



ISP1520

Hi-Speed Universal Serial Bus hub controller

Rev. 02 — 04 May 2004

Product data

1. General description

The ISP1520 is a stand-alone Universal Serial Bus (USB) hub controller IC that complies with *Universal Serial Bus Specification Rev. 2.0*. It supports data transfer at high-speed (480 Mbit/s), full-speed (12 Mbit/s) and low-speed (1.5 Mbit/s).

The upstream facing port can be connected to a Hi-Speed USB host or hub or to an Original USB host or hub. If the upstream facing port is connected to a Hi-Speed USB host or hub, then the ISP1520 will operate as a Hi-Speed USB hub. That is, it will support high-speed, full-speed and low-speed devices connected to its downstream facing ports. If the upstream facing port is connected to an Original USB host or hub, then the ISP1520 will operate as an Original USB hub. That is, high-speed devices that are connected to its downstream facing ports will operate in full-speed mode instead.

The ISP1520 is a full hardware USB hub controller. All Original USB devices connected to the downstream facing ports are handled using a single Transaction Translator (TT), when operating in a cross-version environment. This allows the whole 480 Mbit/s upstream bandwidth to be shared by all the Original USB devices on its downstream facing ports.

The ISP1520 has four downstream facing ports. If not used, ports 3 and 4 can be disabled. The vendor ID, product ID and string descriptors on the hub are supplied by the internal ROM; they can also be supplied by an external I²C-bus™ EEPROM or a microcontroller.

The ISP1520 IC is suitable for self-powered hub designs.

An analog overcurrent detection circuitry is built into the ISP1520, which can also accept digital overcurrent signals from external circuits; for example, Micrel MOSFET switch MIC2026. The circuitry can be configured to trip on a global or an individual overcurrent condition.

Each port comes with two status indicator LEDs.

Target applications of the ISP1520 are monitor hubs, docking stations for notebooks, internal USB hub for motherboards, hub for extending Intel® Easy PCs, hub boxes, and so on.



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2. Features

- Complies with:
 - ◆ *Universal Serial Bus Specification Rev. 2.0*
 - ◆ Advanced Configuration and Power Interface (ACPI™), OnNow™ and USB power management requirements.
- Supports data transfer at high-speed (480 Mbit/s), full-speed (12 Mbit/s) and low-speed (1.5 Mbit/s)
- Self-powered capability
- USB suspend mode support
- Configurable number of ports
- Internal power-on reset and low voltage reset circuit
- Port status indicators
- Integrates high performance USB interface device with hub handler, Philips Serial Interface Engine (SIE) and transceivers
- Built-in overcurrent detection circuit
- Individual or ganged power switching, individual or global overcurrent protection, and non-removable port support by I/O pins configuration
- Simple I²C-bus (master/slave) interface to read device descriptor parameters, language ID, manufacturer ID, product ID, serial number ID and string descriptors from a dedicated external EEPROM, or to allow the microcontroller to set up hub descriptors
- Visual USB traffic monitoring (GoodLink™) for the upstream facing port
- Uses 12 MHz crystal oscillator with on-chip Phase-Locked Loop (PLL) for low ElectroMagnetic Interference (EMI)
- Full industrial operating temperature range from 0 °C to 70 °C
- Available in LQFP64 package.

3. Applications

- Monitor hubs
- Docking stations for notebooks
- Internal hub for USB motherboards
- Hub for extending Easy PCs
- Hub boxes.

4. Abbreviations

ACPI — Advanced Configuration and Power Interface

EMI — ElectroMagnetic Interference

ESD — ElectroStatic Discharge

NAK — Not AcKnowledge

PID — Packet Identifier

PLL — Phase-Locked Loop

SIE — Serial Interface Engine

TT — Transaction Translator

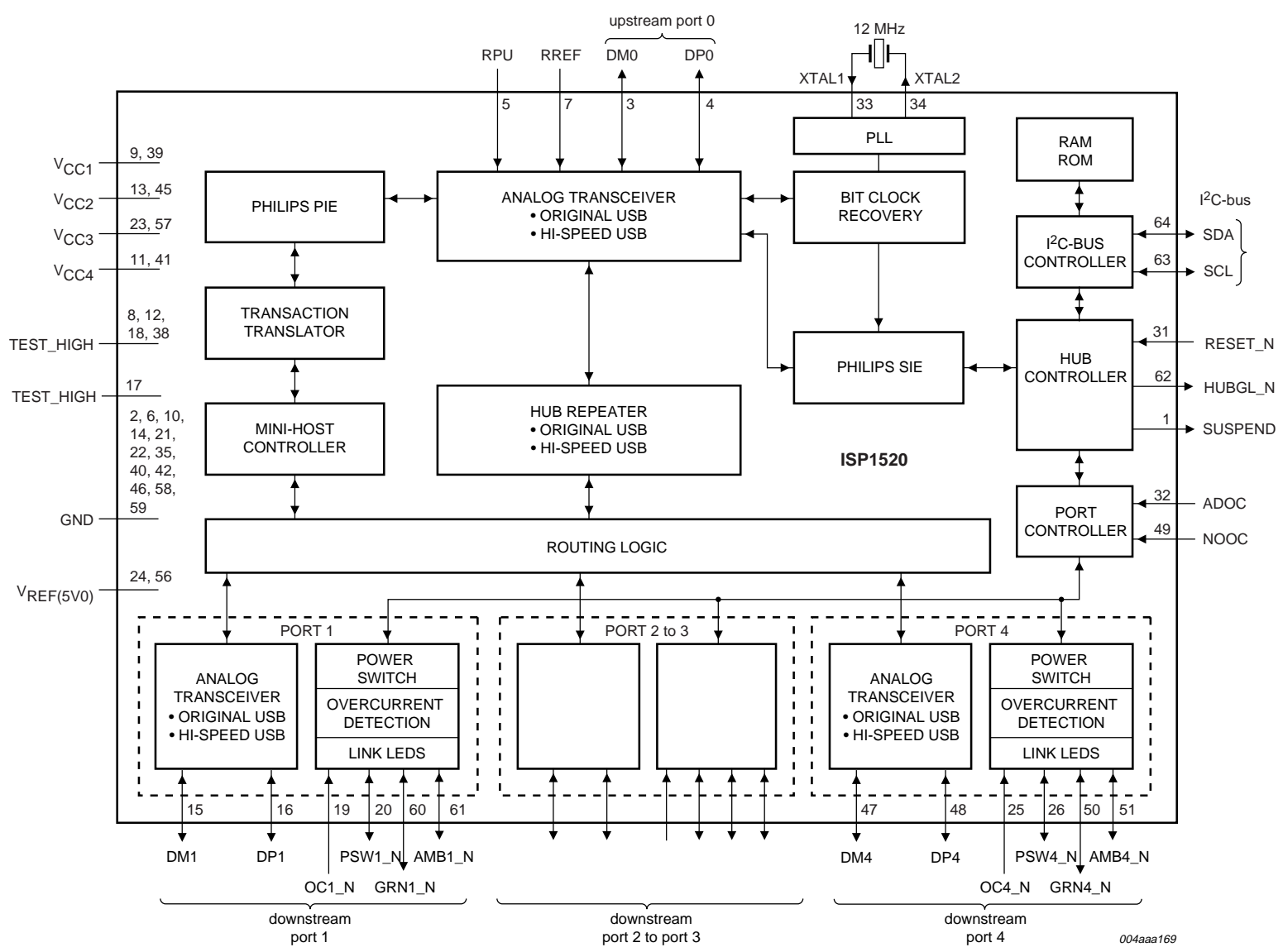
USB — Universal Serial Bus.

5. Ordering information

Table 1: Ordering information

| Type number | Package | | |
|-------------|---------|---|----------|
| | Name | Description | Version |
| ISP1520BD | LQFP64 | plastic low profile quad flat package; 64 leads; body 10 × 10 × 1.4 mm | SOT314-2 |

6. Block diagram



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Fig 1. Block diagram.

7. Pinning information

7.1 Pinning

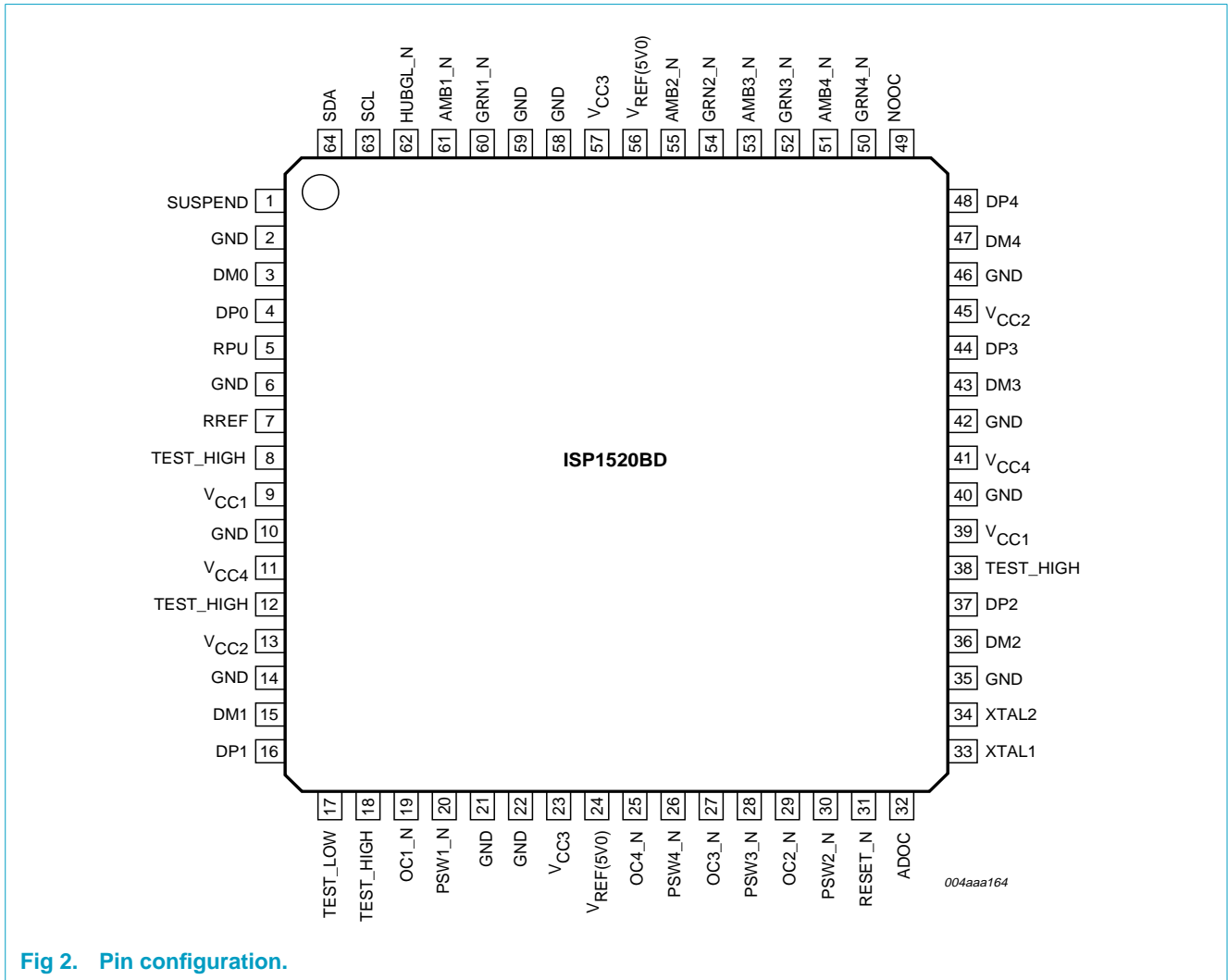


Fig 2. Pin configuration.

7.2 Pin description

Table 2: Pin description^[1]

| Symbol ^[2] | Pin | Type | Description |
|-----------------------|-----|------|---|
| SUSPEND | 1 | O | suspend indicator output; HIGH indicates that the hub is in the suspend mode |
| GND | 2 | - | ground supply |
| DM0 | 3 | AI/O | upstream facing port D- connection (analog) |
| DP0 | 4 | AI/O | upstream facing port D+ connection (analog) |
| RPU | 5 | AI | pull-up resistor connection; connect this pin through a resistor of 1.5 kΩ ± 5 % to 3.3 V |
| GND | 6 | - | ground supply |

Table 2: Pin description^[1]...continued

| Symbol ^[2] | Pin | Type | Description |
|-----------------------|-----|------|---|
| RREF | 7 | AI | reference resistor connection; connect this pin through a resistor of $12\text{ k}\Omega \pm 1\%$ to an analog band gap ground reference |
| TEST_HIGH | 8 | - | test pin; connect to 3.3 V |
| V _{CC1} | 9 | - | analog supply voltage 1 (3.3 V) |
| GND | 10 | - | ground supply |
| V _{CC4} | 11 | - | crystal and PLL supply voltage 4 (3.3 V) |
| TEST_HIGH | 12 | - | test pin; connect to 3.3 V |
| V _{CC2} | 13 | - | transceiver supply voltage 2 (3.3 V) |
| GND | 14 | - | ground supply |
| DM1 | 15 | AI/O | downstream facing port 1 D ⁻ connection (analog) ^[3] |
| DP1 | 16 | AI/O | downstream facing port 1 D ⁺ connection (analog) ^[3] |
| TEST_LOW | 17 | - | connect to GND |
| TEST_HIGH | 18 | - | connect to +5.0 V through a 10 k Ω resistor |
| OC1_N | 19 | AI/I | overcurrent sense input for downstream facing port 1 (analog/digital) |
| PSW1_N | 20 | I/O | output — power switch control output (open-drain) with an internal pull-up resistor for downstream facing port 1 input — function of the pin when used as an input is given in Table 5 |
| GND | 21 | - | ground supply |
| GND | 22 | - | ground supply |
| V _{CC3} | 23 | - | digital supply voltage 3 (3.3 V) |
| V _{REF(5V0)} | 24 | - | reference voltage (5 V \pm 5 %); used to power internal pull-up resistors of PSW _n _N pins and also for the analog overcurrent detection |
| OC4_N | 25 | AI/I | overcurrent sense input for downstream facing port 4 (analog/digital) |
| PSW4_N | 26 | I/O | output — power switch control output (open-drain) with an internal pull-up resistor for downstream facing port 4 input — function of the pin when used as an input is given in Table 5 |
| OC3_N | 27 | AI/I | overcurrent sense input for downstream facing port 3 (analog/digital) |
| PSW3_N | 28 | I/O | output — power switch control output (open-drain) with an internal pull-up resistor for downstream facing port 3 input — function of the pin when used as an input is given in Table 5 |
| OC2_N | 29 | AI/I | overcurrent sense input for downstream facing port 2 (analog/digital) |
| PSW2_N | 30 | I/O | output — power switch control output (open-drain) with an internal pull-up resistor for downstream facing port 2 input — function of the pin when used as an input is given in Table 5 |

Table 2: Pin description^[1]...continued

| Symbol ^[2] | Pin | Type | Description |
|-----------------------|-----|------|--|
| RESET_N | 31 | I | asynchronous reset input; when reset is active, the internal switch to the 1.5 k Ω external resistor is opened, and all pins DP _n and DM _n are three-state; it is recommended that you connect to V _{BUS} through an RC circuit; refer to the schematics in the <i>ISP1520 Hub Demo Board User's Guide</i> |
| ADOC | 32 | I | analog or digital overcurrent detect selection input; a LOW selects the digital mode and a HIGH (3.3 V) selects the analog mode |
| XTAL1 | 33 | I | crystal oscillator input (12 MHz) |
| XTAL2 | 34 | O | crystal oscillator output (12 MHz) |
| GND | 35 | - | ground supply |
| DM2 | 36 | AI/O | downstream facing port 2 D- connection (analog) ^[3] |
| DP2 | 37 | AI/O | downstream facing port 2 D+ connection (analog) ^[3] |
| TEST_HIGH | 38 | - | test pin; connect to 3.3 V |
| V _{CC1} | 39 | - | analog supply voltage 1 (3.3 V) |
| GND | 40 | - | ground supply |
| V _{CC4} | 41 | - | crystal and PLL supply voltage 4 (3.3 V) |
| GND | 42 | - | ground supply |
| DM3 | 43 | AI/O | downstream facing port 3 D- connection (analog) ^[4] |
| DP3 | 44 | AI/O | downstream facing port 3 D+ connection (analog) ^[4] |
| V _{CC2} | 45 | - | transceiver supply voltage 2 (3.3 V) |
| GND | 46 | - | ground supply |
| DM4 | 47 | AI/O | downstream facing port 4 D- connection (analog) ^[4] |
| DP4 | 48 | AI/O | downstream facing port 4 D+ connection (analog) ^[4] |
| NOOC | 49 | I | no overcurrent protection selection input; connect this pin to HIGH (3.3 V) to select no overcurrent protection; if no overcurrent is selected, all OC _n _N pins must be connected to V _{REF(SV0)} |
| GRN4_N | 50 | I/O | output — green LED port indicator (open-drain) for downstream facing port 4 input — function of the pin when used as an input is given in Table 9 |
| AMB4_N | 51 | I/O | output — amber LED port indicator (open-drain) for downstream facing port 4 input — function of the pin when used as an input is given in Table 8 |
| GRN3_N | 52 | I/O | output — green LED port indicator (open-drain) for downstream facing port 3 input — function of the pin when used as an input is given in Table 9 |
| AMB3_N | 53 | I/O | output — amber LED port indicator (open-drain) for downstream facing port 3 input — function of the pin when used as an input is given in Table 8 |

Table 2: Pin description^[1]...continued

| Symbol ^[2] | Pin | Type | Description |
|-----------------------|-----|------|---|
| GRN2_N | 54 | I/O | output — green LED port indicator (open-drain) for downstream facing port 2 input — function of the pin when used as an input is given in Table 9 |
| AMB2_N | 55 | I/O | output — amber LED port indicator (open-drain) for downstream facing port 2 input — function of the pin when used as an input is given in Table 8 |
| V _{REF(5V0)} | 56 | - | reference voltage (5 V ± 5 %); used to power internal pull-up resistors of PSWn_N pins and also for the analog overcurrent detection |
| V _{CC3} | 57 | - | digital supply voltage 3 (3.3 V) |
| GND | 58 | - | ground supply |
| GND | 59 | - | ground supply |
| GRN1_N | 60 | I/O | output — green LED port indicator (open-drain) for downstream facing port 1 input — function of the pin when used as an input is given in Table 9 |
| AMB1_N | 61 | I/O | output — amber LED port indicator (open-drain) for downstream facing port 1 input — function of the pin when used as an input is given in Table 8 |
| HUBGL_N | 62 | O | hub GoodLink LED indicator output; the LED is off until the hub is configured; a transaction between the host and the hub will blink the LED off for 100 ms; this LED is off in the suspend mode (open-drain) |
| SCL | 63 | I/O | I ² C-bus clock (open-drain); see Table 11 |
| SDA | 64 | I/O | I ² C-bus data (open-drain); see Table 11 |

[1] The maximum current the ISP1520 can sink on a pin is 8 mA.

[2] Symbol names ending with underscore N (for example, NAME_N) represent active LOW signals.

[3] Downstream ports 1 and 2 cannot be disabled.

[4] To disable a downstream port n, connect both pins DPn and DMn to V_{CC} (3.3 V); unused ports must be disabled in reverse order starting from port 4.

8. Functional description

8.1 Analog transceivers

The integrated transceivers directly interface to USB lines. They can transmit and receive serial data at high-speed (480 Mbit/s), full-speed (12 Mbit/s) and low-speed (1.5 Mbit/s).

8.2 Hub controller core

The main components of the hub core are:

- Philips Serial Interface Engine (SIE)
- Routing logic
- Transaction Translator (TT)
- Mini-host controller
- Hub repeater
- Hub controller
- Port controller
- Bit clock recovery.

8.2.1 Philips serial interface engine

The Philips SIE implements the full USB protocol layer. It is completely hardwired for speed and needs no firmware intervention. The functions of this block include: synchronization, pattern recognition, parallel or serial conversion, bit (de-)stuffing, CRC checking and generation, Packet IDentifier verification and generation, address recognition, and handshake evaluation and generation.

8.2.2 Routing logic

The routing logic directs signaling to the appropriate modules (mini-host controller, Original USB repeater and Hi-Speed USB repeater) according to the topology in which the hub is placed.

8.2.3 Transaction translator

The TT acts as a go-between mechanism that links devices operating in the Original USB mode and the Hi-Speed USB upstream mode. For the 'IN' direction, data is concatenated in TT buffers till the proper length is reached, before the host takes the transaction. In the reverse direction (OUT), the mini-host dispenses the data contained in TT buffers over a period that fits into the Original USB bandwidth. This continues until all outgoing data is emptied. TT buffers are used only on split transactions.

8.2.4 Mini-host controller

The internal mini-host generates all the Original USB IN, OUT or SETUP tokens for the downstream facing ports, while the upstream facing port is in the high-speed mode. The responses from the Original USB devices are collected in TT buffers, until the end of the complete split transaction clears the TT buffers.

8.2.5 Hub repeater

A hub repeater is responsible for managing connectivity on a per packet basis. It implements packet signaling connectivity and resume connectivity. There are two repeaters in the ISP1520: a Hi-Speed USB repeater and an Original USB repeater. The only major difference between these two repeaters is the speed at which they operate. When the hub is connected to an Original USB system, it automatically switches itself to function as a pure Original USB hub.

8.2.6 Hub and port controllers

The hub controller provides status report. The port controller provides control for individual downstream facing port; it controls the port routing module. Any port status change will be reported to the host via the hub status change (interrupt) endpoint.

8.2.7 Bit clock recovery

The bit clock recovery circuit extracts the clock from the incoming USB data stream.

8.3 Phase-locked loop clock multiplier

A 12 MHz to 480 MHz clock multiplier PLL is integrated on-chip. This allows the use of low-cost 12 MHz crystals. The low crystal frequency also minimizes ElectroMagnetic Interference (EMI). No external components are required for the operation of the PLL.

8.4 I²C-bus controller

A simple serial I²C-bus interface is provided to transfer vendor ID, product ID and string descriptor from an external I²C-bus EEPROM (for example, Philips PCF8582 or equivalent) or microcontroller. A master/slave I²C-bus protocol is implemented according to the timing requirements as mentioned in the I²C-bus standard specifications. The maximum data count during I²C-bus transfers for the ISP1520 is 256 bytes.

8.5 Overcurrent detection circuit

An overcurrent detection circuit is integrated on-chip. The main features of this circuit are: self reporting, automatic resetting, low-trip time and low cost. This circuit offers an easy solution at no extra hardware cost on the board.

8.6 GoodLink

Indication of a good USB connection is provided through GoodLink technology. An LED can be directly connected to pin HUBGL_N via an external 330 Ω resistor.

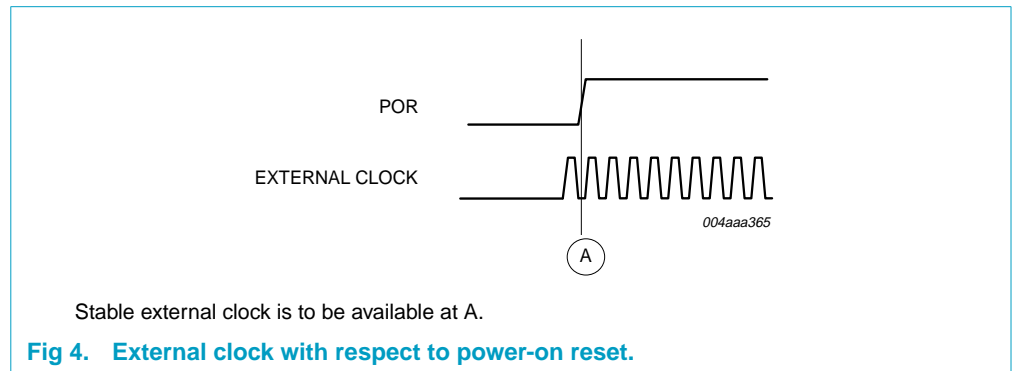
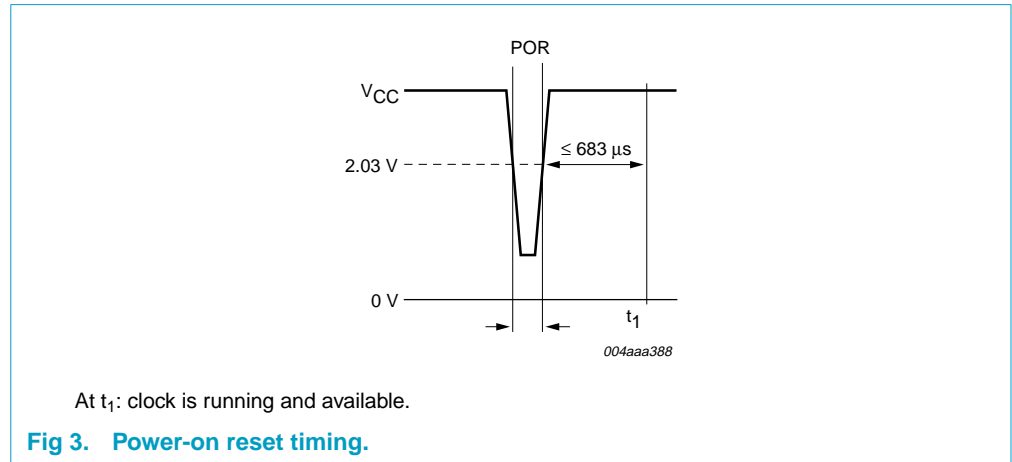
During enumeration, the LED blinks on momentarily. After successful configuration, the LED blinks off for 100 ms upon each transaction.

This feature provides a user-friendly indication of the status of the hub, the connected downstream devices and the USB traffic. It is a useful diagnostics tool to isolate faulty USB equipment and helps to reduce field support and hotline costs.

8.7 Power-on reset

The ISP1520 has an internal Power-On Reset (POR) circuit.

The triggering voltage of the POR circuit is 2.03 V nominal. A POR is automatically generated when V_{CC} goes below the trigger voltage for a duration longer than 1 μ s.



9. Configuration selections

The ISP1520 is configured through I/O pins and, optionally, through an external I²C-bus, in which case the hub can update its configuration descriptors as a master or as a slave.

Table 3 shows the configuration parameters.

Table 3: Configuration parameters

| Mode and selection | Option | Configuration method | | | |
|-----------------------------------|--|-------------------------------|-------------------|--|--------------|
| | | Pin control | | Software control | |
| | | Control pin | Reference | Affected field | Reference |
| Number of downstream facing ports | 2 ports 3 ports 4 ports | DM1/DP1 to DM4/DP4 | see Section 9.1.1 | bNbrPorts0 | see Table 22 |
| Power switching mode | ganged multiple ganged ^[1] individual | PSW1_N to PSW4_N | see Section 9.1.2 | wHubCharacteristics: bits D1 and D0 bPwrOn2PwrGood: time interval | see Table 22 |
| Overcurrent protection mode | none global ^[2] multiple ganged individual | NOOC and OC1_N to OC4_N | see Section 9.1.3 | wHubCharacteristics: bits D4 and D3 | see Table 22 |
| Non-removable ports | any port can be non-removable | AMBn_N | see Section 9.1.4 | wHubCharacteristics: bit D2 (compound hub) DeviceRemovable: bit map | see Table 22 |
| Port indicator support | no yes | all GRNn_N | see Section 9.1.5 | wHubCharacteristics: bit D7 | see Table 22 |

[1] Multiple ganged power mode is reported as individual power mode; refer to the USB 2.0 specification.

[2] When the hub uses the global overcurrent protection mode, the overcurrent indication is through the wHubStatus field bit 1 (overcurrent) and the corresponding change bit (overcurrent change).

9.1 Configuration through I/O pins

9.1.1 Number of downstream facing ports

To discount a physical downstream facing port, connect pins DP and DM of that downstream facing port to V_{CC} (3.3 V) starting from the highest port number (4).

The sum of physical ports configured is reflected in the bNbrPorts field.

Table 4: Downstream facing port number pin configuration

| Number of physical downstream facing port | DM1/DP1 | DM2/DP2 | DM3/DP3 | DM4/DP4 |
|---|--------------------|--------------------|--------------------|--------------------|
| 4 | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down |
| 3 | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | V _{CC} |
| 2 | 15 kΩ pull-down | 15 kΩ pull-down | V _{CC} | V _{CC} |

9.1.2 Power switching

Power switching of downstream ports can be done **individually** or **ganged**, where all ports are simultaneously switched with one power switch. The ISP1520 supports both modes, which can be selected using input PSWn_N; see Table 5.

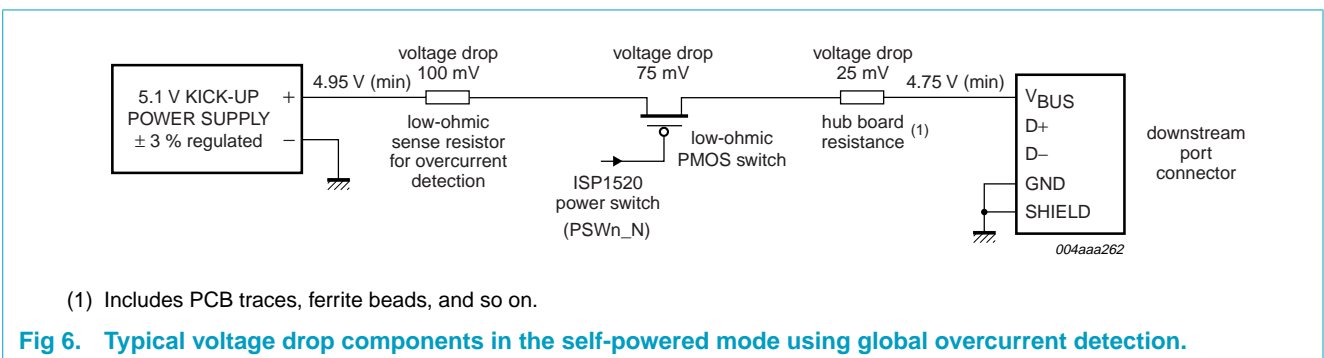
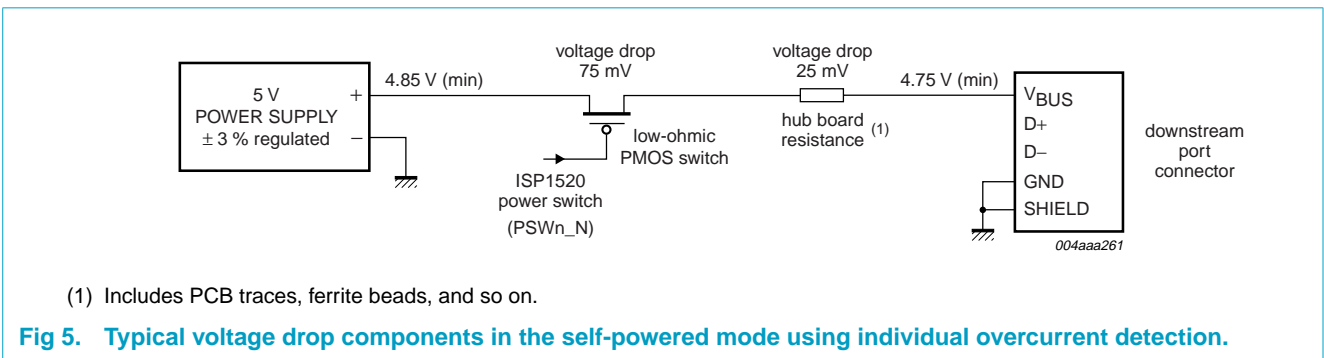
Voltage drop requirements: Self-powered hubs are required to provide a minimum of 4.75 V to its output port connectors at all legal load conditions. To comply with Underwriters Laboratory Inc. (UL) safety requirements, the power from any port must be limited to 25 W (5 A at 5 V). Overcurrent protection may be implemented on a global or individual basis.

Assuming a 5 V ± 3 % power supply, the worst-case supply voltage is 4.85 V. This only allows a voltage drop of 100 mV across the hub Printed-Circuit Board (PCB) to each downstream connector. This includes a voltage drop across the:

- Power supply connector
- Hub PCB (power and ground traces, ferrite beads)
- Power switch (FET on-resistance)
- Overcurrent sense device.

The PCB resistance and power supply connector resistance may cause a drop of 25 mV, leaving only 75 mV as the voltage drop allowed across the power switch and overcurrent sense device. The individual voltage drop components are shown in Figure 5.

For global overcurrent detection, an increased voltage drop is needed for the overcurrent sense device (in this case, a low-ohmic resistor). This can be realized by using a special power supply of 5.1 V ± 3 %, as shown in Figure 6.



PSWn_N pins have integrated weak pull-up resistors inside the chip.

Table 5: Power switching mode: pin configuration

| Power switching mode | PSW1_N | PSW2_N | PSW3_N | PSW4_N |
|----------------------|------------------|------------------|------------------|------------------|
| Ganged | internal pull-up | ground | ground | ground |
| Individual | internal pull-up | internal pull-up | internal pull-up | internal pull-up |

9.1.3 Overcurrent protection mode

The ISP1520 supports all overcurrent protection modes: none, global and individual.

No overcurrent protection mode reporting is selected when pin NOOC = HIGH. Global and individual overcurrent protection modes are selected using pins PSWn_N, following the power switching modes selection scheme; see [Table 6](#).

For the global overcurrent protection mode, only PSW1_N and OC1_N are active; that is, in this mode, the remaining overcurrent indicator pins are disabled. To inhibit the analog overcurrent detection, the OC_N pins must be connected to $V_{REF(5V0)}$.

Table 6: Overcurrent protection mode pin configuration

| Power switching mode | NOOC | PSW1_N | PSW2_N | PSW3_N | PSW4_N |
|----------------------|------|------------------|------------------|------------------|------------------|
| None | HIGH | ground | ground | ground | ground |
| Global | LOW | internal pull-up | ground | ground | ground |
| Individual | LOW | internal pull-up | internal pull-up | internal pull-up | internal pull-up |

Both analog and digital overcurrent modes are supported; see [Table 7](#).

For digital overcurrent detection, the normal digital TTL level is accepted on the overcurrent input pins. For analog overcurrent detection, the threshold is given in the DC characteristics. In this mode, to filter out false overcurrent conditions because of inrush and spikes, a dead time of 15 ms is built into the IC, that is, overcurrent must persist for 15 ms before it is reported to the host.

Table 7: Overcurrent detection mode selection pin configuration

| Pin ADOC | Mode selection | Description |
|----------|----------------|-----------------------------|
| 3.3 V | analog | threshold ΔV_{trip} |
| Ground | digital | normal digital TTL level |

9.1.4 Non-removable port

A non-removable port, by definition, is a port that is embedded inside the hub application box and is not externally accessible. The LED port indicators (pins AMBn_N) of such a port are not used. Therefore, the corresponding amber LED port indicators are disabled to signify that the port is non-removable; see [Table 8](#).

More than one non-removable port can be specified by appropriately connecting the corresponding amber LED indicators. At least one port should, however, be left as a removable port.

The detection of any non-removable port sets the hub descriptor into a compound hub.

Table 8: Non-removable port pin configuration

| AMBn_N (n = 1 to 4) | Non-removable port |
|------------------------|--------------------|
| Ground | non-removable |
| Pull-up with amber LED | removable |

9.1.5 Port indicator support

The port indicator support can be disabled by grounding all green port indicators (all pins GRNn_N); see Table 9. This is a global feature. It is not possible to disable port indicators for only one port.

Table 9: Port indicator support: pin configuration

| GRN1_N to GRN4_N | Port indicator support |
|---|------------------------|
| Ground | not supported |
| LED pull-up green LED for at least one port | supported |

9.2 Device descriptors and string descriptors settings using I²C-bus

9.2.1 Background information on I²C-bus

The I²C-bus is suitable for bi-directional communication between ICs or modules. It consists of two bi-directional lines: SDA for data signals and SCL for clock signals. Both these lines must be connected to a positive supply voltage through a pull-up resistor.

The basic I²C-bus protocol is defined as:

- Data transfer is initiated only when the bus is not busy.
- Changes in the data line occur when the clock is LOW and must be stable when the clock is HIGH. Any changes in data lines when the clock is HIGH will be interpreted as control signals.

Different conditions on I²C-bus: The I²C-bus protocol defines the following conditions:

Not busy — both SDA and SCL remain HIGH

START — a HIGH-to-LOW transition on SDA, while SCL is HIGH

STOP — a LOW-to-HIGH transition on SDA, while SCL is HIGH

Data valid — after a START condition, data on SDA must be stable for the duration of the HIGH period of SCL.

Data transfer: The master initiates each data transfer using a START condition and terminates it by generating a STOP condition. To facilitate the next byte transfer, each byte of data must be acknowledged by the receiver. The acknowledgement is done by pulling the SDA line LOW on the ninth bit of the data. An extra clock pulse needs to be generated by the master to accommodate this bit.

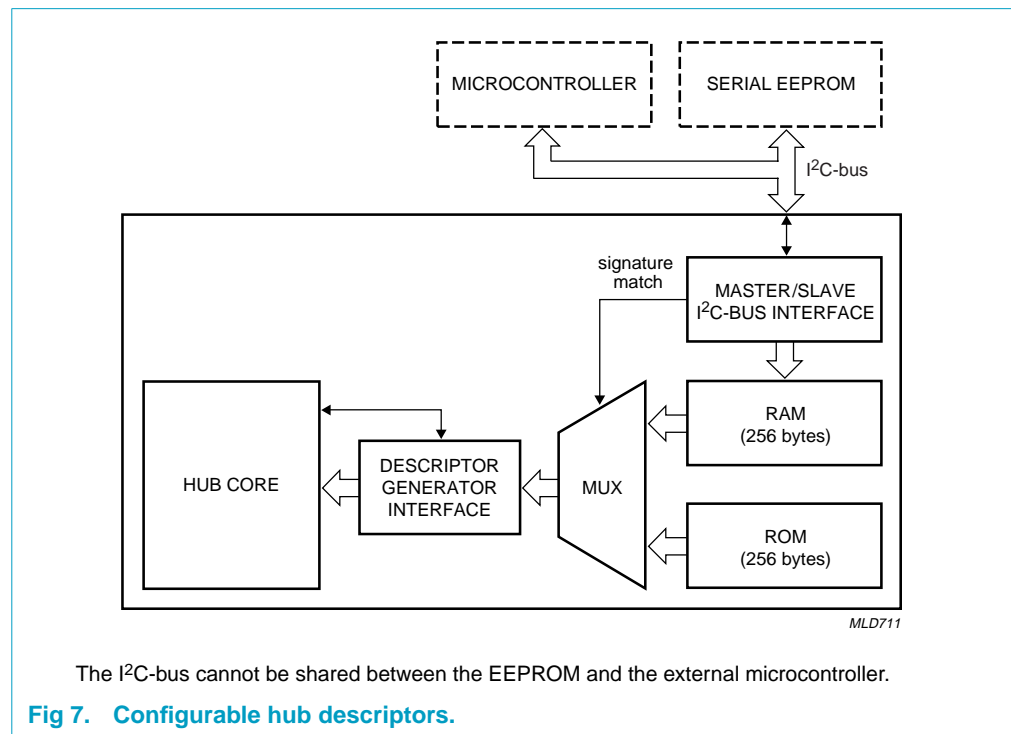
For more detailed information on the operation of the bus, refer to *The I²C-bus specification*.

I²C-bus address: The address of the ISP1520 is given in [Table 10](#).

Table 10: I²C-bus slave address

| | MSB | | Slave address | | | | | LSB | | |
|-------|-----|----|---------------|----|----|----|----|-----|-----|--|
| Bit | A7 | A6 | A5 | A4 | A3 | A2 | A1 | | R/W | |
| Value | 0 | 0 | 1 | 1 | 0 | 1 | 0 | | 0/1 | |

9.2.2 Architecture of configurable hub descriptors



The configurable hub descriptors can be masked in the internal ROM memory; see [Figure 7](#). These descriptors can also be supplied from an external EEPROM or a microcontroller. The ISP1520 implements both the master and slave I²C-bus controllers. The information from the external EEPROM or the microcontroller is transferred into the internal RAM during the power-on reset. A signature word is used to identify correct descriptors. If the signature matches, the content of the RAM is chosen instead of the ROM.

When the external microcontroller mode is selected and while the external microcontroller is writing to the internal RAM, any request to configurable descriptors will be responded to with a Not Acknowledge (NAK). There is no specified time-out period for the NAK signal. This data is then passed to the host during the enumeration process.

The three configuration methods are selected by connecting pins SCL and SDA in the manner given in [Table 11](#).

Table 11: Configuration method

| Configuration method | SCL | SDA |
|--------------------------|--|-----------------------|
| Internal ROM | ground | ground |
| External EEPROM | 2.2 to 4.7 kΩ pull-up | 2.2 to 4.7 kΩ pull-up |
| External microcontroller | driven LOW by the microcontroller during reset | 2.2 to 4.7 kΩ pull-up |

9.2.3 ROM or EEPROM map

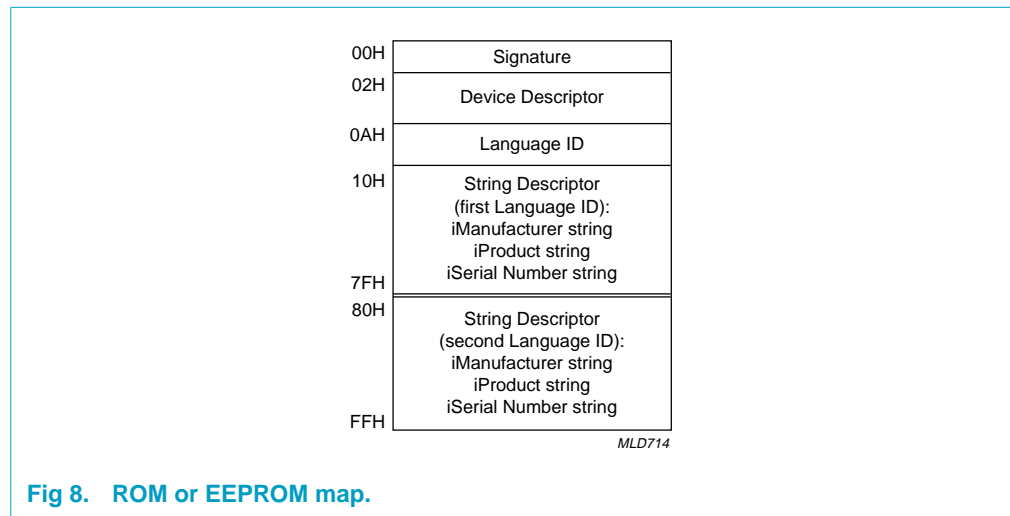


Fig 8. ROM or EEPROM map.

Remark: A 128-byte EEPROM supports one language ID only, and a 256-byte EEPROM supports two language IDs.

9.2.4 ROM or EEPROM detailed map

Table 12: ROM or EEPROM detailed map

| Address (Hex) | Content | Default (Hex) | Example (Hex) | Comment |
|--|------------------------|---------------|---------------|---|
| Signature descriptor | | | | |
| 00 | signature (low) | 55 | - | signature to signify valid data comment |
| 01 | signature (high) | AA | - | |
| Device descriptor | | | | |
| 02 | idVendor (low) | CC | - | Philips Semiconductors vendor ID |
| 03 | idVendor (high) | 04 | - | |
| 04 | idProduct (low) | 20 | - | ISP1520 product ID |
| 05 | idProduct (high) | 15 | - | |
| 06 | bcdDevice (low) | 00 | - | device release; silicon revision |
| 07 | bcdDevice (high) | 02 | - | increments this value |
| 08 | RSV, iSN, iP, iM | - | 00 | if all the three strings are supported, the value of this byte is 39H |
| 09 | reserved | - | FF | - |
| String descriptor Index 0 (language ID) | | | | |
| 0A | bLength ^[1] | - | 06 | two language ID support |

Table 12: ROM or EEPROM detailed map...continued

| Address (Hex) | Content | Default (Hex) | Example (Hex) | Comment |
|--|-----------------|---------------|-------------------|---|
| 0B | bDescriptorType | - | 03 ^[2] | STRING |
| 0C | wLANGID[0] | - | 09 | LANGID code zero (first language ID) (English—USA in this example) |
| 0D | | - | 04 | |
| 0E | wLANGID[1] | - | 09 | LANGID code one (second language ID) (English—UK in this example) |
| 0F | | - | 08 | |
| String descriptor Index 1 (iManufacturer)^[3] | | | | |
| 10 | bLength | - | 2E | string descriptor length (manufacturer ID) |
| 11 | bDescriptorType | - | 03 ^[2] | STRING |
| 12 13 | bString | - | 50 00 | P of Philips |
| 14 15 | | - | 68 00 | h |
| 16 17 | | - | 69 00 | i |
| 18 19 | | - | 6C 00 | l |
| 1A 1B | | - | 69 00 | i |
| 1C 1D | | - | 70 00 | p |
| 1E 1F | | - | 73 00 | s |
| 20 21 | | - | 20 00 | |
| 22 23 | | - | 53 00 | S of Semiconductors |
| 24 25 | | - | 65 00 | e |
| 26 27 | | - | 6D 00 | m |
| 28 29 | | - | 69 00 | i |
| 2A 2B | | - | 63 00 | c |
| 2C 2D | | - | 6F 00 | o |
| 2E 2F | | - | 6E 00 | n |
| 30 31 | | - | 64 00 | d |
| 32 33 | | - | 75 00 | u |
| 34 35 | | - | 63 00 | c |
| 36 37 | | - | 74 00 | t |
| 38 39 | | - | 6F 00 | o |
| 3A 3B | | - | 72 00 | r |
| 3C 3D | | - | 73 00 | s |
| String descriptor Index 2 (iProduct) | | | | |
| 3E | bLength | - | 10 | string descriptor length (product ID) |
| 3F | bDescriptorType | - | 03 ^[2] | STRING |
| 40 41 | bString | - | 49 00 | I of ISP1520 |
| 42 43 | | - | 53 00 | S |
| 44 45 | | - | 50 00 | P |
| 46 47 | | - | 31 00 | 1 |
| 48 49 | | - | 35 00 | 5 |
| 4A 4B | | - | 32 00 | 2 |
| 4C 4D | | - | 30 00 | 0 |

Table 12: ROM or EEPROM detailed map...continued

| Address (Hex) | Content | Default (Hex) | Example (Hex) | Comment |
|--|-----------------|---------------|-------------------|--|
| String descriptor Index 3 (iSerialNumber) | | | | |
| Remark: If supported, this string must be unique. | | | | |
| 4E | bLength | - | 3A | string descriptor length (serial number) |
| 4F | bDescriptorType | - | 03 ^[2] | STRING |
| 50 51 | bString | - | 39 00 | 9 of 947337877678 = wired support |
| 52 53 | | - | 34 00 | 4 |
| 54 55 | | - | 37 00 | 7 |
| 56 57 | | - | 33 00 | 3 |
| 58 59 | | - | 33 00 | 3 |
| 5A 5B | | - | 37 00 | 7 |
| 5C 5D | | - | 38 00 | 8 |
| 5E 5F | | - | 37 00 | 7 |
| 60 61 | | - | 37 00 | 7 |
| 62 63 | | - | 36 00 | 6 |
| 64 65 | | - | 37 00 | 7 |
| 66 67 | | - | 38 00 | 8 |
| 68 69 | | - | 20 00 | |
| 6A 6B | | - | 3D 00 | = |
| 6C 6D | | - | 20 00 | |
| 6E 6F | | - | 77 00 | w |
| 70 71 | | - | 69 00 | i |
| 72 73 | | - | 72 00 | r |
| 74 75 | | - | 65 00 | e |
| 76 77 | | - | 64 00 | d |
| 78 79 | | - | 20 00 | |
| 7A 7B | | - | 73 00 | s |
| 7C 7D | | - | 75 00 | u |
| 7E 7F | | - | 70 00 | p |
| 80 81 | | - | 70 00 | p |
| 82 83 | | - | 6F 00 | o |
| 84 85 | | - | 72 00 | r |
| 86 87 | | - | 74 00 | t |

Table 12: ROM or EEPROM detailed map...continued

| Address (Hex) | Content | Default (Hex) | Example (Hex) | Comment |
|--|-----------------|---------------|-------------------|--|
| String descriptor Index 1 (iManufacturer) second language | | | | |
| 88 | bLength | - | 2E | string descriptor length (manufacturer ID) |
| 89 | bDescriptorType | - | 03 ^[2] | STRING |
| 8A 8B | bString | - | 50 00 | P of Philips |
| 8C 8D | | - | 68 00 | h |
| 8E 8F | | - | 69 00 | i |
| 90 91 | | - | 6C 00 | l |
| 92 93 | | - | 69 00 | i |
| 94 95 | | - | 70 00 | p |
| 96 97 | | - | 73 00 | s |
| 98 99 | | - | 20 00 | |
| 9A 9B | | - | 53 00 | S of Semiconductors |
| 9C 9D | | - | 65 00 | e |
| 9E 9F | | - | 6D 00 | m |
| A0 A1 | | - | 69 00 | i |
| A2 A3 | | - | 63 00 | c |
| A4 A5 | | - | 6F 00 | o |
| A6 A7 | | - | 6E 00 | n |
| A8 A9 | | - | 64 00 | d |
| AA AB | | - | 75 00 | u |
| AC AD | | - | 63 00 | c |
| AE AF | | - | 74 00 | t |
| B0 B1 | | - | 6F 00 | o |
| B2 B3 | | - | 72 00 | r |
| B4 B5 | | - | 73 00 | s |
| String descriptor Index 2 (iProduct) | | | | |
| B6 | bLength | - | 10 ^[1] | string descriptors (product ID) |
| B7 | bDescriptorType | - | 03 ^[2] | STRING |
| B8 B9 | bString | - | 49 00 | I of ISP1520 |
| BA BB | | - | 53 00 | S |
| BC BD | | - | 50 00 | P |
| BE BF | | - | 31 00 | 1 |
| C0 C1 | | - | 35 00 | 5 |
| C2 C3 | | - | 32 00 | 2 |
| C4 C5 | | - | 30 00 | 0 |
| String descriptor Index 3 (iSerialNumber) | | | | |
| C6 | bLength | - | 16 ^[1] | string descriptors (serial number) |
| C7 | bDescriptorType | - | 03 ^[2] | STRING |
| C8 C9 | bString | - | 36 00 | 6 of 6568824022 |
| CA CB | | - | 35 00 | 5 |

Table 12: ROM or EEPROM detailed map...continued

| Address (Hex) | Content | Default (Hex) | Example (Hex) | Comment |
|---------------|---------|---------------|---------------|--|
| CC CD | | - | 36 00 | 6 |
| CE CF | | - | 38 00 | 8 |
| D0 D1 | | - | 38 00 | 8 |
| D2 D3 | | - | 32 00 | 2 |
| D4 D5 | | - | 34 00 | 4 |
| D6 D7 | | - | 30 00 | 0 |
| D8 D9 | | - | 32 00 | 2 |
| DA DB | | - | 32 00 | 2 |
| DC DD | | - | FF FF | |
| DE DF | | - | FF FF | |
| E0 E1 | | - | FF FF | |
| E2 E3 | | - | FF FF | |
| E4 E5 | | - | FF FF | |
| E6 E7 | | - | FF FF | |
| E8 E9 | | - | FF FF | |
| EA EB | | - | FF FF | |
| EC ED | | - | FF FF | |
| EE EF | | - | FF FF | |
| F0 F1 | | - | FF FF | |
| F2 F3 | | - | FF FF | |
| F4 F5 | | - | FF FF | |
| F6 F7 | | - | FF FF | |
| F8 F9 | | - | FF FF | |
| FA FB | | - | FF FF | |
| FC FD | | - | FF FF | |
| FE | | - | FF | |
| FF | | - | FF | upper boundary of all string descriptors |

- [1] If this string descriptor is not supported, this bLength field must be programmed with the value 02H.
- [2] If this string descriptor is not supported, this bDescriptorType field must be used (programmed with any value, for example, 03H).
- [3] String descriptor index (iManufacturer) starts from the address 0EH for one language ID support and 10H for two languages ID support.

10. Hub controller description

Each USB device is composed of several independent logic endpoints. An endpoint acts as a terminus of communication flow between the host and the device. At design time, each endpoint is assigned a unique number (endpoint identifier; see [Table 13](#)). The combination of the device address (given by the host during enumeration), the endpoint number and the transfer direction allows each endpoint to be uniquely referenced.

The ISP1520 has two endpoints: endpoint 0 (control) and endpoint 1 (interrupt).

Table 13: Hub endpoints

| Function | Endpoint identifier | Transfer type | Direction ^[1] | Maximum packet size (bytes) |
|------------------|---------------------|---------------|--------------------------|-----------------------------|
| Hub ports 0 to 4 | 0 | control | OUT | 64 |
| | | | IN | 64 |
| | 1 | interrupt | IN | 1 |

[1] IN: input for the USB host; OUT: output from the USB host.

10.1 Endpoint 0

According to the USB specification, all devices must implement a default control endpoint. This endpoint is used by the host to configure the USB device. It provides access to the device configuration and allows generic USB status and control access.

The ISP1520 supports the following descriptor information through its control endpoint 0:

- Device descriptor
- Device_qualifier descriptor
- Configuration descriptor
- Interface descriptor
- Endpoint descriptor
- Hub descriptor
- Other_speed_configuration descriptor.

The maximum packet size of this endpoint is 64 bytes.

10.2 Endpoint 1

Endpoint 1 can be accessed only after the hub has been configured by the host (by sending the Set Configuration command). It is used by the ISP1520 to send the status change information to the host.

Endpoint 1 is an interrupt endpoint. The host polls this endpoint once every 255 ms. After the hub is configured, an IN token is sent by the host to request the port change status. If the hub detects no change in the port status, it returns a NAK to this request, otherwise the Status Change byte is sent. [Table 14](#) shows the content of the change byte.

Table 14: Status Change byte: bit allocation

| Bit | Name | Value | Description |
|--------|----------------------|-------|--|
| 0 | Hub Status Change | 0 | no change in the hub status |
| | | 1 | change in the hub status detected |
| 1 to 4 | Port n Status Change | 0 | no change in the status of port n (n = 1 to 4) |
| | | 1 | change in the status of port n (n = 1 to 4) |
| 5 to 7 | - | - | not used |

11. Descriptors

The ISP1520 hub controller supports the following standard USB descriptors:

- Device
- Device_qualifier
- Other_speed_configuration
- Configuration
- Interface
- Endpoint
- Hub.

The hub returns different descriptors based on the mode of operation: full-speed or high-speed.

Table 15: Device descriptor

| Offset (bytes) | Field name | Value (Hex) | | Comments |
|----------------|--------------------|-------------|------------|--|
| | | Full-speed | High-speed | |
| 0 | bLength | 12 | 12 | descriptor length = 18 bytes |
| 1 | bDescriptorType | 01 | 01 | type = DEVICE |
| 2 | bcdUSB | 00 | 00 | see USB specification Rev. 2.0 |
| 3 | | 02 | 02 | |
| 4 | bDeviceClass | 09 | 09 | HUB_CLASSCODE |
| 5 | bDeviceSubClass | 00 | 00 | HubSubClassCode |
| 6 | bDeviceProtocol | 00 | 01 | HubProtocolHSpeedOneTT |
| 7 | bMaxPacketSize0 | 40 | 40 | packet size = 64 bytes |
| 8 | idVendor | CC | CC | Philips Semiconductors vendor ID (04CC); can be customized |
| 9 | | 04 | 04 | |
| 10 | idProduct | 20 | 20 | the ISP1520 product ID; can be customized |
| 11 | | 15 | 15 | |
| 12 | bcdDevice | 00 | 00 | device ID; can be customized |
| 13 | | 02 | 02 | |
| 14 | iManufacturer | 01 | 01 | can be customized |
| 15 | iProduct | 02 | 02 | can be customized |
| 16 | iSerialNumber | 03 | 03 | can be customized; this value must be unique |
| 17 | bNumConfigurations | 01 | 01 | one configuration |

Table 16: Device_qualifier descriptor

| Offset (bytes) | Field name | Value (Hex) | | Comments |
|----------------|--------------------|-------------|------------|--------------------------------|
| | | Full-speed | High-speed | |
| 0 | bLength | 0A | 0A | descriptor length = 10 bytes |
| 1 | bDescriptorType | 06 | 06 | type = DeviceQualifierType |
| 2 | bcdUSB | 00 | 00 | see USB specification Rev. 2.0 |
| 3 | | 02 | 02 | |
| 4 | bDeviceClass | 09 | 09 | HUB_CLASSCODE |
| 5 | bDeviceSubClass | 00 | 00 | HubSubClassCode |
| 6 | bDeviceProtocol | 00 | 01 | HubProtocolHSpeedOneTT |
| 7 | bMaxPacketSize0 | 40 | 40 | packet size = 64 bytes |
| 8 | bNumConfigurations | 01 | 01 | number of configurations |

Table 17: Other_speed_configuration descriptor

| Offset (bytes) | Field name | Value (Hex) | | Comments |
|----------------|---------------------|-------------|------------|------------------------------------|
| | | Full-speed | High-speed | |
| 0 | bLength | 09 | 09 | descriptor length = 9 bytes |
| 1 | bDescriptorType | 07 | 07 | type = OtherSpeedConfigurationType |
| 2 | wTotalLength | 19 | 19 | TotalConfByte |
| 3 | | 00 | 00 | |
| 4 | bNumInterfaces | 01 | 01 | - |
| 5 | bConfigurationValue | 01 | 01 | - |
| 6 | iConfiguration | 00 | 00 | no string supported |
| 7 | bmAttributes | E0 | E0 | self-powered |
| | | A0 | A0 | others |
| 8 | bMaxPower | 00 | 00 | self-powered |

Table 18: Configuration descriptor

| Offset (bytes) | Field name | Value (Hex) | | Comments |
|----------------|--------------------------|-------------|------------|--|
| | | Full-speed | High-speed | |
| 0 | bLength | 09 | 09 | descriptor length = 9 bytes |
| 1 | bDescriptorType | 02 | 02 | type = CONFIGURATION |
| 2 | wTotalLength | 19 | 19 | total length of configuration, interface and endpoint descriptors = 25 bytes |
| 3 | | 00 | 00 | |
| 4 | bNumInterfaces | 01 | 01 | one interface |
| 5 | bConfigurationValue | 01 | 01 | configuration value = 1 |
| 6 | iConfiguration | 00 | 00 | no configuration string descriptor |
| 7 | bmAttributes | E0 | E0 | self-powered |
| 8 | bMaxPower ^[1] | 00 | 00 | self-powered |

[1] Value in units of 2 mA.

Table 19: Interface descriptor

| Offset (bytes) | Field name | Value (Hex) | | Comments |
|----------------|--------------------|-------------|------------|------------------------------------|
| | | Full-speed | High-speed | |
| 0 | bLength | 09 | 09 | descriptor length = 9 bytes |
| 1 | bDescriptorType | 04 | 04 | type = INTERFACE |
| 2 | bInterfaceNumber | 00 | 00 | - |
| 3 | bAlternateSetting | 00 | 00 | no alternate setting |
| 4 | bNumEndpoints | 01 | 01 | status change (interrupt) endpoint |
| 5 | bInterfaceClass | 09 | 09 | HUB_CLASSCODE |
| 6 | bInterfaceSubClass | 00 | 00 | HubSubClassCode |
| 7 | bInterfaceProtocol | 00 | 00 | - |
| 8 | bInterface | 00 | 00 | no interface string descriptor |

Table 20: Endpoint descriptor

| Offset (bytes) | Field name | Value (Hex) | | Comments |
|----------------|------------------|-------------|------------|------------------------------------|
| | | Full-speed | High-speed | |
| 0 | bLength | 07 | 07 | descriptor length = 7 bytes |
| 1 | bDescriptorType | 05 | 05 | type = ENDPOINT |
| 2 | bEndpointAddress | 81 | 81 | endpoint 1 at the address number 1 |
| 3 | bmAttributes | 03 | 03 | interrupt endpoint |
| 4 | wMaxPacketSize | 01 | 01 | packet size = 1 byte |
| 5 | | 00 | 00 | |
| 6 | bInterval | FF | 0C | polling interval |

Table 21: Hub descriptor

| Offset (bytes) | Field name | Value (Hex) | | Comments |
|----------------|-------------------------------|-------------|------------|--|
| | | Full-speed | High-speed | |
| 0 | bDescLength | 09 | 09 | descriptor length = 9 bytes |
| 1 | bDescriptorType | 29 | 29 | type = HUB |
| 2 | bNbrPorts | 04 | 04 | number of enabled downstream facing ports; selectable by DP/DM strapping |
| | | 03 | 03 | |
| | | 02 | 02 | |
| 3 | wHubCharacteristics | A9 | A9 | see Table 22 |
| 4 | | 00 | 00 | |
| 5 | bPwrOn2PwrGood ^[1] | 32 | 32 | ganged or individual mode = 100 ms |
| 6 | bHubContrCurrent | 64 | 64 | - |
| 7 | DeviceRemovable | 00 | 00 | four downstream facing ports, no embedded port |
| 8 | PortPwrCtrlMask | FF | FF | - |

[1] Value in units of 2 ms.

Table 22: wHubCharacteristics bit description

| Bit | Function | Value | Description |
|--------|------------------------------|-------|--------------------------------|
| D0, D1 | logical power switching mode | 00 | ganged |
| | | 01 | individual and multiple ganged |
| | | 11 | - |
| D2 | compound hub selection | 0 | non-compound |
| | | 1 | compound |
| D3, D4 | overcurrent protection mode | 00 | global |
| | | 01 | individual and multiple ganged |
| | | 10 | none |
| | | 11 | - |
| D5 | - | - | - |
| D6 | - | - | - |
| D7 | port indicator | 0 | global feature |
| | | 1 | - |

12. Hub requests

The hub must react to a variety of requests initiated by the host. Some requests are standard and are implemented by any USB device whereas others are hub-class specific requests.

12.1 Standard USB requests

Table 23 shows the supported standard USB requests.

Table 23: Standard USB requests

| Request | bmRequestType byte 0 (bits 7 to 0) | bRequest byte 1 (hex) | wValue bytes 2, 3 (hex) | wIndex bytes 4, 5 (hex) | wLength bytes 6, 7 (hex) | Data response |
|---------------------------------|--|-----------------------------|----------------------------------|-------------------------------|--------------------------------|---|
| Address | | | | | | |
| Set Address | 0000 0000 | 05 | device address ^[1] | 00, 00 | 00, 00 | none |
| Configuration | | | | | | |
| Get Configuration | 1000 0000 | 08 | 00, 00 | 00, 00 | 01, 00 | configuration value |
| Set Configuration (0) | 0000 0000 | 09 | 00, 00 | 00, 00 | 00, 00 | none |
| Set Configuration (1) | 0000 0000 | 09 | 01, 00 | 00, 00 | 00, 00 | none |
| Descriptors | | | | | | |
| Get Configuration Descriptor | 1000 0000 | 06 | 00, 02 | 00, 00 | length ^[2] | configuration interface and endpoint descriptors |
| Get Device Descriptor | 1000 0000 | 06 | 00, 01 | 00, 00 | length ^[2] | device descriptor |
| Get String Descriptor (0) | 1000 0000 | 06 | 03, 00 | 00, 00 | length ^[2] | language ID descriptor |
| Get String Descriptor (1) | 1000 0000 | 06 | 03, 01 | 00, 00 | length ^[2] | manufacturer string |
| Get String Descriptor (2) | 1000 0000 | 06 | 03, 02 | 00, 00 | length ^[2] | product string |
| Get String Descriptor (3) | 1000 0000 | 06 | 03, 03 | 00, 00 | length ^[2] | serial number string |

Table 23: Standard USB requests...continued

| Request | bmRequestType byte 0 (bits 7 to 0) | bRequest byte 1 (hex) | wValue bytes 2, 3 (hex) | wIndex bytes 4, 5 (hex) | wLength bytes 6, 7 (hex) | Data response |
|---|--|-----------------------------|-------------------------------|-------------------------------|--------------------------------|-------------------|
| Feature | | | | | | |
| Clear Device Feature (Remote_Wakeup) | 0000 0000 | 01 | 01, 00 | 00, 00 | 00, 00 | none |
| Clear Endpoint (1) Feature (Halt/Stall) | 0000 0010 | 01 | 00, 00 | 81, 00 | 00, 00 | none |
| Set Device Feature (Remote_Wakeup) | 0000 0000 | 03 | 01, 00 | 00, 00 | 00, 00 | none |
| Set Endpoint (1) Feature (Halt/Stall) | 0000 0010 | 03 | 00, 00 | 81, 00 | 00, 00 | none |
| Status | | | | | | |
| Get Device Status | 1000 0000 | 00 | 00, 00 | 00, 00 | 02, 00 | device status |
| Get Interface Status | 1000 0001 | 00 | 00, 00 | 00, 00 | 02, 00 | zero |
| Get Endpoint (0) Status | 1000 0010 | 00 | 00, 00 | 00/80, 00 ^[3] | 02, 00 | endpoint 0 status |
| Get Endpoint (1) Status | 1000 0010 | 00 | 00, 00 | 81, 00 | 02, 00 | endpoint 1 status |

[1] Device address: 0 to 127.

[2] Returned value in bytes.

[3] MSB specifies endpoint direction: 0 = OUT, 1 = IN. The ISP1520 accepts either value.

12.2 Hub class requests

Table 24 shows the hub class requests.

Table 24: Hub class requests

| Request | bmRequestType byte 0 (bits 7 to 0) | bRequest byte 1 (hex) | wValue bytes 2, 3 (hex) | wIndex bytes 4, 5 (hex) | wLength bytes 6, 7 (hex) | Data |
|-----------------------------------|--|-----------------------------|-------------------------------|-------------------------------|--------------------------------|-------------------------------|
| Descriptor | | | | | | |
| Get Hub Descriptor | 1010 0000 | 06 | descriptor type and index | 00, 00 | length ^[2] | descriptor |
| Feature | | | | | | |
| Clear Hub Feature (C_LOCAL_POWER) | 0010 0000 | 01 | 00, 00 | 00, 00 | 00, 00 | none |
| Clear Port Feature | 0010 0011 | 01 | feature ^[3] , 00 | port ^[4] , 00 | 00, 00 | none |
| Set Port Feature | 0010 0011 | 03 | feature ^[3] , 00 | port ^[4] , 00 | 00, 00 | none |
| Status | | | | | | |
| Get Hub Status | 1010 0000 | 00 | 00, 00 | 00, 00 | 04, 00 | hub status and change status |
| Get Port Status | 1010 0011 | 00 | 00, 00 | port ^[4] , 00 | 04, 00 | port status and change status |
| TT | | | | | | |
| ClearTTBuffer | 0010 0011 | 08 | Dev_Addr, EP_nr | 01, 00 | 00, 00 | none |
| ResetTT | 0010 0000 | 09 | 00, 00 | 01, 00 | 00, 00 | none |

Table 24: Hub class requests...continued

| Request | bmRequestType byte 0 (bits 7 to 0) | bRequest byte 1 (hex) | wValue bytes 2, 3 (hex) | wIndex bytes 4, 5 (hex) | wLength bytes 6, 7 (hex) | Data |
|-------------------|--|-----------------------------|-------------------------------|-------------------------------|--------------------------------|----------|
| GetTTState | 1010 0011 | 10 | TT-flags | 01, 00 | -[1] | TT state |
| StopTT | 0010 0011 | 11 | 00, 00 | 01, 00 | 00, 00 | none |
| Test modes | | | | | | |
| Test_J | 0010 0011 | 03 | 15, 00 | port ^[4] , 01 | 00, 00 | none |
| Test_K | 0010 0011 | 03 | 15, 00 | port ^[4] , 02 | 00, 00 | none |
| Test_SE0_NAK | 0010 0011 | 03 | 15, 00 | port ^[4] , 03 | 00, 00 | none |
| Test_Packet | 0010 0011 | 03 | 15, 00 | port ^[4] , 04 | 00, 00 | none |
| Test_Force_Enable | 0010 0011 | 03 | 15, 00 | port ^[4] , 05 | 00, 00 | none |

- [1] Returns vendor-specific data.
- [2] Returned value in bytes.
- [3] Feature selector value; see Table 25.
- [4] Downstream port identifier: 1 to N with N is number of enabled ports (2 to 4).

Table 25: Hub class feature selector

| Feature selector name | Recipient | Value |
|-----------------------|-----------|-------|
| C_HUB_LOCAL_POWER | hub | 00 |
| C_HUB_OVER_CURRENT | hub | 01 |
| PORT_CONNECTION | port | 00 |
| PORT_ENABLE | port | 01 |
| PORT_SUSPEND | port | 02 |
| PORT_OVER_CURRENT | port | 03 |
| PORT_RESET | port | 04 |
| PORT_POWER | port | 08 |
| PORT_LOW_SPEED | port | 09 |
| C_PORT_CONNECTION | port | 16 |
| C_PORT_ENABLE | port | 17 |
| C_PORT_SUSPEND | port | 18 |
| C_PORT_OVER_CURRENT | port | 19 |
| C_PORT_RESET | port | 20 |
| PORT_TEST | port | 21 |
| PORT_INDICATOR | port | 22 |

12.3 Detailed responses to hub requests

12.3.1 Get configuration

This request returns the configuration value of the device. This request returns one byte of data; see Table 26.

Table 26: Get hub configuration response

| Bit | Function | Value | Description |
|--------|---------------------|-------|--------------------------|
| 0 | configuration value | 0 | device is not configured |
| | | 1 | device is configured |
| 1 to 7 | reserved | 0 | - |

12.3.2 Get device status

This request returns two bytes of data; see [Table 27](#).

Table 27: Get device status response

| Bit | Function | Value | Description |
|---------|----------------|-------|--------------|
| 0 | self-powered | 1 | self-powered |
| 1 | remote wake-up | 0 | disabled |
| | | 1 | enabled |
| 2 to 15 | reserved | 0 | - |

12.3.3 Get interface status

The request returns two bytes of data; see [Table 28](#).

Table 28: Get interface status response

| Bit | Function | Value | Description |
|---------|----------|-------|-------------|
| 0 to 15 | reserved | 0 | - |

12.3.4 Get endpoint status

The request returns two bytes of data; see [Table 29](#).

Table 29: Get endpoint status response

| Bit | Function | Value | Description |
|---------|----------|-------|------------------------|
| 0 | halt | 0 | endpoint is not halted |
| | | 1 | endpoint is halted |
| 1 to 15 | reserved | 0 | - |

12.3.5 Get hub status

The request returns four bytes of data; see [Table 30](#).

Table 30: Get hub status response

| Bit | Function | Value | Description |
|---------|-----------------------|-------|---|
| 0 | local power source | 0 | local power supply good |
| | | 1 | local power supply lost (inactive) |
| 1 | overcurrent indicator | 0 | no overcurrent condition currently exists |
| | | 1 | a hub overcurrent condition exists |
| 2 to 15 | reserved | 0 | - |

Table 30: Get hub status response...continued

| Bit | Function | Value | Description |
|----------|------------------------------|-------|-------------------------------------|
| 16 | local power status change | 0 | no change in the local power status |
| | | 1 | local power status has changed |
| 17 | overcurrent indicator change | 0 | no change in overcurrent |
| | | 1 | overcurrent status has changed |
| 18 to 31 | reserved | 0 | - |

12.3.6 Get port status

This request returns four bytes of data. The first word contains the port status bits (wPortStatus), and the next word contains the port status change bits (wPortChange). The contents of wPortStatus is given in Table 31, and the contents of wPortChange is given in Table 32.

Table 31: Get port status response (wPortStatus)

| Bit | Function | Value | Description |
|----------|----------------------------|-------|---|
| 0 | current connect status | 0 | no device is present |
| | | 1 | a device is present on this port |
| 1 | port enabled or disabled | 0 | port is disabled |
| | | 1 | port is enabled |
| 2 | suspend | 0 | port is not suspended |
| | | 1 | port is suspended |
| 3 | overcurrent indicator | 0 | no overcurrent condition exists |
| | | 1 | an overcurrent condition exists |
| 4 | reset | 0 | reset signaling is not asserted |
| | | 1 | reset signaling is asserted |
| 5 to 7 | reserved | 0 | - |
| 8 | port power | 0 | port is in the powered-off state |
| | | 1 | port is not in the powered-off state |
| 9 | low-speed device attached | 0 | full-speed or high-speed device is attached |
| | | 1 | low-speed device is attached |
| 10 | high-speed device attached | 0 | full-speed device is attached |
| | | 1 | high-speed device is attached |
| 11 | port test mode | 0 | not in the port test mode |
| | | 1 | in the port test mode |
| 12 | port indicator control | 0 | displays default colors |
| | | 1 | displays software controlled color |
| 13 to 15 | reserved | 0 | - |

Table 32: Get port status change response (wPortChange)

| Bit | Function | Value | Description |
|---------|-------------------------------|-------|---|
| 0 | connect status change | 0 | no change in the current connect status |
| | | 1 | change in the current connect status |
| 1 | port enable or disable change | 0 | port is enabled |
| | | 1 | port is disabled |
| 2 | suspend change | 0 | no change |
| | | 1 | resume complete |
| 3 | overcurrent indicator change | 0 | no change in the overcurrent indicator |
| | | 1 | change in the overcurrent indicator |
| 4 | reset change | 0 | no change |
| | | 1 | reset complete |
| 5 to 15 | reserved | 0 | - |

12.4 Various get descriptors

bmRequestType — 10000000B

bmRequest — GET_DESCRIPTOR = 6

Table 33: Get descriptor request

| Request name | wValue | | wIndex | Data |
|-------------------------------------|------------------|-----------------|------------------|--|
| | Descriptor index | Descriptor type | Zero/Language ID | |
| Get device descriptor | 00 | 01 | 0 | device descriptor |
| Get configuration descriptor | 00 | 02 | 0 | configuration interface and endpoint descriptors |
| Get language ID string descriptor | 00 | 03 | 0 | language ID support string |
| Get manufacturer string descriptor | 01 | 03 | n | manufacturer string in LANGID n |
| Get product string descriptor | 02 | 03 | n | product string in LANGID n |
| Get serial number string descriptor | 03 | 03 | n | serial number string in LANGID n |

13. Limiting values

Table 34: Absolute maximum ratings

In accordance with the Absolute Maximum Rating System (IEC 60134).

| Symbol | Parameter | Conditions | Min | Max | Unit |
|----------------|---------------------------------|--|--------------|-------|------|
| V_{CC} | supply voltage 3.3 V | | -0.5 | +4.6 | V |
| $V_{REF(5V0)}$ | input reference voltage 5.0 V | | -0.5 | +5.25 | V |
| $V_{I(5V0)}$ | input voltage on 5 V buffers | $3.0\text{ V} < V_{CC} < 3.6\text{ V}$ | [1] -0.5 | +6.0 | V |
| $V_{I(3V3)}$ | input voltage on 3.3 V buffers | $3.0\text{ V} < V_{CC} < 3.6\text{ V}$ | -0.5 | +4.6 | V |
| $V_{O(3V3)}$ | output voltage on 3.3 V buffers | | -0.5 | +4.6 | V |
| I_{lu} | latch-up current | $V_I < 0$ or $V_I > V_{CC}$ | - | 100 | mA |
| V_{esd} | electrostatic discharge voltage | on pins DM1 to DM4, DP1 to DP4, OC1_N to OC4_N, and all $V_{REF(5V0)}$ and GND pins; $I_{LI} < 1\text{ }\mu\text{A}$ | [2][3] -4000 | +4000 | V |
| | | on all other pins; $I_{LI} < 1\text{ }\mu\text{A}$ | [2][3] -2000 | +2000 | V |
| T_{stg} | storage temperature | | -40 | +125 | °C |

[1] Valid only when supply voltage is present.

[2] Test method available on request.

[3] Equivalent to discharging a 100 pF capacitor via a 1.5 kΩ resistor (Human Body Model).

14. Recommended operating conditions

Table 35: Recommended operating ranges

| Symbol | Parameter | Min | Typ | Max | Unit |
|----------------|------------------------------------|---------|-----|----------------|------|
| V_{CC} | supply voltage 3.3 V | 3.0 | 3.3 | 3.6 | V |
| $V_{REF(5V0)}$ | input reference voltage 5 V | [1] 4.5 | 5.0 | 5.25 | V |
| $V_{I(3V3)}$ | input voltage on 3.3 V pins | 0 | - | V_{CC} | V |
| $V_{I(5V0)}$ | input voltage on 5 V tolerant pins | 0 | - | $V_{REF(5V0)}$ | V |
| T_{amb} | operating temperature | 0 | - | 70 | °C |

[1] All internal pull-up resistors are connected to this voltage.

15. Static characteristics

Table 36: Static characteristics: supply pins

$V_{CC} = 3.0\text{ V to }3.6\text{ V}$; $T_{amb} = 0\text{ }^{\circ}\text{C to }70\text{ }^{\circ}\text{C}$; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-------------------|----------------------------|---|-------|-------|-----|------|
| Full-speed | | | | | | |
| $I_{REF(5V0)}$ | supply current 5 V | | - | 0.5 | - | mA |
| $I_{CC(tot)}$ | total supply current 3.3 V | $I_{CC(tot)} = I_{CC1} + I_{CC2} + I_{CC3} + I_{CC4}$ | [1] - | 91 | - | mA |
| High-speed | | | | | | |
| $I_{CC(tot)}$ | total supply current 3.3 V | suspend mode; internal clock stopped | [2] - | 0.5 | - | mA |
| | | no device connected | - | 136.3 | - | mA |
| | | 1 active device connected | - | 180 | - | mA |
| | | 2 active devices connected | - | 221 | - | mA |
| | | 3 active devices connected | - | 256 | - | mA |
| | | 4 active devices connected | - | 288 | - | mA |

[1] Irrespective of the number of devices connected, the value of I_{CC} is always 91 mA in full-speed.

[2] Including R_{pu} drop current.

Table 37: Static characteristics: digital input and outputs^[1]

$V_{CC} = 3.0\text{ V to }3.6\text{ V}$; $T_{amb} = 0\text{ }^{\circ}\text{C to }70\text{ }^{\circ}\text{C}$; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--|------------------------------------|----------------------------------|-----|-----|-----|---------------|
| Digital input pins | | | | | | |
| V_{IL} | LOW-level input voltage | | - | - | 0.8 | V |
| V_{IH} | HIGH-level input voltage | | 2.0 | - | - | V |
| I_{LI} | input leakage current | | -1 | - | +1 | μA |
| Schmitt-trigger input pins | | | | | | |
| $V_{th(LH)}$ | positive-going threshold voltage | | 1.4 | - | 1.9 | V |
| $V_{th(HL)}$ | negative-going threshold voltage | | 0.9 | - | 1.5 | V |
| V_{hys} | hysteresis voltage | | 0.4 | - | 0.7 | V |
| Overcurrent detection pins OC1_N to OC4_N | | | | | | |
| ΔV_{trip} | overcurrent detection trip voltage | $\Delta V = V_{CC} - V_{OCn_N}$ | - | 84 | - | mV |
| Digital output pins | | | | | | |
| V_{OL} | LOW-level output voltage | | - | - | 0.4 | V |
| V_{OH} | HIGH-level output voltage | | 2.4 | - | - | V |
| Open-drain output pins | | | | | | |
| I_{OZ} | OFF-state output current | | -1 | - | +1 | μA |

[1] All pins are 5 V tolerant.

Table 38: Static characteristics: I²C-bus interface block

$V_{CC} = 3.0\text{ V to }3.6\text{ V}$; $T_{amb} = 0\text{ }^{\circ}\text{C to }70\text{ }^{\circ}\text{C}$; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---------------------------------------|-------|-----|-----|------|
| Input pin SCL and input/output pin SDA^[1] | | | | | | |
| V _{IL} | LOW-level input voltage | | - | - | 0.9 | V |
| V _{IH} | HIGH-level input voltage | | 2.1 | - | - | V |
| V _{hys} | hysteresis voltage | | 0.15 | - | - | V |
| V _{OL} | LOW-level output voltage | | - | - | 0.4 | V |
| t _f | output fall time V _{IH} to V _{IL} | 10 < C _b = 10 pF to 400 pF | [2] - | 0 | 250 | ns |

[1] All pins are 5 V tolerant.

[2] The bus capacitance (C_b) is specified in pF. To meet the specification for V_{OL} and the maximum rise time (300 ns), use an external pull-up resistor with R_{max} = 850/C_b kΩ and R_{min} = (V_{CC} - 0.4)/3 kΩ.

Table 39: Static characteristics: USB interface block (DP0 to DP4 and DM0 to DM4)

$V_{CC} = 3.0\text{ V to }3.6\text{ V}$; $T_{amb} = 0\text{ }^{\circ}\text{C to }70\text{ }^{\circ}\text{C}$; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---------------------|----------|-----|------|------|
| Input levels for high-speed | | | | | | |
| V _{HSSQ} | squelch detection threshold (differential signal amplitude) | squelch detected | - | - | 100 | mV |
| | | no squelch detected | 150 | - | - | mV |
| V _{HSCM} | data signaling common-mode voltage range | | -50 | - | +500 | mV |
| Output levels for high-speed | | | | | | |
| V _{HSOI} | idle state | | -10 | - | +10 | mV |
| V _{HSOH} | data signaling HIGH | | 360 | - | 440 | mV |
| V _{HSOL} | data signaling LOW | | -10 | - | +10 | mV |
| V _{CHIRPJ} | chirp J level (differential voltage) | | [1] 700 | - | 1100 | mV |
| V _{CHIRPK} | chirp K level (differential voltage) | | [1] -900 | - | -500 | mV |
| Input levels for full-speed and low-speed | | | | | | |
| V _{IL} | LOW-level input voltage | | - | - | 0.8 | V |
| V _{IH} | HIGH-level input voltage (drive) | | 2.0 | - | - | V |
| V _{IHZ} | HIGH-level input voltage (floating) | | 2.7 | - | 3.6 | V |
| V _{DI} | differential input sensitivity | DP - DM | 0.2 | - | - | V |
| V _{CM} | differential common-mode range | | 0.8 | - | 2.5 | V |
| Output levels for full-speed and low-speed | | | | | | |
| V _{OL} | LOW-level output voltage | | 0 | - | 0.3 | V |
| V _{OH} | HIGH-level output voltage | | 2.8 | - | 3.6 | V |
| V _{CRS} | output signal crossover point voltage | | [2] 1.3 | - | 2.0 | V |
| Leakage current | | | | | | |
| I _{LZ} | OFF-state leakage current | | -1 | - | +1 | μA |
| Capacitance | | | | | | |
| C _{IN} | transceiver capacitance | pin to GND | - | - | 20 | pF |

Table 39: Static characteristics: USB interface block (DP0 to DP4 and DM0 to DM4)...*continued* $V_{CC} = 3.0\text{ V to }3.6\text{ V}$; $T_{amb} = 0\text{ }^{\circ}\text{C to }70\text{ }^{\circ}\text{C}$; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------------------|---|------------|---------|-----|-----|------------------|
| Resistance | | | | | | |
| Z_{INP} | input impedance | | 10 | - | - | $\text{M}\Omega$ |
| Termination | | | | | | |
| V_{TERM} | termination voltage for pull-up resistor on pin RPU | | [3] 3.0 | - | 3.6 | V |

[1] For minimum value, the HS termination resistor is disabled and the pull-up resistor is connected. Only during reset, when both the hub and the device are capable of high-speed operation.

[2] Characterized only, not tested. Limits guaranteed by design.

[3] In the suspend mode, the minimum voltage is 2.7 V.

16. Dynamic characteristics

Table 40: Dynamic characteristics: system clock timing

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-----------------------------|-------------------------------------|------------|--------|-----|-----|---------------|
| Reset | | | | | | |
| $t_{W(POR)}$ | internal power-on reset pulse width | | 0.2 | - | 1 | μs |
| $t_{W(RESET_N)}$ | pulse width on pin RESET_N | | 0.2 | - | - | μs |
| Crystal oscillator | | | | | | |
| f_{clk} | clock frequency | crystal | [1][2] | 12 | - | MHz |
| External clock input | | | | | | |
| δ | clock duty cycle | | - | 50 | - | % |

[1] Recommended accuracy of the clock frequency is 500 ppm for the crystal.

[2] Suggested values for external capacitors when using a crystal are 22 to 27 pF.

Table 41: Dynamic characteristics: overcurrent sense timing

$V_{CC} = 3.0\text{ V to }3.6\text{ V}$; $T_{amb} = 0\text{ }^{\circ}\text{C to }70\text{ }^{\circ}\text{C}$; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--|--|--------------|-----|-----|-----|------|
| Overcurrent sense pins OC1_N to OC4_N | | | | | | |
| t_{trip} | overcurrent trip response time from OCn_N LOW to PSWn_N HIGH | see Figure 9 | - | - | 15 | ms |

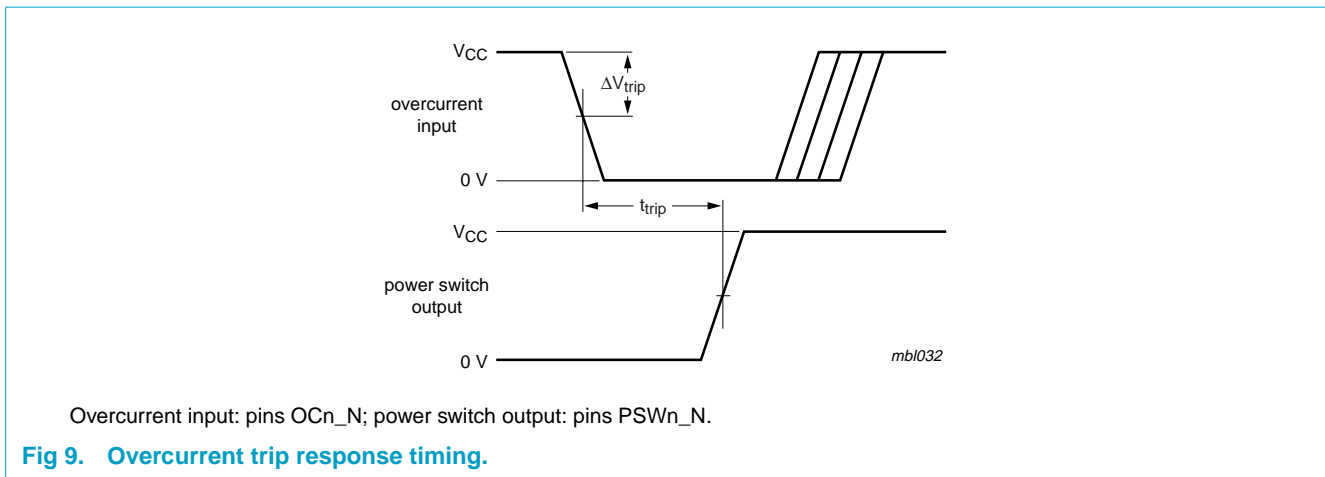


Table 42: Dynamic characteristics: digital pins^[1]

$V_{CC} = 3.0\text{ V to }3.6\text{ V}$; $T_{amb} = 0\text{ }^{\circ}\text{C to }70\text{ }^{\circ}\text{C}$; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|------------------------------|------------------------|------------|-----|-----|-----|------|
| $t_{t(HL)}$, $t_{t(LH)}$ | output transition time | | 4 | - | 15 | ns |

[1] All pins are 5 V tolerant.

Table 43: Dynamic characteristics: high-speed source electrical characteristics

$V_{CC} = 3.0\text{ V to }3.6\text{ V}$; $T_{amb} = 0\text{ }^{\circ}\text{C to }70\text{ }^{\circ}\text{C}$; test circuit [Figure 21](#); unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-------------------------------|--|--------------|----------|-----|---------------------------|---------------|
| Driver characteristics | | | | | | |
| t_{HSR} | rise time | 10 % to 90 % | 500 | - | - | ps |
| t_{HSF} | fall time | 90 % to 10 % | 500 | - | - | ps |
| Clock timing | | | | | | |
| t_{HSDRAT} | data rate | | 479.76 | - | 480.24 | Mbit/s |
| t_{HSFRAM} | microframe interval | | 124.9375 | - | 125.0625 | μs |
| t_{HSRFI} | consecutive microframe interval difference | | 1 | - | four high-speed bit times | ns |

Table 44: Dynamic characteristics: full-speed source electrical characteristics

$V_{CC} = 3.0\text{ V to }3.6\text{ V}$; $T_{amb} = 0\text{ }^{\circ}\text{C to }70\text{ }^{\circ}\text{C}$; test circuit [Figure 22](#); unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--|--|--|------------|-----|-------|----------|
| Driver characteristics | | | | | | |
| t_{FR} | rise time | $C_L = 50\text{ pF}$; 10 % to 90 % of $ V_{OH} - V_{OL} $ | 4 | - | 20 | ns |
| t_{FF} | fall time | $C_L = 50\text{ pF}$; 90 % to 10 % of $ V_{OH} - V_{OL} $ | 4 | - | 20 | ns |
| t_{FRFM} | differential rise and fall time matching | | [1] 90 | - | 111.1 | % |
| Z_{DRV} | driver output resistance | for the driver that is not high-speed capable | 28 | - | 44 | Ω |
| V_{CRS} | output signal crossover voltage | | [1][2] 1.3 | - | 2.0 | V |
| Data source timing ^[2] | | | | | | |
| t_{DJ1} | source differential jitter for consecutive transitions | see Figure 10 | [1] -3.5 | - | +3.5 | ns |
| t_{DJ2} | source differential jitter for paired transitions | see Figure 10 | [1] -4 | - | +4 | ns |
| t_{FEOPT} | source SE0 interval of EOP | see Figure 11 | 160 | - | 175 | ns |
| t_{FDEOP} | source differential data-to-EOP transition skew | see Figure 11 | -2 | - | +5 | ns |
| Receiver timing ^[2] | | | | | | |
| t_{JR1} | receiver data jitter tolerance for consecutive transitions | see Figure 12 | -18.5 | - | +18.5 | ns |
| t_{JR2} | receiver data jitter tolerance for paired transitions | see Figure 12 | -9 | - | +9 | ns |
| t_{FEOPR} | receiver SE0 width | accepted as EOP; see Figure 11 | 82 | - | - | ns |
| t_{FST} | width of SE0 interval during differential transaction | rejected as EOP; see Figure 13 | - | - | 14 | ns |
| Hub timing (downstream ports configured as full-speed) ^[2] | | | | | | |
| t_{FHDD} | hub differential data delay (without cable) | see Figure 14 ; $C_L = 0\text{ pF}$ | - | - | 44 | ns |

Table 44: Dynamic characteristics: full-speed source electrical characteristics...continued

$V_{CC} = 3.0\text{ V to }3.6\text{ V}$; $T_{amb} = 0\text{ }^{\circ}\text{C to }70\text{ }^{\circ}\text{C}$; test circuit [Figure 22](#); unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-------------|-------------------------------------|-------------------------------|-----|-----|-----|------|
| t_{FSOP} | data bit width distortion after SOP | see Figure 14 | -5 | - | +5 | ns |
| t_{FEOPD} | hub EOP delay relative to t_{HDD} | see Figure 15 | 0 | - | 15 | ns |
| t_{FHESK} | hub EOP output width skew | see Figure 15 | -15 | - | +15 | ns |

- [1] Excluding the first transition from Idle state.
- [2] Characterized only, not tested. Limits guaranteed by design.

Table 45: Dynamic characteristics: low-speed source electrical characteristics

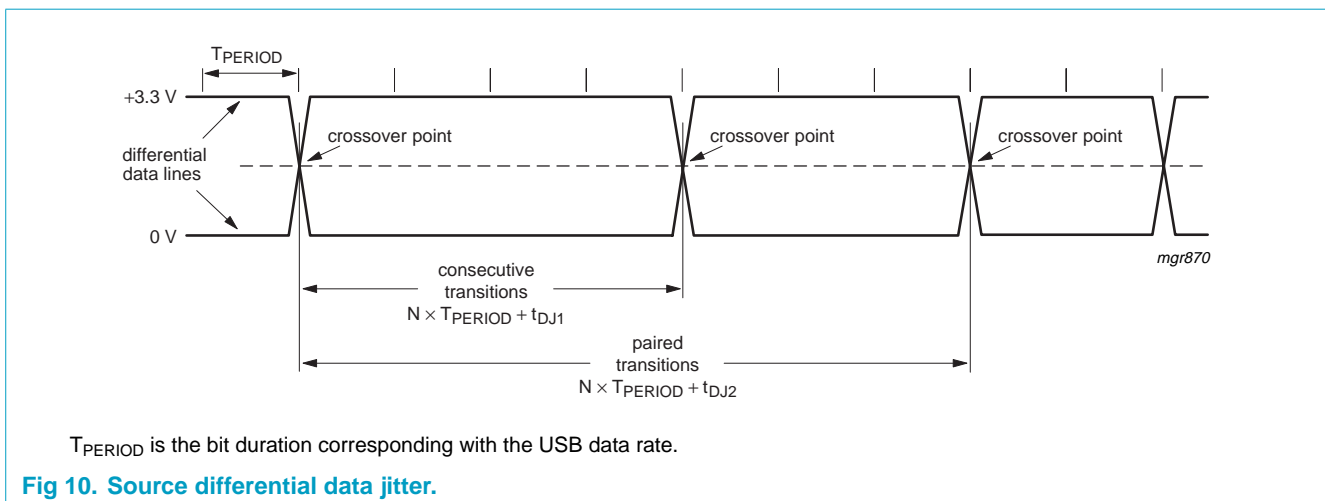
$V_{CC} = 3.0\text{ V to }3.6\text{ V}$; $T_{amb} = 0\text{ }^{\circ}\text{C to }70\text{ }^{\circ}\text{C}$; test circuit [Figure 22](#); unless otherwise specified.

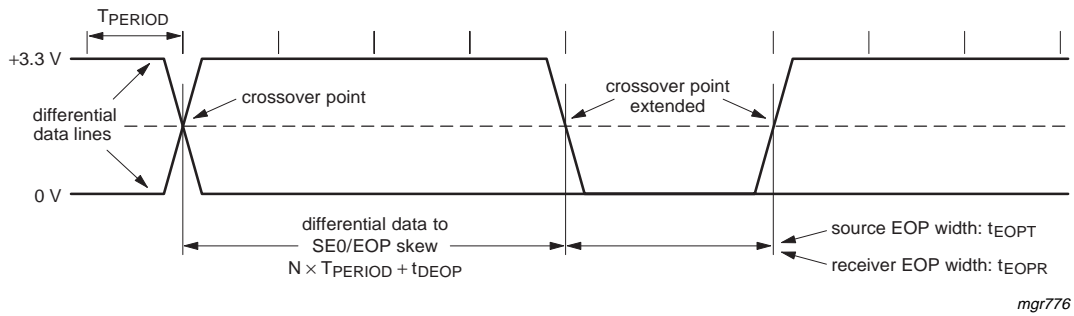
| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-------------------------------|--|------------|------------|-----|-----|------|
| Driver characteristics | | | | | | |
| t_{LR} | rise time | | 75 | - | 300 | ns |
| t_{LF} | fall time | | 75 | - | 300 | ns |
| t_{LRFM} | differential rise and fall time matching | | [1] 80 | - | 125 | % |
| V_{CRS} | output signal crossover voltage | | [1][2] 1.3 | - | 2.0 | V |

Hub timing (downstream ports configured as full-speed)

| | | | | | | |
|-------------|-------------------------------------|-------------------------------|----------|---|------|----|
| t_{LHDD} | hub differential data delay | see Figure 14 | - | - | 300 | ns |
| t_{LSOP} | data bit width distortion after SOP | see Figure 14 | [2] -60 | - | +60 | ns |
| t_{LEOPD} | hub EOP delay relative to t_{HDD} | see Figure 15 | [2] 0 | - | 200 | ns |
| t_{LHESK} | hub EOP output width skew | see Figure 15 | [2] -300 | - | +300 | ns |

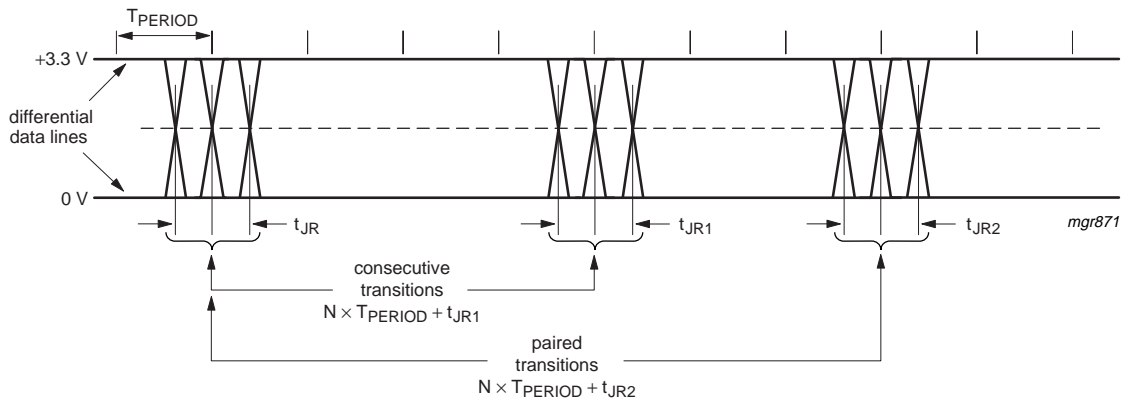
- [1] Excluding the first transition from Idle state.
- [2] Characterized only, not tested. Limits guaranteed by design.





T_{PERIOD} is the bit duration corresponding with the USB data rate.
Full-speed timing symbols have a subscript prefix 'F', low-speed timing a prefix 'L'.

Fig 11. Source differential data-to-EOP transition skew and EOP width.



T_{PERIOD} is the bit duration corresponding with the USB data rate.
 t_{JR} is the jitter reference point.

Fig 12. Receiver differential data jitter.

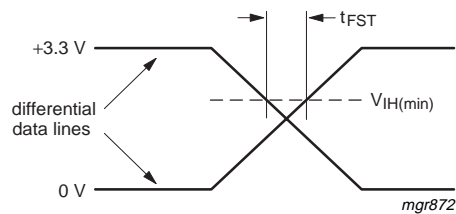


Fig 13. Receiver SE0 width tolerance.

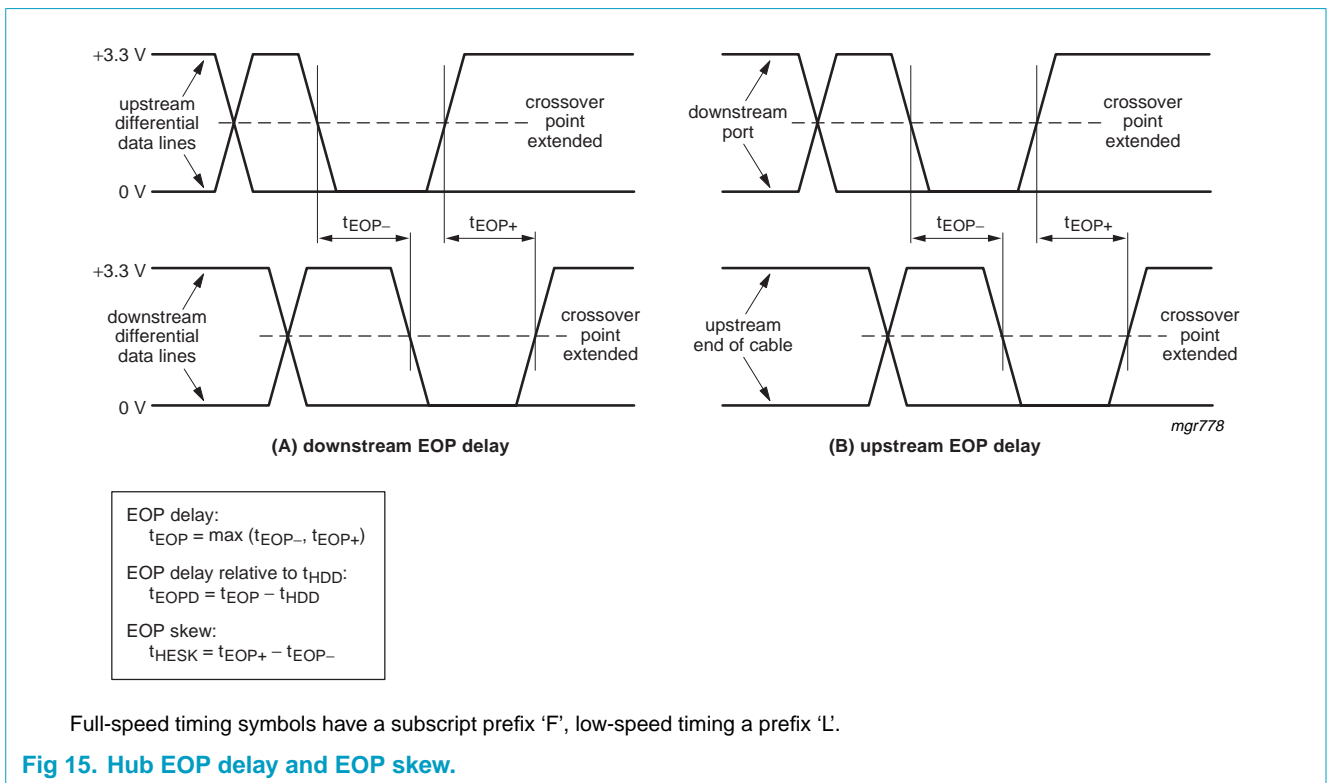
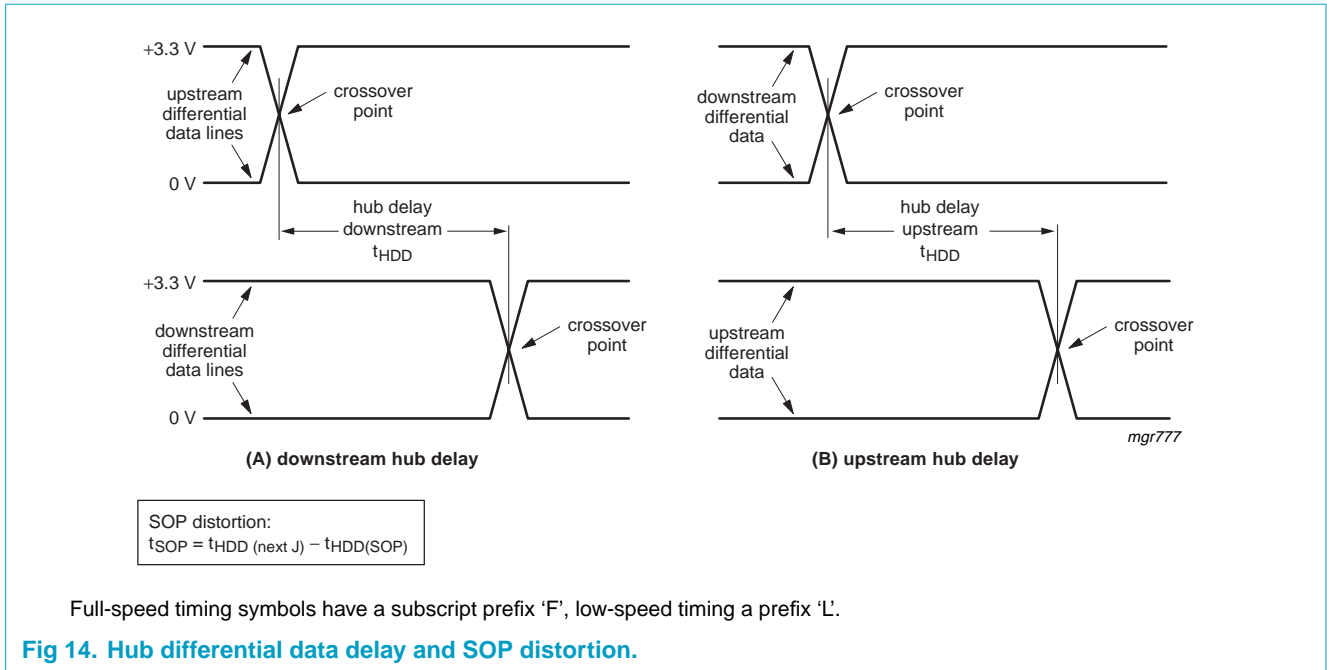


Table 46: Dynamic characteristics: I²C-bus (pins SDA and SCL)

V_{CC} and T_{amb} within recommended operating range; $V_{DD} = +5\text{ V}$; $V_{SS} = V_{GND}$; V_{IL} and V_{IH} between V_{SS} and V_{DD} .

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|--|----------------------------|-------|-------|------|---------------|
| Clock frequency | | | | | | |
| f_{SCL} | SCL clock frequency | $f_{XTAL} = 12\text{ MHz}$ | [1] 0 | 93.75 | 100 | kHz |
| General timing | | | | | | |
| t_{LOW} | SCL LOW time | | 4.7 | - | - | μs |
| t_{HIGH} | SCL HIGH time | | 4.0 | - | - | μs |
| t_r | SCL and SDA rise time | | [2] - | - | 1000 | ns |
| t_f | SCL and SDA fall time | | - | - | 300 | ns |
| C_b | capacitive load for each bus line | | - | - | 400 | pF |
| SDA timing | | | | | | |
| t_{BUF} | bus free time | | 4.7 | - | - | μs |
| $t_{SU;STA}$ | set-up time for (repeated) START condition | | 4.7 | - | - | μs |
| $t_{HD;STA}$ | hold time (repeated) START condition | | 4.0 | - | - | μs |
| $t_{SU;DAT}$ | data set-up time | | 250 | - | - | ns |
| $t_{HD;DAT}$ | data hold time | | 0 | - | - | μs |
| $t_{SU;STO}$ | set-up time for STOP condition | | 4.0 | - | - | μs |
| Additional I²C-bus timing | | | | | | |
| $t_{VD;DAT}$ | SCL LOW to data-out valid time | | - | - | 0.4 | μs |

[1] $f_{SCL} = \frac{1}{64} \times f_{XTAL}$.

[2] Rise time is determined by C_b and pull-up resistor value R_p (typical 4.7 k Ω).

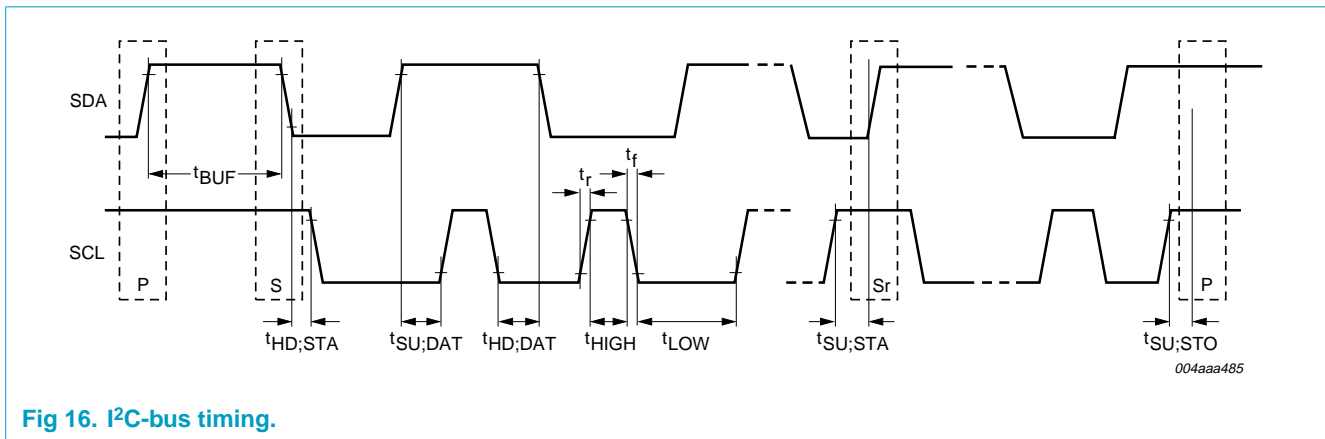
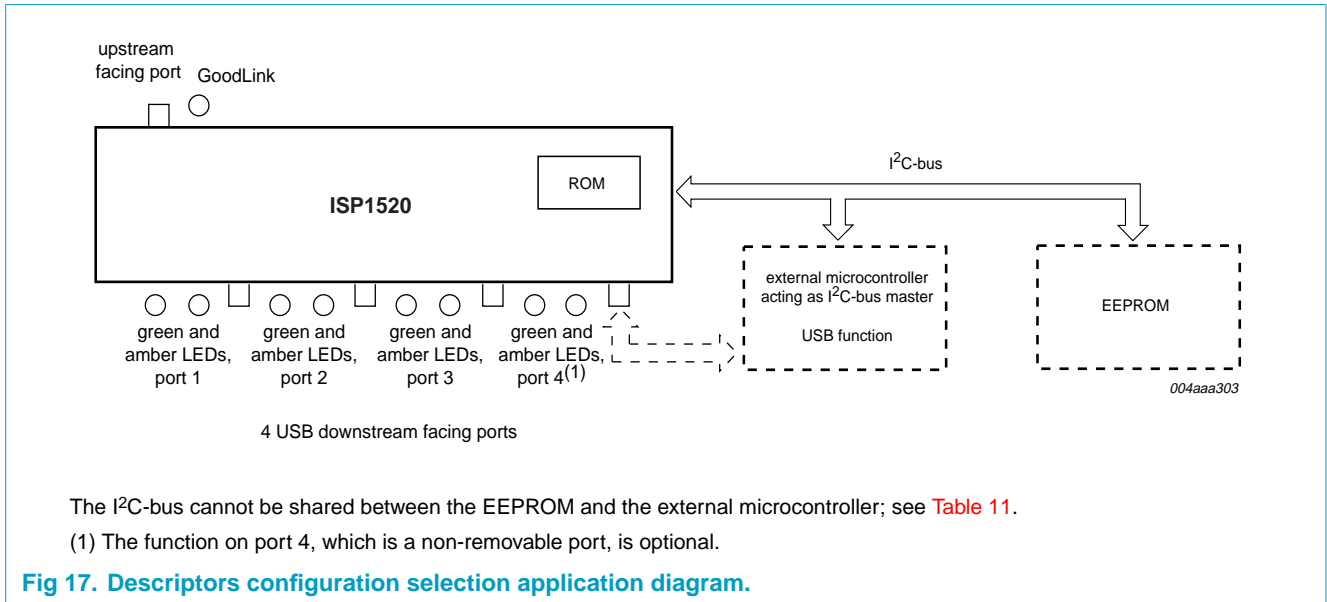


Fig 16. I²C-bus timing.

17. Application information

17.1 Descriptor configuration selection



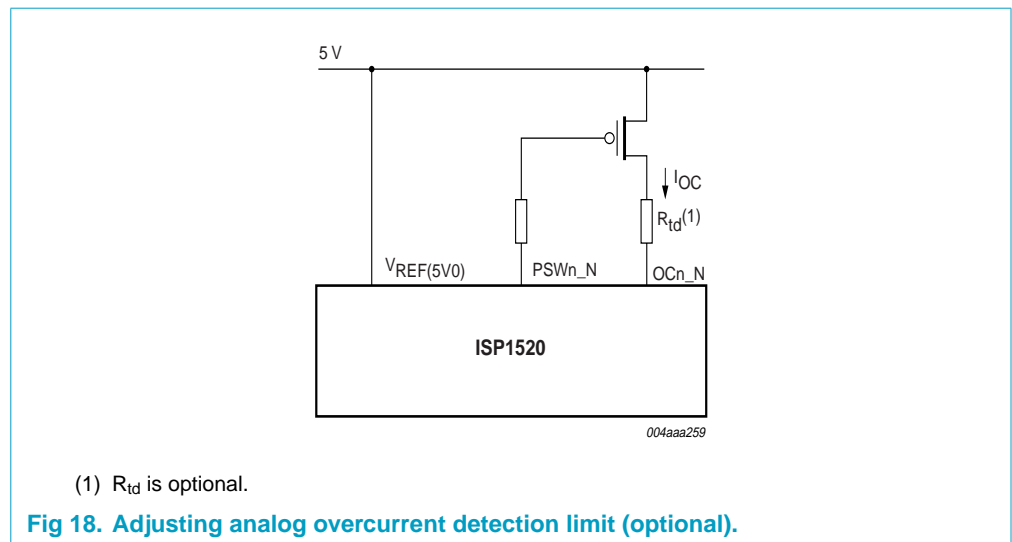
17.2 Overcurrent detection limit adjustment

For an overcurrent limit of 500 mA per port, a PMOS with R_{DS(on)} of approximately 100 mΩ is required. If a PMOS with a lower R_{DS(on)} is used, analog overcurrent detection can be adjusted by using a series resistor; see [Figure 18](#).

$$\Delta V_{\text{PMOS}} = \Delta V_{\text{trip}} = \Delta V_{\text{trip(intrinsic)}} - (I_{\text{OC(nom)}} \times R_{\text{td}}), \text{ where:}$$

$$\Delta V_{\text{PMOS}} = \text{voltage drop on PMOS}$$

$$I_{\text{OC(nom)}} = 0.6 \mu\text{A}.$$



17.3 Self-powered hub configurations

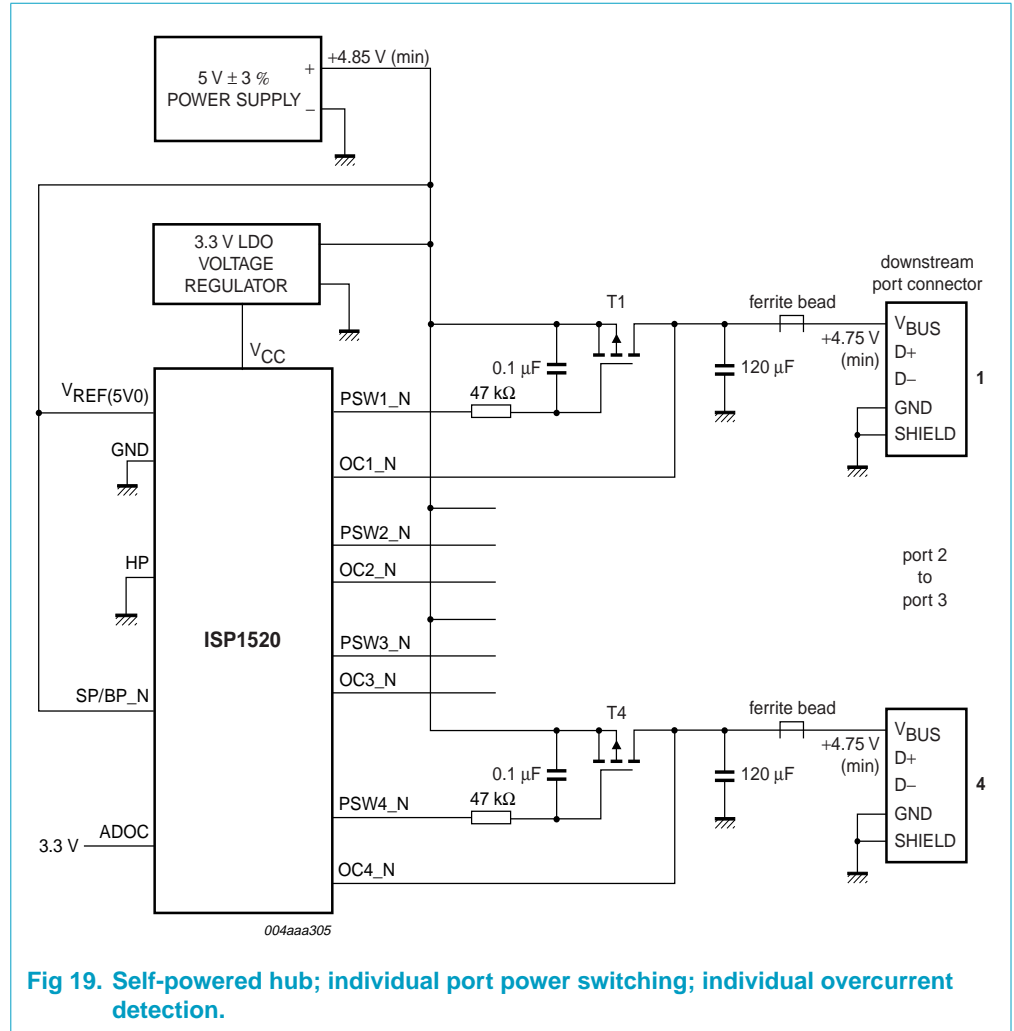
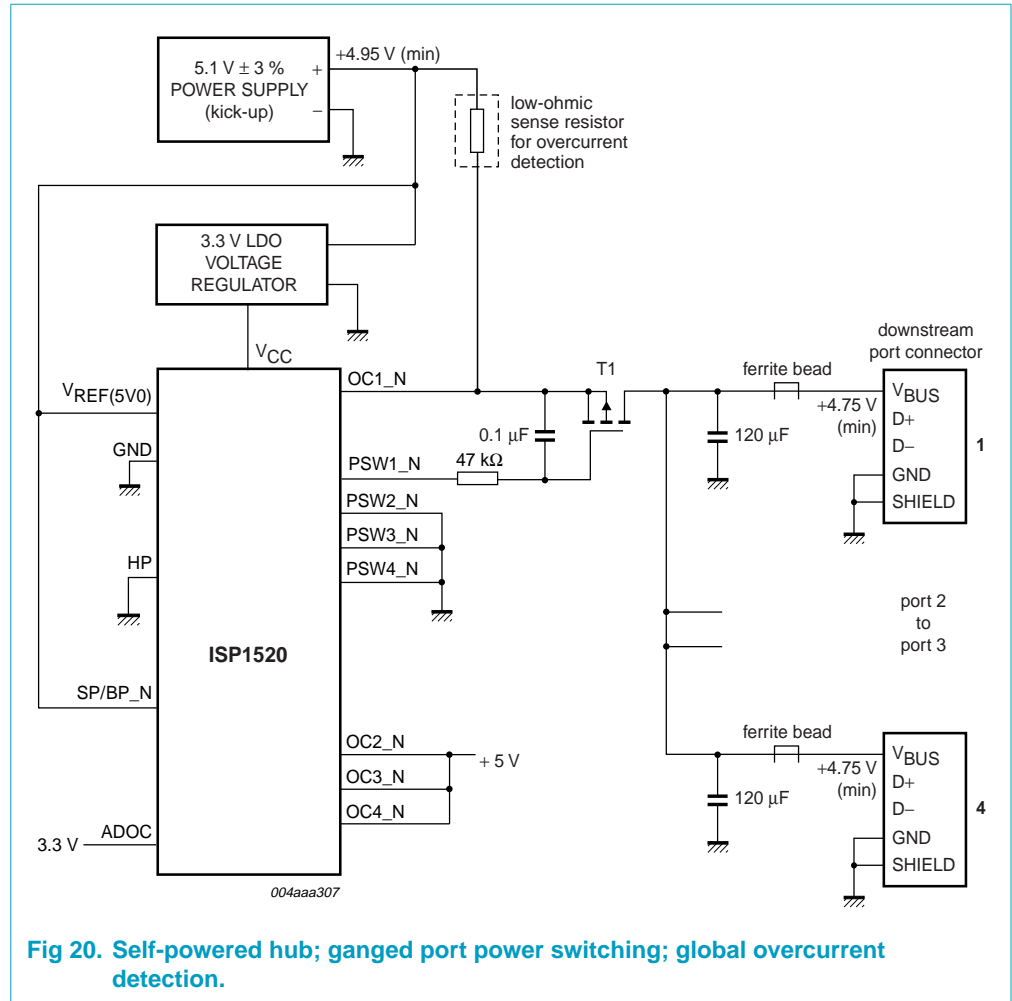
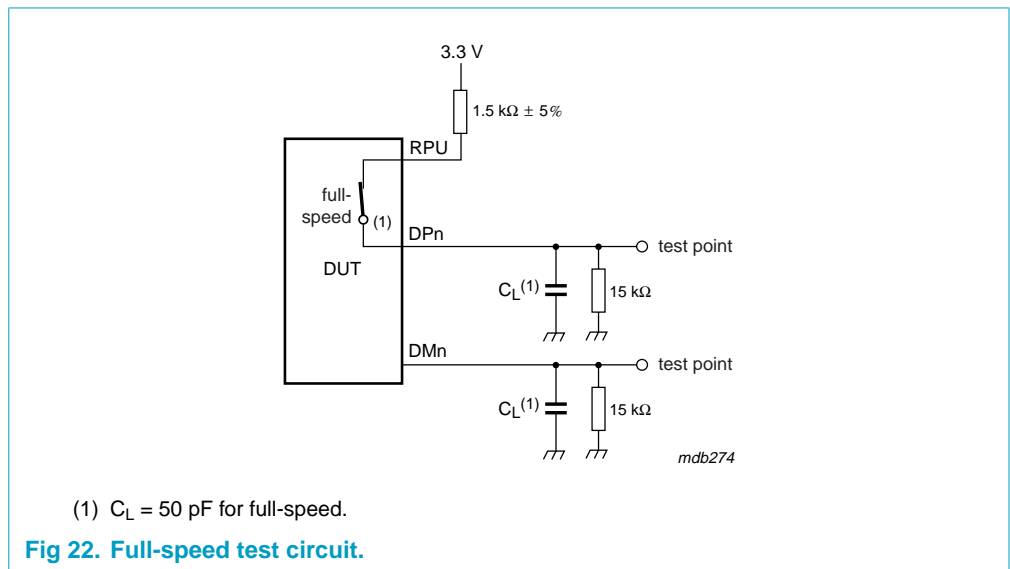
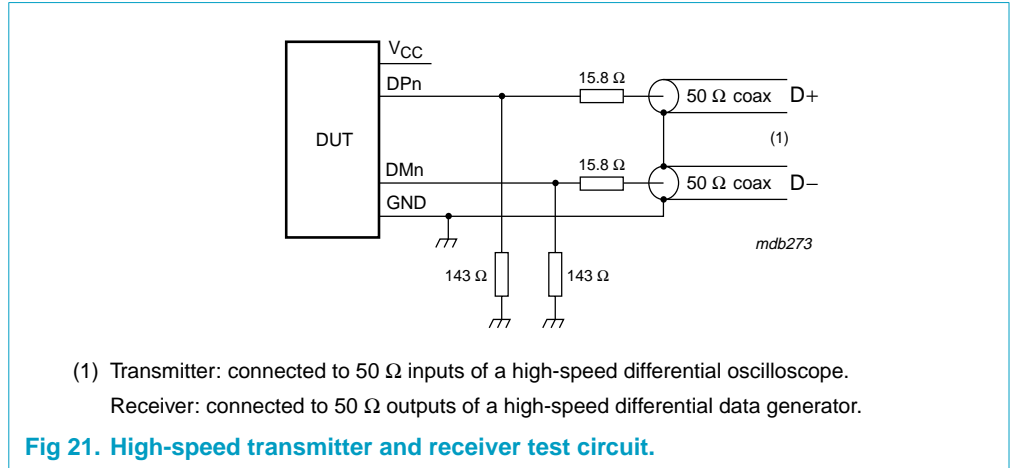


Fig 19. Self-powered hub; individual port power switching; individual overcurrent detection.



18. Test information



19. Package outline

LQFP64: plastic low profile quad flat package; 64 leads; body 10 x 10 x 1.4 mm

SOT314-2

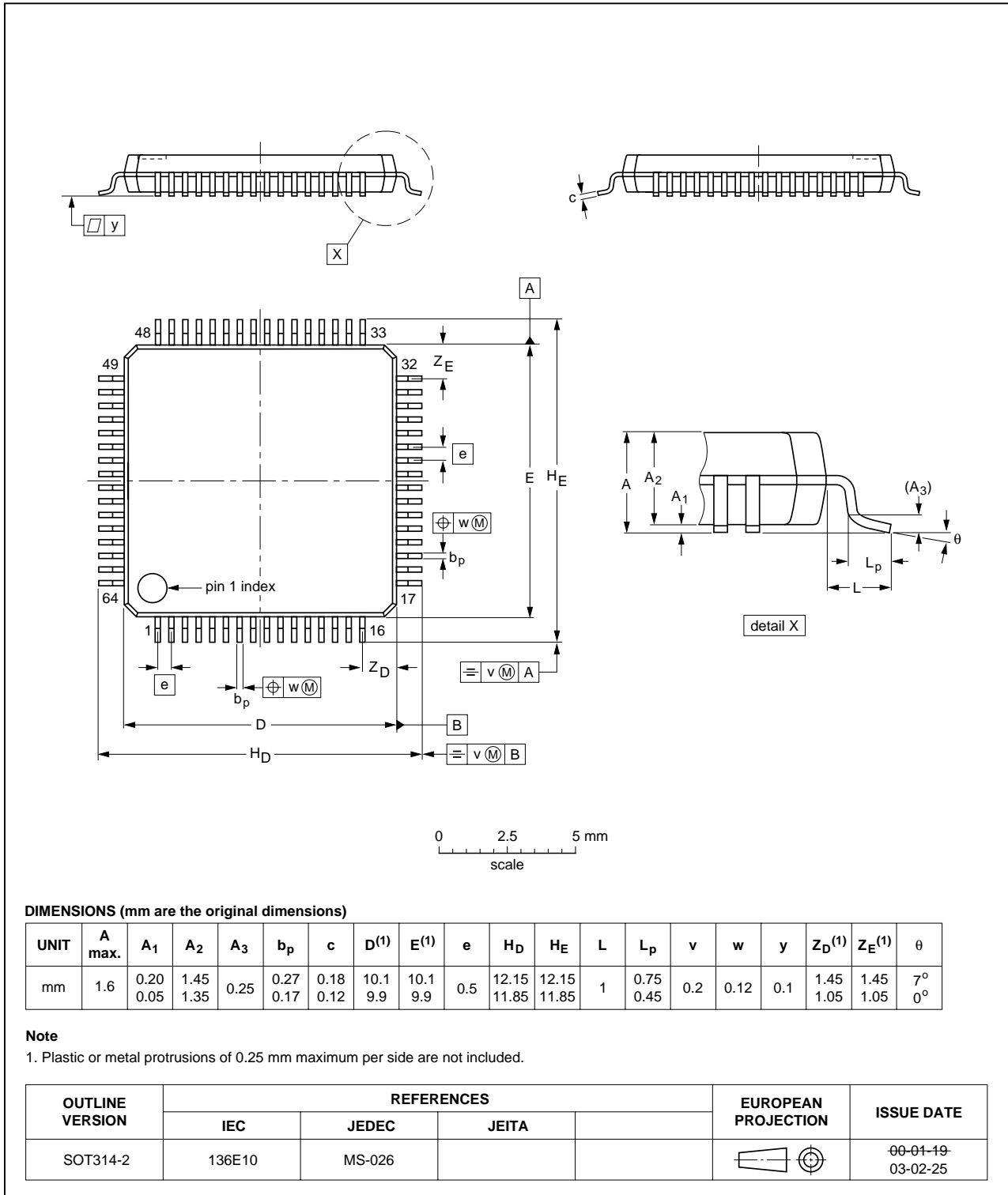


Fig 23. LQFP64 package outline.

20. Soldering

20.1 Introduction to soldering surface mount packages

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *Data Handbook IC26; Integrated Circuit Packages* (document order number 9398 652 90011).

There is no soldering method that is ideal for all surface mount IC packages. Wave soldering can still be used for certain surface mount ICs, but it is not suitable for fine pitch SMDs. In these situations reflow soldering is recommended. In these situations reflow soldering is recommended.

20.2 Reflow soldering

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement. Driven by legislation and environmental forces the worldwide use of lead-free solder pastes is increasing.

Several methods exist for reflowing; for example, convection or convection/infrared heating in a conveyor type oven. Throughput times (preheating, soldering and cooling) vary between 100 and 200 seconds depending on heating method.

Typical reflow peak temperatures range from 215 to 270 °C depending on solder paste material. The top-surface temperature of the packages should preferably be kept:

- below 225 °C (SnPb process) or below 245 °C (Pb-free process)
 - for all BGA, HTSSON..T and SSOP..T packages
 - for packages with a thickness ≥ 2.5 mm
 - for packages with a thickness < 2.5 mm and a volume ≥ 350 mm³ so called thick/large packages.
- below 240 °C (SnPb process) or below 260 °C (Pb-free process) for packages with a thickness < 2.5 mm and a volume < 350 mm³ so called small/thin packages.

Moisture sensitivity precautions, as indicated on packing, must be respected at all times.

20.3 Wave soldering

Conventional single wave soldering is not recommended for surface mount devices (SMDs) or printed-circuit boards with a high component density, as solder bridging and non-wetting can present major problems.

To overcome these problems the double-wave soldering method was specifically developed.

If wave soldering is used the following conditions must be observed for optimal results:

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.

- For packages with leads on two sides and a pitch (e):
 - larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;
 - smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

The footprint must incorporate solder thieves at the downstream end.

- For packages with leads on four sides, the footprint must be placed at a 45° angle to the transport direction of the printed-circuit board. The footprint must incorporate solder thieves downstream and at the side corners.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Typical dwell time of the leads in the wave ranges from 3 to 4 seconds at 250 °C or 265 °C, depending on solder material applied, SnPb or Pb-free respectively.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

20.4 Manual soldering

Fix the component by first soldering two diagonally-opposite end leads. Use a low voltage (24 V or less) soldering iron applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C.

When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

20.5 Package related soldering information

Table 47: Suitability of surface mount IC packages for wave and reflow soldering methods

| Package ^[1] | Soldering method | |
|--|-----------------------------------|-----------------------|
| | Wave | Reflow ^[2] |
| BGA, HTSSON..T ^[3] , LBGA, LFBGA, SQFP, SSOP..T ^[3] , TFBGA, USON, VFBGA | not suitable | suitable |
| DHVQFN, HBCC, HBGA, HLQFP, HSO, HSOP, HSQFP, HSSON, HTQFP, HTSSOP, HVQFN, HVSON, SMS | not suitable ^[4] | suitable |
| PLCC ^[5] , SO, SOJ | suitable | suitable |
| LQFP, QFP, TQFP | not recommended ^{[5][6]} | suitable |
| SSOP, TSSOP, VSO, VSSOP | not recommended ^[7] | suitable |
| CWQCCN..L ^[8] , PMFP ^[9] , WQCCN..L ^[8] | not suitable | not suitable |

[1] For more detailed information on the BGA packages refer to the *(LF)BGA Application Note* (AN01026); order a copy from your Philips Semiconductors sales office.

[2] All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect). For details, refer to the Drypack information in the *Data Handbook IC26; Integrated Circuit Packages; Section: Packing Methods*.

- [3] These transparent plastic packages are extremely sensitive to reflow soldering conditions and must on no account be processed through more than one soldering cycle or subjected to infrared reflow soldering with peak temperature exceeding $217\text{ °C} \pm 10\text{ °C}$ measured in the atmosphere of the reflow oven. The package body peak temperature must be kept as low as possible.
- [4] These packages are not suitable for wave soldering. On versions with the heatsink on the bottom side, the solder cannot penetrate between the printed-circuit board and the heatsink. On versions with the heatsink on the top side, the solder might be deposited on the heatsink surface.
- [5] If wave soldering is considered, then the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.
- [6] Wave soldering is suitable for LQFP, QFP and TQFP packages with a pitch (e) larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.
- [7] Wave soldering is suitable for SSOP, TSSOP, VSO and VSOP packages with a pitch (e) equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.5 mm.
- [8] Image sensor packages in principle should not be soldered. They are mounted in sockets or delivered pre-mounted on flex foil. However, the image sensor package can be mounted by the client on a flex foil by using a hot bar soldering process. The appropriate soldering profile can be provided on request.
- [9] Hot bar soldering or manual soldering is suitable for PMFP packages.

21. Revision history

Table 48: Revision history

| Rev | Date | CPCN | Description |
|-----|----------|------|--|
| 02 | 20040504 | - | Product data (9397 750 11689) Modifications: <ul style="list-style-type: none"> • Removed information on bus-power and hybrid-power • Changed active LOW pin symbol representation from overscore (for example, $\overline{\text{NAME}}$) to underscore N (NAME_N) • Globally changed $V_{CC(5V0)}$ to $V_{REF(5V0)}$ • Table 2: updated • Updated Section 9.1.3 • Updated Table 7 • Table 34 and Table 35: changed the value of $V_{REF(5V0)}$ • Globally changed the value of T_{amb} • Table 36: removed $I_{CC(5V0)}$ • Updated Figure 16 • Updated Figure 19 and Figure 20. |
| 01 | 20030625 | - | Preliminary data (9397 750 10689) |

22. Data sheet status

| Level | Data sheet status ^[1] | Product status ^{[2][3]} | Definition |
|-------|----------------------------------|----------------------------------|--|
| I | Objective data | Development | This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice. |
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[2] The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL <http://www.semiconductors.philips.com>.

[3] For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

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