, through the detection of removal of termination of D+ and D-. The status of power source for charging is indicated by BUSJ. When BUSJ is low, the hub is *Bus Powered*, and presumably has been provided 500mA only, which is barely enough to sustain the normal USB function of the hub plus 4 more *Low Power Device* (100mA). In this case, Charging is certainly not allowed. When BUSJ is high, the hub is *Self Powered*, and presumably has its own power source and has enough power for portable devices to charge.

An optional external Serial EEPROM could still be hooked on LED1 and TESTJ to provide alternate Product ID, Vendor ID, Device Release Number, and number of downstream ports – if the system designer would like some number less than 4.

EEPROM CONTENTS

Address	Contents	Note
0x00	0x40	Constant, low byte of check code.
0x01	0x1A	Constant, high byte of check code.
0x02	Vendor ID (Low)	Low byte of Vendor ID, idVendor field of *Standard Device Descriptor.*
0x03	Vendor ID (High)	High byte of Vendor ID.
0x04	Product ID (Low)	Low byte of Product ID, idProduct field of *Standard Device Descriptor.*
0x05	Product ID (High)	High Byte of Product ID.
0x06	Device Release (Low)	Low byte of Device Release Number, must be Binary Coded Decimal, bcdDevice field of *Standard Device Descriptor.*
0x07	Device Release (High)	High byte of Device Release Number, must be Binary Coded Decimal.
0x08 ~ 0x19	Filling	All 0x00.
0x1A	Port Number	Number of Downstream Ports, bNbrPorts field of *Hub Descriptor.*
0x1B ~ 0x1E	Filling	All 0x00.
0x1F	Check Sum	The 8-bit sum of all value from 0x00 to 0x1E.

The first two bytes are the check code from the existence of EEPROM, their value must be 0x1A40. Any other value would cause the EEPROM loading mechanism of *FE1.1s* to conclude that the contents of this EEPROM is unusable, and use the default value instead.

The last byte, 0x1F, is a checksum made up of the sum of all value from 0x00 to 0x1E. The number must match to render the contents of the EEPROM usable. Otherwise, the loading mechanism of *FE1.1s* would discard the value from EEPROM and use default value instead.

ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Min.	Max.	Unit
Storage Temperature	TS	-55	+150	°C
Power Supply Voltage	VDD5 VD33	-0.5 -0.5	+6.0 +4.0	V
ESD Human Body Mode		-2000	+2000	V
ESD Machine Mode		-200	+200	V
ESD Charged Device Mode		-500	+500	V
Latch Up		-200	+200	mA

Recommanded Operating Ranges

Parameter	Symbol	Min.	Typ.	Max.	Unit
Operating Temperature	TA	0		70	°C
Operating Voltage	VDD5 VD33	4.5 3.0	5.0 3.3	5.5 3.6	V
LOW level voltage of digital input	VIL	-0.3		0.8	V
HIGH level voltage of digital input	VIH	2.0		5.5	V
Threshold voltage of digital input	VTH	1.45	1.58	1.74	V
Low-to-High level of Schmitt-trigger input	VT+	1.44	1.5	1.56	V
High-to-Low level of Schmitt-trigger input	VT-	0.89	0.94	0.99	V
LOW level voltage of digital output	VOL			0.4	V
HIGH level voltage of digital output	VOH	2.4			V
XIN input capacitance	Cin		32		ρF
Internal Pull-Up Resister Range	R_{PU}	39	65	116	KΩ

POWER CONSUMPTION

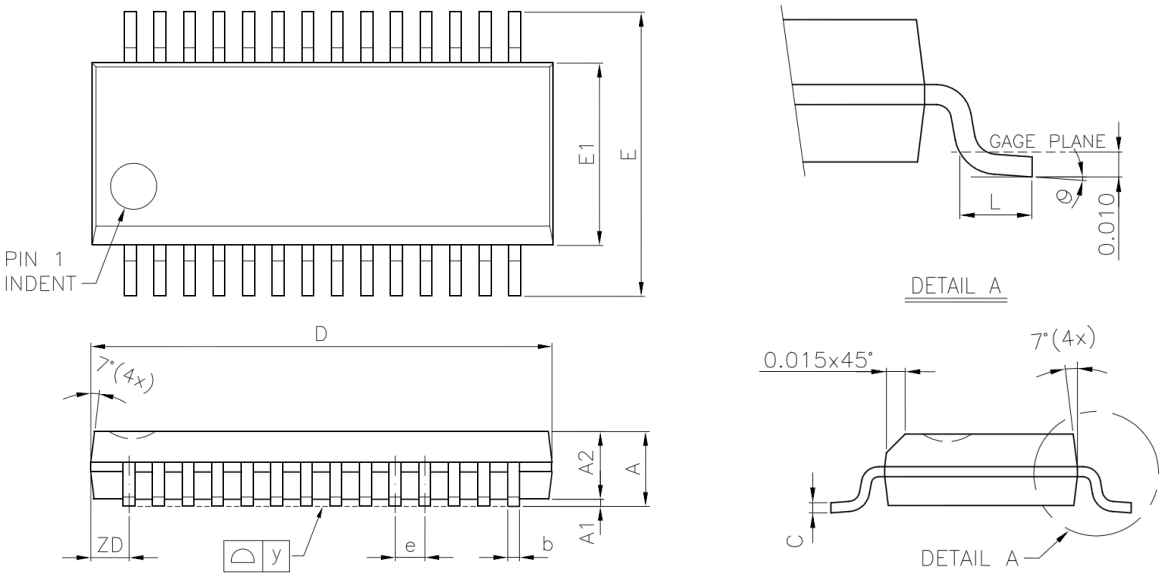
ABSOLUTE MAXIMUM RATINGS

Symbol	Condition			Typical	Unit
	Active	Host	Devices		
I_suspend	Suspend			800	µA
I_suspend_cm	Suspend in Charging Mode			1300	µA
Icc	4	High-Speed	4 x High-Speed	84	mA
		High-Speed	4 x Full-Speed	41	mA
		Full-Speed	4 x Full-Speed	28	mA
	3	High-Speed	3 x High-Speed	73	mA
		High-Speed	3 x Full-Speed	41	mA
		Full-Speed	3 x Full-Speed	28	mA
	2	High-Speed	2 x High-Speed	62	mA
		High-Speed	2 x Full-Speed	41	mA
		Full-Speed	2 x Full-Speed	28	mA
	1	High-Speed	1 x High-Speed	51	mA
		High-Speed	1 x Full-Speed	41	mA
		Full-Speed	1 x Full-Speed	28	mA
	No Active	High-Speed	None	40	mA
		Full-Speed	None	28	mA

Note: The power consumption is measured when the bus is in IDLE state – there is no activities other than the Start-Of-Frame (SOF) and INTERRUPT-IN packets for the hub itself on the bus. The peak power consumption varies depending upon the system configuration, type of operations, and over-all bus utilization.

PACKAGE I

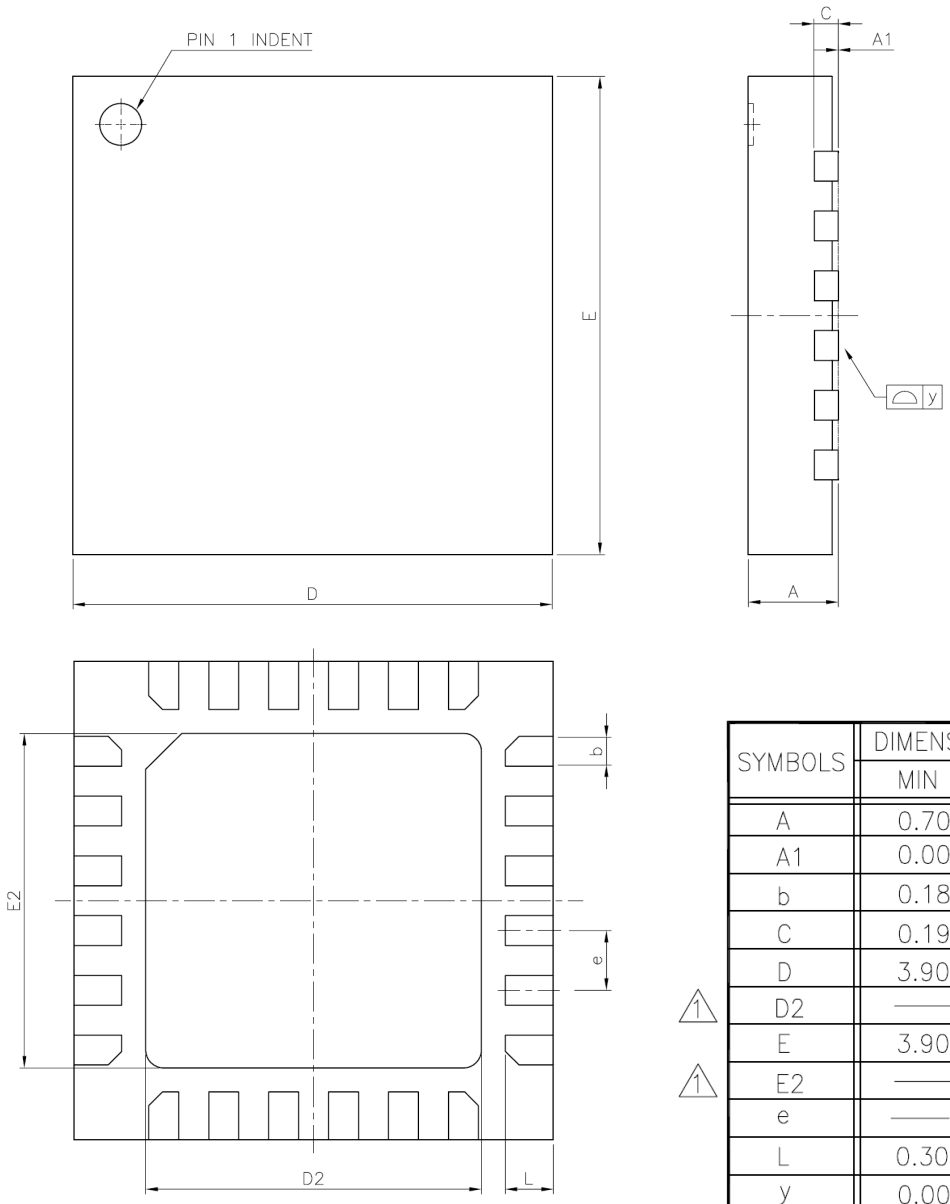
28-pin SSOP (Body Size: 10x4 mm, Pitch: 0.64mm)



SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	1.47	1.60	1.73	0.058	0.063	0.068
A1	0.10	——	0.25	0.004	——	0.010
A2	1.37	1.45	1.52	0.054	0.057	0.060
b	0.23	0.25	0.36	0.009	0.010	0.014
C	0.19	0.20	0.25	0.0075	0.008	0.0098
D	9.80	9.91	10.01	0.386	0.390	0.394
E	5.79	5.99	6.20	0.228	0.236	0.244
E1	3.81	3.91	3.99	0.150	0.154	0.157
e	——	0.635	——	——	0.025	——
L	0.38	0.71	1.27	0.015	0.028	0.050
ZD	——	0.825	——	——	0.0325	——
y	——	——	0.076	——	——	0.003
θ	0°	——	8°	0°	——	8°

PACKAGE II

24-pin WQFN (Body Size: 4x4 mm, Pitch: 0.5mm, Exposed Pad: 2.8x2.8mm)



SYMBOLS	DIMENSIONS IN MILLIMETERS		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
b	0.18	0.23	0.30
C	0.19	0.20	0.25
D	3.90	4.00	4.10
1 D2	——	2.80	——
E	3.90	4.00	4.10
1 E2	——	2.80	——
e	——	0.50	——
L	0.30	0.40	0.50
y	0.00	——	0.076

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