# ISP1521

## Hi-Speed USB hub controller

**Rev. 07 — 4 February 2010**

## 1. General description

The ISP1521 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 ISP1521 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 ISP1521 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 ISP1521 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 ISP1521 has seven downstream facing ports. If not used, ports 3 to 7 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 $I^2C$-bus EEPROM or a microcontroller.

The ISP1521 is suitable for self-powered hub designs.

An analog overcurrent detection circuitry is built into the ISP1521, 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 ISP1521 are monitor hubs, docking stations for notebooks, internal USB hub for motherboards, hub for extending Intel Easy PCs, hub boxes, and so on.

## 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
- Configurable number of ports
- Internal Power-On Reset (POR) and low voltage reset circuit
- Port status indicators
- Integrates high performance USB interface device with hub handler, ST-Ericsson Serial Interface Engine (SIE) and transceivers
- Built-in overcurrent detection circuit
- Individual or ganged power switching, individual or global overcurrent protection, and nonremovable port support by I/O pins configuration
- Simple I$^2$C-bus (master or 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[1]) for the upstream facing port
- Uses 12 MHz crystal oscillator with on-chip Phase-Locked Loop (PLL) for low ElectroMagnetic Interference (EMI)
- Supports temperature range from −40 °C to +70 °C
- Available in LQFP80 package

## 3. Applications

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

## 4. Ordering information

**Table 1. Ordering information**

| Commercial product code | Package description | Packing | Minimum sellable quantity |
|---|---|---|---|
| ISP1521BEUM | LQFP80; 80 leads; body 12 × 12 × 1.4 (mm) | 13 inch tape and reel dry pack | 1000 pieces |

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1. GoodLink is a trademark of ST-Ericsson.
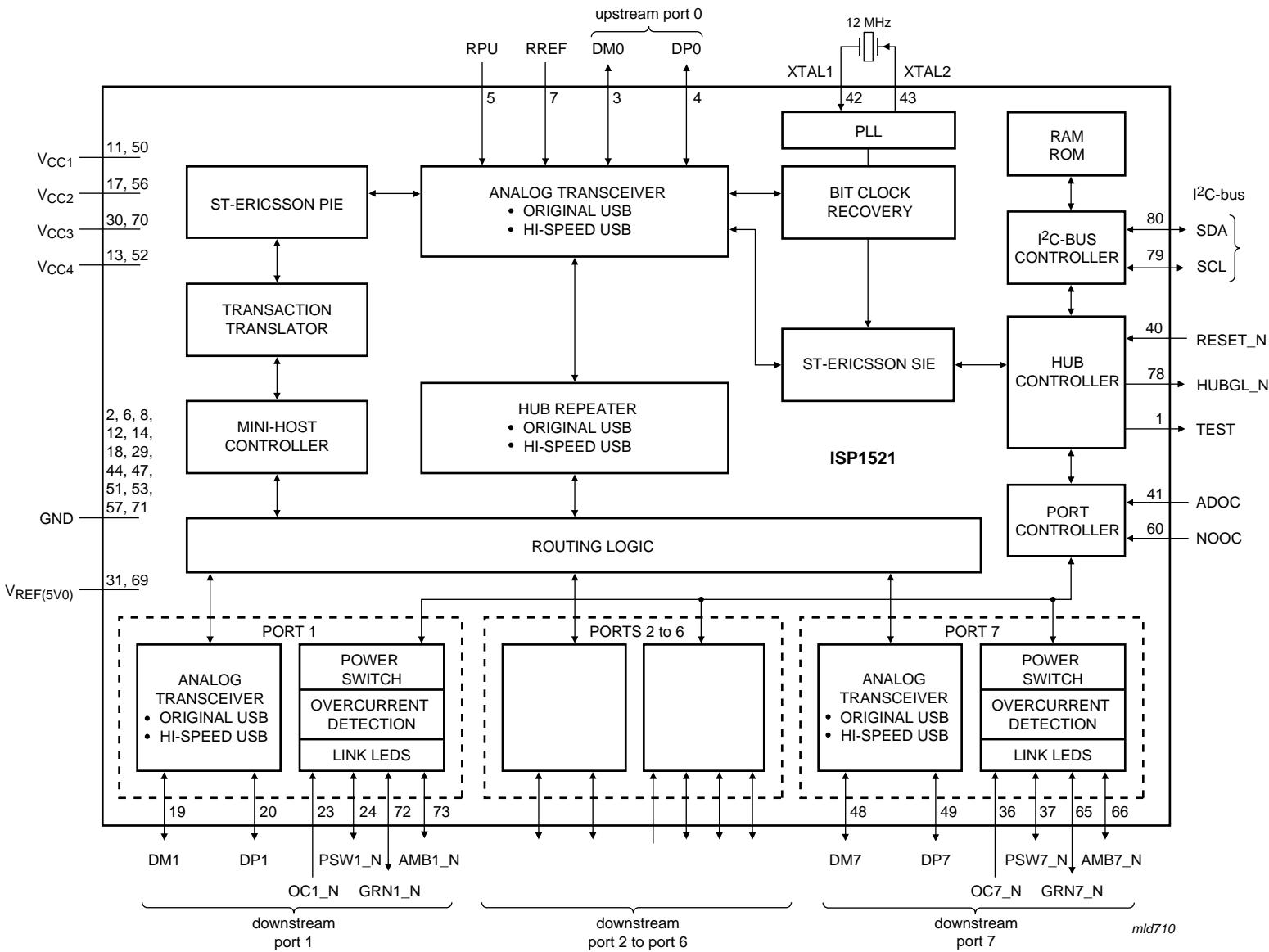
**Fig 1.    Block diagram**

# 6. Pinning information

## 6.1 Pinning
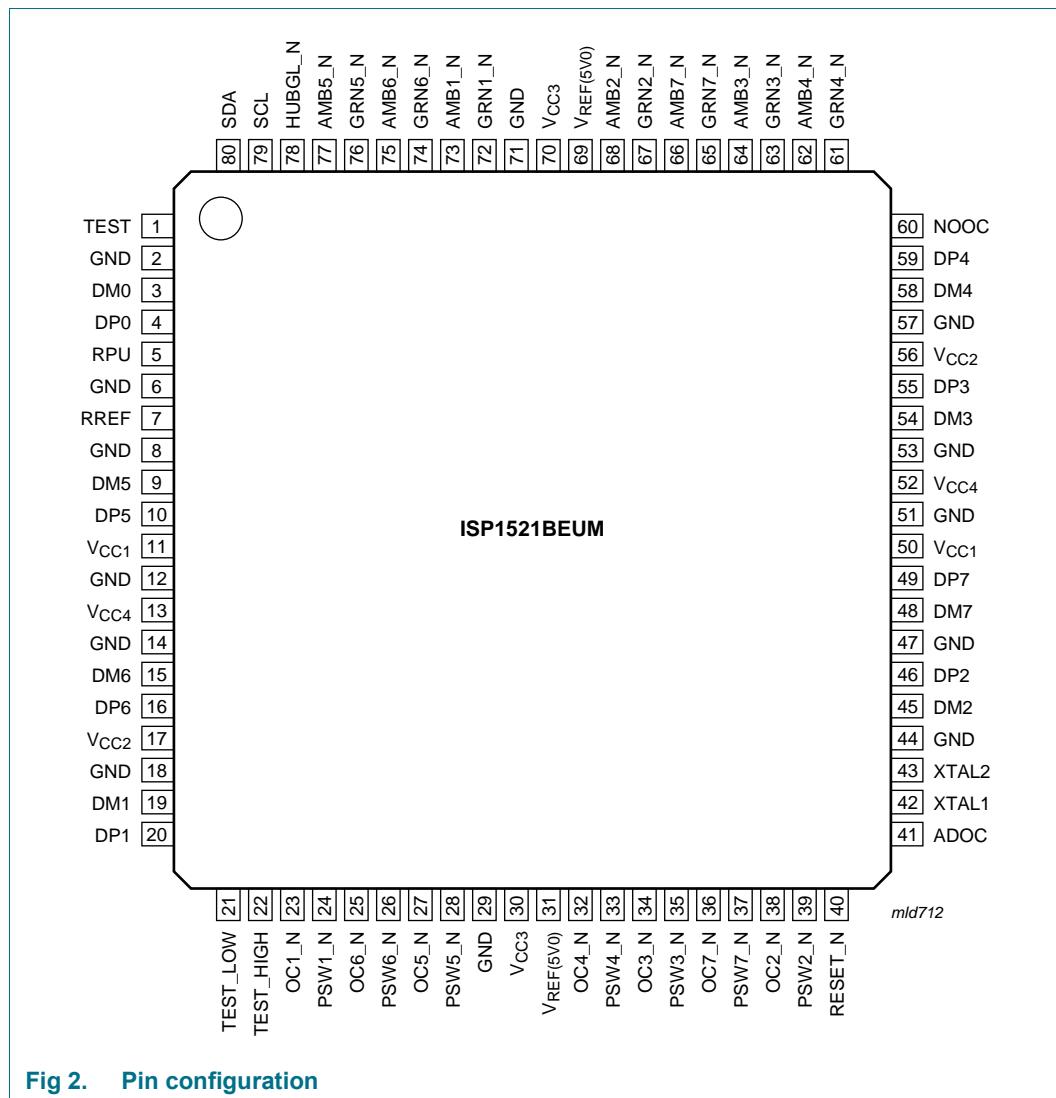


**Fig 2.    Pin configuration**

## 6.2 Pin description

**Table 2.    Pin description**

| Symbol[1] | Pin | Type | Description[2] |
|---|---|---|---|
| TEST | 1 | - | connect to ground through a 100 kΩ resistor |
| GND | 2 | - | ground supply |
| DM0 | 3 | AI/O | upstream facing port 0 D− connection (analog) |
| DP0 | 4 | AI/O | upstream facing port 0 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** ...continued

| Symbol[1] | Pin | Type | Description[2] |
|---|---|---|---|
| RREF | 7 | AI | reference resistor connection; connect this pin through a resistor of 12 k$\Omega$ $\pm$ 1 % to an analog band gap ground reference |
| GND | 8 | - | ground supply |
| DM5 | 9 | AI/O | downstream facing port 5 D– connection (analog)[3] |
| DP5 | 10 | AI/O | downstream facing port 5 D+ connection (analog)[3] |
| $V_{CC1}$ | 11 | - | supply voltage 1 (3.3 V) (analog) |
| GND | 12 | - | ground supply |
| $V_{CC4}$ | 13 | - | supply voltage 4 (3.3 V) (crystal and PLL) |
| GND | 14 | - | ground supply |
| DM6 | 15 | AI/O | downstream facing port 6 D– connection (analog)[3] |
| DP6 | 16 | AI/O | downstream facing port 6 D+ connection (analog)[3] |
| $V_{CC2}$ | 17 | - | supply voltage 2 (3.3 V) (transceiver) |
| GND | 18 | - | ground supply |
| DM1 | 19 | AI/O | downstream facing port 1 D– connection (analog)[4] |
| DP1 | 20 | AI/O | downstream facing port 1 D+ connection (analog)[4] |
| TEST_LOW | 21 | - | connect to GND |
| TEST_HIGH | 22 | - | connect to 5.0 V through a 10 k$\Omega$ resistor |
| OC1_N | 23 | AI/I | overcurrent sense input for downstream facing port 1 (analog/digital) |
| PSW1_N | 24 | I/O | **output —** power switch control output (open-drain) with an internal pull-up resistor for downstream facing port 1<br>**input —** function of the pin when used as an input is given in Table 5 |
| OC6_N | 25 | AI/I | overcurrent sense input for downstream facing port 6 (analog/digital) |
| PSW6_N | 26 | I/O | **output —** power switch control output (open-drain) with an internal pull-up resistor for downstream facing port 6<br>**input —** function of the pin when used as an input is given in Table 5 |
| OC5_N | 27 | AI/I | overcurrent sense input for downstream facing port 5 (analog/digital) |
| PSW5_N | 28 | I/O | **output —** power switch control output (open-drain) with an internal pull-up resistor for downstream facing port 5<br>**input —** function of the pin when used as an input is given in Table 5 |
| GND | 29 | - | ground supply |
| $V_{CC3}$ | 30 | - | supply voltage 3 (3.3 V) (digital) |
| $V_{REF(5V0)}$ | 31 | - | reference voltage (5 V $\pm$ 5 %); used to power internal pull-up resistors of PSWn_N pins and also for the analog overcurrent detection |
| OC4_N | 32 | AI/I | overcurrent sense input for downstream facing port 4 (analog/digital) |

**Table 2.**  **Pin description** *…continued*

| Symbol[1] | Pin | Type | Description[2] |
|---|---|---|---|
| PSW4_N | 33 | I/O | **output —** power switch control output (open-drain) with an internal pull-up resistor for downstream facing port 4<br>**input —** function of the pin when used as an input is given in Table 5 |
| OC3_N | 34 | AI/I | overcurrent sense input for downstream facing port 3 (analog/digital) |
| PSW3_N | 35 | I/O | **output —** power switch control output (open-drain) with an internal pull-up resistor for downstream facing port 3<br>**input —** function of the pin when used as an input is given in Table 5 |
| OC7_N | 36 | AI/I | overcurrent sense input for downstream facing port 7 (analog/digital) |
| PSW7_N | 37 | I/O | **output —** power switch control output (open-drain) with an internal pull-up resistor for downstream facing port 7<br>**input —** function of the pin when used as an input is given in Table 5 |
| OC2_N | 38 | AI/I | overcurrent sense input for downstream facing port 2 (analog/digital) |
| PSW2_N | 39 | I/O | **output —** power switch control output (open-drain) with an internal pull-up resistor for downstream facing port 2<br>**input —** function of the pin when used as an input is given in Table 5 |
| RESET_N | 40 | I | asynchronous reset input; when reset is active, the internal switch to the 1.5 kΩ external resistor is opened, and all pins DPn and DMn are 3-state; it is recommended that you connect to any one of the 3.3 V $V_{CC}$ pins through an RC circuit; refer to the schematics in *ISP1521 Hi-Speed USB hub demo board user manual (UM10011)* |
| ADOC | 41 | I | analog or digital overcurrent detect selection input; LOW selects digital mode and HIGH (3.3 V or 5.0 V) selects analog mode |
| XTAL1 | 42 | I | crystal oscillator input (12 MHz) |
| XTAL2 | 43 | O | crystal oscillator output (12 MHz) |
| GND | 44 | - | ground supply |
| DM2 | 45 | AI/O | downstream facing port 2 D– connection (analog)[4] |
| DP2 | 46 | AI/O | downstream facing port 2 D+ connection (analog)[4] |
| GND | 47 | - | ground supply |
| DM7 | 48 | AI/O | downstream facing port 7 D– connection (analog)[3] |
| DP7 | 49 | AI/O | downstream facing port 7 D+ connection (analog)[3] |
| $V_{CC1}$ | 50 | - | supply voltage 1 (3.3 V) (analog) |
| GND | 51 | - | ground supply |
| $V_{CC4}$ | 52 | - | supply voltage 4 (3.3 V) (crystal and PLL) |
| GND | 53 | - | ground supply |
| DM3 | 54 | AI/O | downstream facing port 3 D– connection (analog)[3] |
| DP3 | 55 | AI/O | downstream facing port 3 D+ connection (analog)[3] |
| $V_{CC2}$ | 56 | - | supply voltage 2 (3.3 V) (transceiver) |
| GND | 57 | - | ground supply |

CD00222695

**Product data sheet**     **Rev. 07 — 4 February 2010**     **6 of 53**

**Table 2.** **Pin description** …*continued*

| Symbol[1] | Pin | Type | Description[2] |
|---|---|---|---|
| DM4 | 58 | AI/O | downstream facing port 4 D− connection (analog)[3] |
| DP4 | 59 | AI/O | downstream facing port 4 D+ connection (analog)[3] |
| NOOC | 60 | 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 pins must be connected to $V_{REF(5V0)}$ |
| GRN4_N | 61 | I/O | **output —** green LED port indicator (open-drain) for downstream facing port 4<br><br>**input —** function of the pin when used as an input is given in Table 9 |
| AMB4_N | 62 | I/O | **output —** amber LED port indicator (open-drain) for downstream facing port 4<br><br>**input —** function of the pin when used as an input is given in Table 8 |
| GRN3_N | 63 | I/O | **output —** green LED port indicator (open-drain) for downstream facing port 3<br><br>**input —** function of the pin when used as an input is given in Table 9 |
| AMB3_N | 64 | I/O | **output —** amber LED port indicator (open-drain) for downstream facing port 3<br><br>**input —** function of the pin when used as an input is given in Table 8 |
| GRN7_N | 65 | I/O | **output —** green LED port indicator (open-drain) for downstream facing port 7<br><br>**input —** function of the pin when used as an input is given in Table 9 |
| AMB7_N | 66 | I/O | **output —** amber LED port indicator (open-drain) for downstream facing port 7<br><br>**input —** function of the pin when used as an input is given in Table 8 |
| GRN2_N | 67 | I/O | **output —** green LED port indicator (open-drain) for downstream facing port 2<br><br>**input —** function of the pin when used as an input is given in Table 9 |
| AMB2_N | 68 | I/O | **output —** amber LED port indicator (open-drain) for downstream facing port 2<br><br>**input —** function of the pin when used as an input is given in Table 8 |
| $V_{REF(5V0)}$ | 69 | - | reference voltage (5 V $\pm$ 5 %); used to power internal pull-up resistors of PSWn_N pins and also for the analog overcurrent detection |
| $V_{CC3}$ | 70 | - | supply voltage 3 (3.3 V) (digital) |
| GND | 71 | - | ground supply |
| GRN1_N | 72 | I/O | **output —** green LED port indicator (open-drain) for downstream facing port 1<br><br>**input —** function of the pin when used as an input is given in Table 9 |

**Table 2.** **Pin description** *…continued*

| Symbol[1] | Pin | Type | Description[2] |
|---|---|---|---|
| AMB1_N | 73 | 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 |
| GRN6_N | 74 | I/O | **output —** green LED port indicator (open-drain) for downstream facing port 6 |
| | | | **input —** function of the pin when used as an input is given in Table 9 |
| AMB6_N | 75 | I/O | **output —** amber LED port indicator (open-drain) for downstream facing port 6 |
| | | | **input —** function of the pin when used as an input is given in Table 8 |
| GRN5_N | 76 | I/O | **output —** green LED port indicator (open-drain) for downstream facing port 5 |
| | | | **input —** function of the pin when used as an input is given in Table 9 |
| AMB5_N | 77 | I/O | **output —** amber LED port indicator (open-drain) for downstream facing port 5 |
| | | | **input —** function of the pin when used as an input is given in Table 8 |
| HUBGL_N | 78 | 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 |
| SCL | 79 | I/O | $I^2C$-bus clock (open-drain); see Table 11 |
| SDA | 80 | I/O | $I^2C$-bus data (open-drain); see Table 11 |

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

[2] The maximum current the ISP1521 can sink on a pin is 8 mA.

[3] 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 7.

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

# 7. Functional description

## 7.1 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).

## 7.2 Hub controller core

The main components of the hub core are:

- ST-Ericsson Serial Interface Engine (SIE)
- Routing logic
- Transaction Translator (TT)
- Mini-Host Controller
- Hub repeater
- Hub controller
- Port controller
- Bit clock recovery.

### 7.2.1 ST-Ericsson serial interface engine

The ST-Ericsson Serial Interface Engine (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 (PID) verification and generation, address recognition, and handshake evaluation and generation.

### 7.2.2 Routing logic

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

### 7.2.3 Transaction translator

The Transaction Translator (TT) acts as a go-between mechanism that links devices operating in Original USB mode and 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.

### 7.2.4 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 high-speed mode. The responses from the Original USB devices are collected in TT buffers, until the end of the complete split transaction clears TT buffers.

### 7.2.5 Hub repeater

A hub repeater manages connectivity on a per packet basis. It implements packet signaling connectivity and resume connectivity. There are two repeaters in the ISP1521: 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 an Original USB hub.

### 7.2.6 Hub and port controllers

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

### 7.2.7 Bit clock recovery

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

## 7.3 Phase-locked loop clock multiplier

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

## 7.4 I$^2$C-bus controller

A simple serial I$^2$C-bus interface is provided to transfer vendor ID, product ID and string descriptor from an external I$^2$C-bus EEPROM or microcontroller. A master/slave I$^2$C-bus protocol is implemented according to timing requirements as mentioned in I$^2$C-bus standard specifications. The maximum data count during I$^2$C-bus transfers for the ISP1521 is 256 bytes.

## 7.5 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.

## 7.6 GoodLink

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

During enumeration, the LED momentarily blinks on. 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.

## 7.7 Power-on reset

The ISP1521 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 $\mu$s.
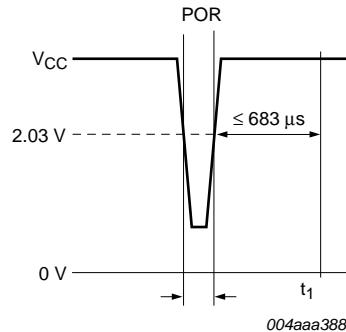


At $t_1$: clock is running and available.

**Fig 3.    Power-on reset timing**
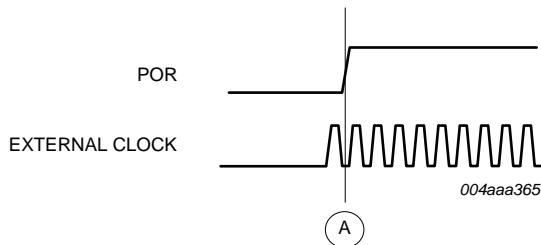


Stable external clock is to be available at A.

**Fig 4.    External clock with respect to power-on reset**

# 8. Configuration selections

The ISP1521 is configured through I/O pins and, optionally, through an external $I^2C$-bus, in which case the hub can update its configuration descriptors as a master or as a slave.

Table 3 shows 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<br>3 ports<br>4 ports<br>5 ports<br>6 ports<br>7 ports | DM1/DP1 to DM7/DP7 | see Section 8.1.1 | bNbrPorts0 | see Table 22 |
| Power switching mode | none<br>ganged<br>multiple ganged[1]<br>individual | PSW1_N to PSW7_N | see Section 8.1.2 | wHubCharacteristics: bits D1 and D0<br><br>bPwrOn2PwrGood: time interval | see Table 22 |
| Overcurrent protection mode | none<br>global[2]<br>multiple ganged<br>individual | NOOC and OC1_N to OC7_N | see Section 8.1.3 | wHubCharacteristics: bits D4 and D3 | see Table 22 |
| Nonremovable ports | any port can be nonremovable | AMBn_N | see Section 8.1.4 | wHubCharacteristics: bit D2 (compound hub)<br><br>DeviceRemovable: bit map | see Table 22 |
| Port indicator support | no<br>yes | all GRNn_N | see Section 8.1.5 | wHubCharacteristics: bit D7 | see Table 22 |

[1]   Multiple ganged power mode is reported as individual power mode; refer to *Universal Serial Bus Specification Rev. 2.0*.

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

CD00222695

**Product data sheet**                    **Rev. 07 — 4 February 2010**                    **12 of 53**

## 8.1 Configuration through I/O pins

### 8.1.1 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 (7); see Table 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 | DM5/DP5 | DM6/DP6 | DM7/DP7 |
|---|---|---|---|---|---|---|---|
| 7 | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down |
| 6 | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | $V_{CC}$ |
| 5 | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | $V_{CC}$ | $V_{CC}$ |
| 4 | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | $V_{CC}$ | $V_{CC}$ | $V_{CC}$ |
| 3 | 15 kΩ pull-down | 15 kΩ pull-down | 15 kΩ pull-down | $V_{CC}$ | $V_{CC}$ | $V_{CC}$ | $V_{CC}$ |
| 2 | 15 kΩ pull-down | 15 kΩ pull-down | $V_{CC}$ | $V_{CC}$ | $V_{CC}$ | $V_{CC}$ | $V_{CC}$ |

### 8.1.2 Power switching

Power switching of downstream ports can be done **individually** or **ganged**, where all ports are simultaneously switched with one power switch. The ISP1521 supports both modes, which can be selected using input PSWn_N; see Table 5.

#### 8.1.2.1 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. 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.

The PCB resistance may cause a drop of 25 mV, which leaves 75 mV for the power switch and overcurrent sense device.
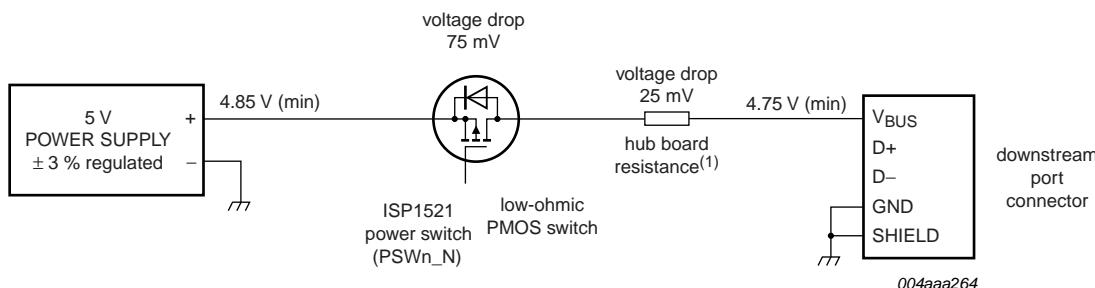


(1)    Includes PCB traces, ferrite beads, and so on.

**Fig 5.    Typical voltage drop components in self-powered mode using individual overcurrent detection**
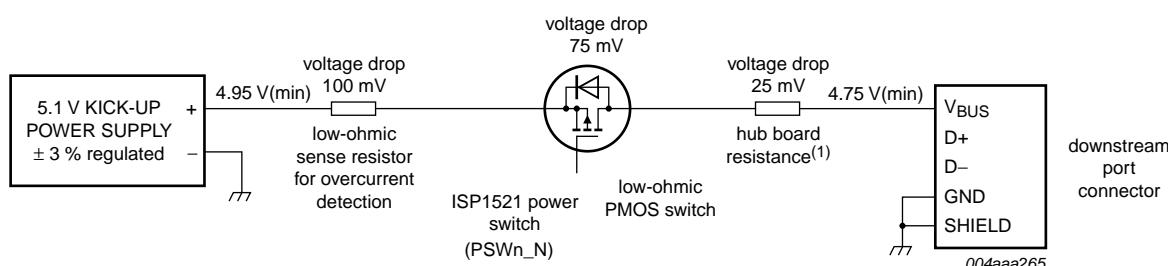


(1)    Includes PCB traces, ferrite beads, and so on.

**Fig 6.    Typical voltage drop components in self-powered mode using global overcurrent detection**

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 | PSW5_N | PSW6_N | PSW7_N |
|---|---|---|---|---|---|---|---|
| None | ground | ground | ground | ground | ground | ground | ground |
| Ganged | internal pull-up | ground | ground | ground | ground | ground | ground |
| Individual | internal pull-up | internal pull-up | internal pull-up | internal pull-up | internal pull-up | internal pull-up | internal pull-up |

### 8.1.3  Overcurrent protection mode

The ISP1521 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 power switching modes selection scheme; see Table 6.

For 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, 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 | PSW5_N | PSW6_N | PSW7_N |
|---|---|---|---|---|---|---|---|---|
| None | HIGH | ground | ground | ground | ground | ground | ground | ground |
| Global | LOW | internal pull-up | ground | ground | ground | ground | ground | ground |
| Individual | LOW | internal pull-up | internal pull-up | internal pull-up | 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 overcurrent input pins. For analog overcurrent detection, the threshold is given in Section 14. In this mode, to filter out false overcurrent conditions because of in rush 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 or 5.0 V | analog | threshold $\Delta V_{trip}$ |
| Ground | digital | normal digital TTL level |

### 8.1.4  Nonremovable port

A nonremovable 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 nonremovable; see Table 8.

More than one nonremovable 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 nonremovable port sets the hub descriptor to a compound hub.

**Table 8.    Nonremovable port pin configuration**

| AMBn_N (n = 1 to 7) | Nonremovable port |
|---|---|
| Ground | nonremovable |
| Pull-up with amber LED | removable |

### 8.1.5  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. You cannot disable port indicators for only one port.

**Table 9.    Port indicator support: pin configuration**

| GRN1_N to GRN7_N | Port indicator support |
|---|---|
| Ground | not supported |
| LED pull-up green LED for at least one port | supported |

## 8.2    Device descriptors and string descriptors settings using I$^2$C-bus

### 8.2.1    Background information on I$^2$C-bus

The I$^2$C-bus is suitable for bidirectional communication between ICs or modules. It consists of two bidirectional 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 I$^2$C-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.

#### 8.2.1.1    Different conditions on I$^2$C-bus

The I$^2$C-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.

#### 8.2.1.2    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 acknowledgment is done by pulling the SDA line LOW on the ninth bit of the data. An extra clock pulse must be generated by the master to accommodate this bit.

For details on the operation of the bus, refer to *The I$^2$C-bus specification*.

#### 8.2.1.3    I$^2$C-bus address

The address of the ISP1521 is given in Table 10.

**Table 10.    I$^2$C-bus slave address**

| Bit | MSB | Slave address | | | | | LSB | Write |
|---|---|---|---|---|---|---|---|---|
| | A7 | A6 | A5 | A4 | A3 | A2 | A1 | |
| **Value** | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |

### 8.2.2 Architecture of configurable hub descriptors
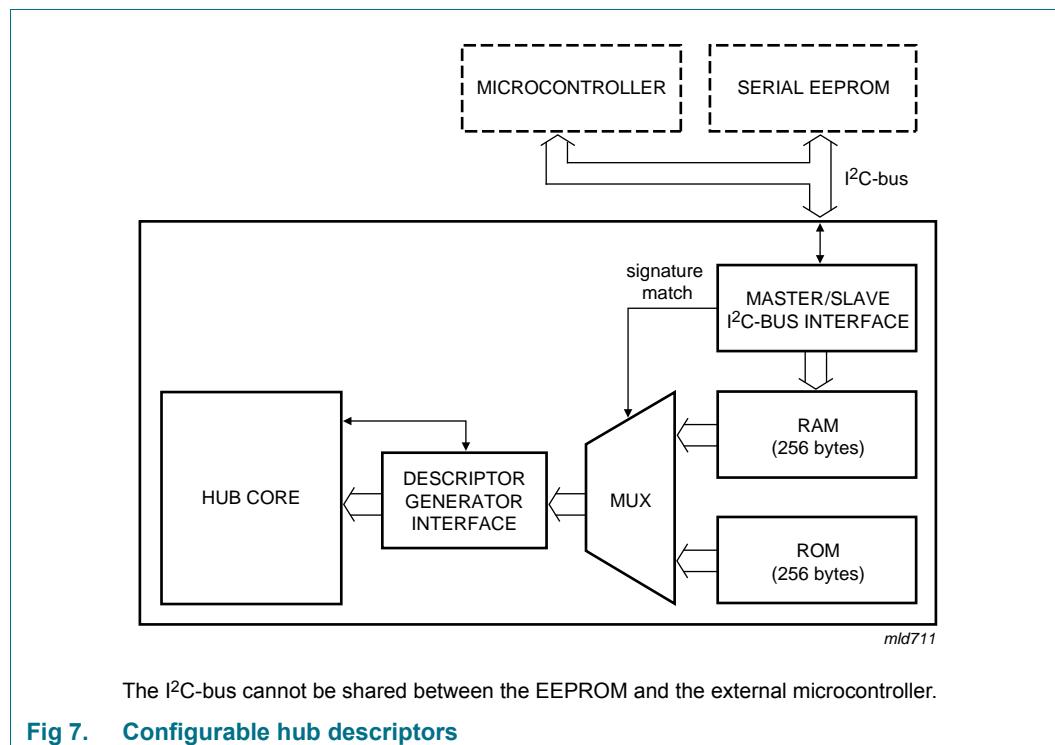


The I$^2$C-bus cannot be shared between the EEPROM and the external microcontroller.

**Fig 7.    Configurable hub descriptors**

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 ISP1521 implements both the master and slave I$^2$C-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 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 kΩ-to-4.7 kΩ pull-up | 2.2 kΩ-to-4.7 kΩ pull-up |
| External microcontroller | driven LOW by the microcontroller during reset | 2.2 kΩ-to-4.7 kΩ pull-up |

### 8.2.3 ROM or EEPROM map
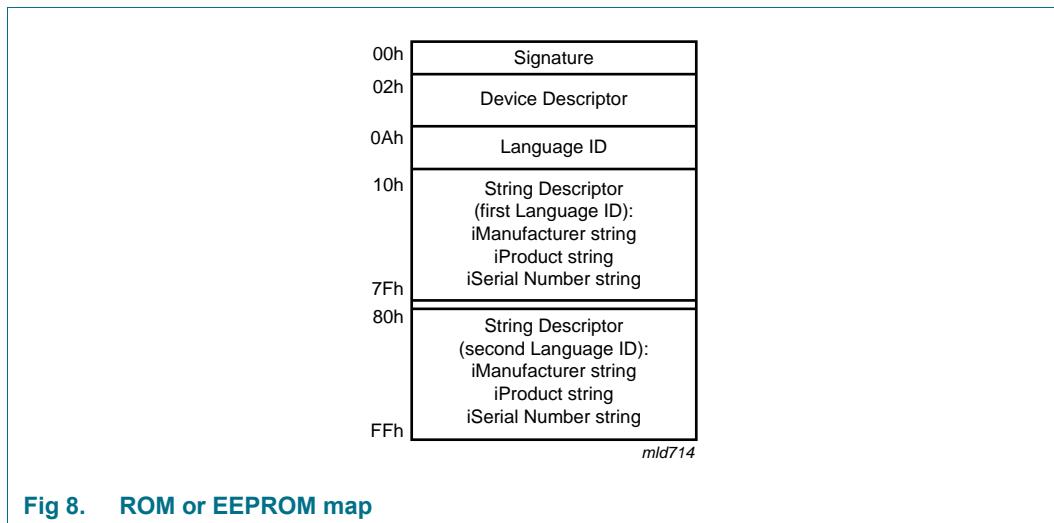


**Fig 8. ROM or EEPROM map**

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

### 8.2.4 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 | - | ST-Ericsson vendor ID |
| 03 | idVendor (high) | 04 | - | |
| 04 | idProduct (low) | 21 | - | ISP1521 product ID |
| 05 | idProduct (high) | 15 | - | |
| 06 | bcdDevice (low) | 00 | - | device release; silicon revision increments this value |
| 07 | bcdDevice (high) | 02 | - | |
| 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 |
| 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 | |

**Table 12.    ROM or EEPROM detailed map** …continued

| Address (hex) | Content | Default (hex) | Example (hex) | Comment |
|---|---|---|---|---|
| **String descriptor Index 1 (iManufacturer)[3]** | | | | |
| 10 | bLength | - | 2E | string descriptor length (manufacturer ID) |
| 11 | bDescriptorType | - | 03[2] | STRING |
| 12 13 | bString | - | 53 00 | S of ST-Ericsson |
| 14 15 | | - | 54 00 | T |
| 16 17 | | - | 2D 00 | - |
| 18 19 | | - | 45 00 | E |
| 1A 1B | | - | 72 00 | r |
| 1C 1D | | - | 69 00 | i |
| 1E 1F | | - | 63 00 | c |
| 20 21 | | - | 73 00 | s |
| 22 23 | | - | 73 00 | s |
| 24 25 | | - | 6F 00 | o |
| 26 27 | | - | 6E 00 | n |
| 28 29 | | - | FF FF | |
| 2A 2B | | - | FF FF | |
| 2C 2D | | - | FF FF | |
| 2E 2F | | - | FF FF | |
| 30 31 | | - | FF FF | |
| 32 33 | | - | FF FF | |
| 34 35 | | - | FF FF | |
| 36 37 | | - | FF FF | |
| 38 39 | | - | FF FF | |
| 3A 3B | | - | FF FF | |
| 3C 3D | | - | FF FF | |
| **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 ISP1521 |
| 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 | | - | 31 00 | 1 |
| **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 |

**Table 12.   ROM or EEPROM detailed map** *…continued*

| Address (hex) | Content | Default (hex) | Example (hex) | Comment |
|---|---|---|---|---|
| 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 |
| **String descriptor Index 1 (iManufacturer) second language** | | | | |
| 88 | bLength | - | 2E | string descriptor length (manufacturer ID) |
| 89 | bDescriptorType | - | 03[2] | STRING |
| 8A 8B | bString | - | 53 00 | S of ST-Ericsson |
| 8C 8D | | - | 54 00 | T |
| 8E 8F | | - | 2D 00 | - |
| 90 91 | | - | 45 00 | E |
| 92 93 | | - | 72 00 | r |
| 94 95 | | - | 69 00 | i |
| 96 97 | | - | 63 00 | c |
| 98 99 | | - | 73 00 | s |
| 9A 9B | | - | 73 00 | s |
| 9C 9D | | - | 6F 00 | o |

**Table 12.    ROM or EEPROM detailed map** *…continued*

| Address (hex) | Content | Default (hex) | Example (hex) | Comment |
|---|---|---|---|---|
| 9E 9F | | - | 6E 00 | n |
| A0 A1 | | - | FF FF | |
| A2 A3 | | - | FF FF | |
| A4 A5 | | - | FF FF | |
| A6 A7 | | - | FF FF | |
| A8 A9 | | - | FF FF | |
| AA AB | | - | FF FF | |
| AC AD | | - | FF FF | |
| AE AF | | - | FF FF | |
| B0 B1 | | - | FF FF | |
| B2 B3 | | - | FF FF | |
| B4 B5 | | - | FF FF | |
| **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 ISP1521 |
| 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 | | - | 31 00 | 1 |
| **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 6565943193 |
| CA CB | | - | 35 00 | 5 |
| CC CD | | - | 36 00 | 6 |
| CE CF | | - | 35 00 | 5 |
| D0 D1 | | - | 39 00 | 9 |
| D2 D3 | | - | 34 00 | 4 |
| D4 D5 | | - | 33 00 | 3 |
| D6 D7 | | - | 31 00 | 1 |
| D8 D9 | | - | 39 00 | 9 |
| DA DB | | - | 33 00 | 3 |
| DC DD | | - | FF FF | |
| DE DF | | - | FF FF | |
| E0 E1 | | - | FF FF | |
| E2 E3 | | - | FF FF | |
| E4 E5 | | - | FF FF | |

**Table 12.    ROM or EEPROM detailed map** *…continued*

| Address (hex) | Content | Default (hex) | Example (hex) | Comment |
|---|---|---|---|---|
| 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 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 address 0Eh for one language ID support and 10h for two languages ID support.

# 9. 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 ISP1521 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 7 | 0 | control | OUT | 64 |
|  |  |  | IN | 64 |
|  | 1 | interrupt | IN | 1 |

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

## 9.1 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 ISP1521 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.

## 9.2 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 ISP1521 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 7 | Port n Status Change | 0 | no change in the status of port n (n = 1 to 7) |
| | | 1 | change in the status of port n (n = 1 to 7) |

# 10. Descriptors

The ISP1521 hub controller supports the following standard USB descriptors:

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

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

**Table 15.    Device descriptor**

| Offset (bytes) | Field name | Value (hex) Full-speed | High-speed | Comments |
|----------------|-----------|------------|------------|----------|
| 0 | bLength | 12 | 12 | descriptor length = 18 bytes |
| 1 | bDescriptorType | 01 | 01 | type = DEVICE |
| 2 | bcdUSB | 00 | 00 | refer to *Universal Serial Bus 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 | ST-Ericsson vendor ID (04CC); can be customized |
| 9 | | 04 | 04 | |
| 10 | idProduct | 21 | 21 | the ISP1521 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 | refer to *Universal Serial Bus 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 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 | 07 | 07 | number of enabled downstream facing ports; selectable by the DP/DM strapping |
| | | 06 | 06 | |
| | | 05 | 05 | |
| | | 04 | 04 | |
| | | 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 |
| | | 00 | 00 | no power switching mode = 0 ms |
| 6 | bHubContrCurrent | 64 | 64 | - |
| 7 | DeviceRemovable | 00 | 00 | seven 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 |
| | | 10 | none |
| | | 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 | - |

# 11. 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.

## 11.1  Standard USB requests

Table 23 shows 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 ISP1521 accepts either value.

## 11.2   Hub class requests

Table 24 shows 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[1] | 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[2], 00 | port[3], 00 | 00, 00 | none |
| Set Port Feature | 0010 0011 | 03 | feature[2], 00 | port[3], 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[3], 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 |
| GetTTState | 1010 0011 | 10 | TT-flags | 01, 00 | -[4] | TT state |

**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 |
|---------|---------|---------|---------|---------|---------|------|
| StopTT | 0010 0011 | 11 | 00, 00 | 01, 00 | 00, 00 | none |
| **Test modes** | | | | | | |
| Test_J | 0010 0011 | 03 | 15, 00 | port[3], 01 | 00, 00 | none |
| Test_K | 0010 0011 | 03 | 15, 00 | port[3], 02 | 00, 00 | none |
| Test_SE0_NAK | 0010 0011 | 03 | 15, 00 | port[3], 03 | 00, 00 | none |
| Test_Packet | 0010 0011 | 03 | 15, 00 | port[3], 04 | 00, 00 | none |
| Test_Force_Enable | 0010 0011 | 03 | 15, 00 | port[3], 05 | 00, 00 | none |

[1]   Returned value in bytes.

[2]   Feature selector value; see Table 25.

[3]   Downstream port identifier: 1 to N where N is the number of enabled ports (2 to 7).

[4]   Returns vendor-specific data.

**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 |

## 11.3   Detailed responses to hub requests

### 11.3.1   Get configuration

This request returns the configuration value of the device. This request returns 1 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 | - |

### 11.3.2  Get device status

This request returns 2 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 | - |

### 11.3.3  Get interface status

The request returns 2 bytes of data; see Table 28.

**Table 28.  Get interface status response**

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

### 11.3.4  Get endpoint status

The request returns 2 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 | - |

### 11.3.5  Get hub status

The request returns 4 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 | - |
| 16 | local power status change | 0 | no change in the local power status |
| | | 1 | local power status has changed |

**Table 30. Get hub status response** ...*continued*

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

### 11.3.6 Get port status

This request returns 4 bytes of data. The first word contains port status bits (wPortStatus), and the next word contains 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 port test mode |
| | | 1 | in 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 |

**Table 32.    Get port status change response (wPortChange)** *...continued*

| Bit | Function | Value | Description |
|-----|----------|-------|-------------|
| 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 | - |

## 11.4  Various get descriptors

**bmRequestType —** 1000 0000b

**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 |

## 12. Limiting values

**Table 34. Limiting values**

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

| Symbol | Parameter | Conditions | | Min | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{CC(3V3)}$ | supply voltage (3.3 V) | | | −0.5 | +4.6 | V |
| $V_{REF(5V0)}$ | input reference voltage 5.0 V | | | −0.5 | +6.0 | 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 |
| $V_{I(3V3)}$ | 3.3 V input voltage | $3.0 \text{ V} < V_{CC} < 3.6 \text{ V}$ | | −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 | $V_I < 0 \text{ V or } V_I > V_{CC}$ | | - | 100 | mA |
| $V_{esd}$ | electrostatic discharge voltage | on pins DM1 to DM7, DP1 to DP7, OC1_N to OC7_N, and all $V_{REF(5V0)}$ and GND pins; $I_{LI} < 1 \text{ μA}$ | [2][3] | −4000 | +4000 | V |
| | | on all other pins; $I_{LI} < 1 \text{ μA}$ | [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 through a 1.5 kΩ resistor (Human Body Model).

## 13. Recommended operating conditions

**Table 35. Recommended operating ranges**

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{CC(3V3)}$ | supply voltage (3.3 V) | | | 3.0 | 3.3 | 3.6 | V |
| $V_{REF(5V0)}$ | input reference voltage 5.0 V | | [1] | 4.5 | 5.0 | 5.5 | V |
| $V_{I(3V3)}$ | 3.3 V input voltage | | | 0 | - | $V_{CC}$ | V |
| $V_{I(5V0)}$ | input voltage on 5 V tolerant pins | | | 0 | - | $V_{REF(5V0)}$ | V |
| $T_{amb}$ | ambient temperature | | | −40 | - | +70 | °C |

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

# 14. Static characteristics

**Table 36. Static characteristics: supply pins**

$V_{CC}$ = 3.0 V to 3.6 V; $T_{amb}$ = −40 °C to +70 °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 | $I_{CC(tot)}$ = $I_{CC1}$ + $I_{CC2}$ + $I_{CC3}$ + $I_{CC4}$ | [1][2] | - | 91 | - | mA |
| **High-speed** | | | | | | | |
| $I_{CC(tot)}$ | total supply current | no device connected | [2][3] | - | 183 | - | mA |
| | | one active device connected | | - | 231 | - | mA |
| | | two active devices connected | | - | 276 | - | mA |
| | | three active devices connected | | - | 318 | - | mA |
| | | four active devices connected | | - | 362 | - | mA |
| | | five active devices connected | | - | 400 | - | mA |
| | | six active devices connected | | - | 446 | - | mA |
| | | seven active devices connected | | - | 492 | - | mA |

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

[2] Total supply current for 3.3 V supply voltage.

[3] Including $R_{pu}$ drop current.

**Table 37. Static characteristics: digital input and output**

$V_{CC}$ = 3.0 V to 3.6 V; $T_{amb}$ = −40 °C to +70 °C; unless otherwise specified.[1]

| 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 OC7_N** | | | | | | |
| $\Delta V_{trip}$ | overcurrent detection trip voltage | $\Delta V = V_{BUS} - V_{OCn\_N}$ | 45 | 84 | 110 | 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: I$^2$C-bus interface block**

$V_{CC}$ = 3.0 V to 3.6 V; $T_{amb}$ = –40 °C to +70 °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 |
| $t_f$ | fall time | $C_b$ = 10 pF to 400 pF | [2][3] | - | 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.

[3] Output fall time $V_{IH}$ to $V_{IL}$.

**Table 39.   Static characteristics: USB interface block (DP0 to DP7 and DM0 to DM7)**

$V_{CC}$ = 3.0 V to 3.6 V; $T_{amb}$ = –40 °C to +70 °C; unless otherwise specified.

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **Input levels for high-speed** | | | | | | | |
| $V_{HSSQ}$ | high-speed squelch detection threshold voltage (differential signal amplitude) | squelch detected | | - | - | 100 | mV |
| | | no squelch detected | | 150 | - | - | mV |
| $V_{HSCM}$ | high-speed data signaling common-mode voltage range | | | –50 | - | +500 | mV |
| **Output levels for high-speed** | | | | | | | |
| $V_{HSOI}$ | high-speed idle level | | | –10 | - | +10 | mV |
| $V_{HSOH}$ | high-speed data signaling HIGH-level voltage | | | 360 | - | 440 | mV |
| $V_{HSOL}$ | high-speed data signaling LOW-level voltage | | | –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 | driven | | 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 voltage | | [2] | 1.3 | - | 2.0 | V |
| **Leakage current** | | | | | | | |
| $I_{LZ}$ | off-state leakage current | | | –1 | - | +1 | μA |
| **Capacitance** | | | | | | | |
| $C_{in}$ | input capacitance | pin to GND | | - | - | 20 | pF |

**Table 39.   Static characteristics: USB interface block (DP0 to DP7 and DM0 to DM7)** *…continued*
$V_{CC}$ = 3.0 V to 3.6 V; $T_{amb}$ = −40 ℃ to +70 ℃; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------|-----------|------------|-----|-----|-----|------|
| **Resistance** | | | | | | |
| $Z_{INP}$ | input impedance | | 10 | - | - | MΩ |
| **Termination** | | | | | | |
| $V_{TERM}$ | termination voltage | for pull-up resistor on pin RPU | 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.

# 15. 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 |
| $t_{W(RESET\_N)}$ | external RESET_N pulse width | | 0.2 | - | - | µs |
| **Crystal oscillator** | | | | | | |
| $f_{clk}$ | clock frequency | crystal [1][2] | - | 12 | - | MHz |
| **External clock input** | | | | | | |
| $\delta$ | 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 pF to 27 pF.

**Table 41. Dynamic characteristics: overcurrent sense timing**
$V_{CC}$ = 3.0 V to 3.6 V; $T_{amb}$ = −40 °C to +70 °C; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Overcurrent sense pins OC1_N to OC7_N** | | | | | | |
| $t_{trip}$ | overcurrent trip response time from OCn_N LOW to PSWn_N HIGH | see Figure 9 | - | - | 15 | ms |



Overcurrent input: pins OCn_N; power switch output: pins PSWn_N.

**Fig 9.   Overcurrent trip response timing**
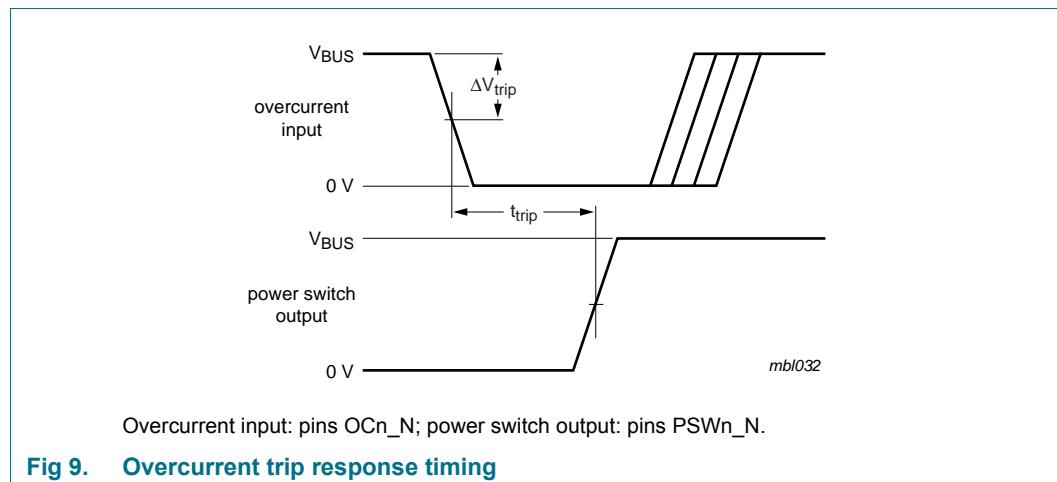
**Table 42. Dynamic characteristics: digital pins**
$V_{CC}$ = 3.0 V to 3.6 V; $T_{amb}$ = −40 °C to +70 °C; unless otherwise specified.[1]

| 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 V to 3.6 V; $T_{amb}$ = −40 °C to +70 °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** | | | | | | |
| $t_{HSDRAT}$ | high-speed 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 V to 3.6 V; $T_{amb}$ = −40 °C to +70 °C; test circuit Figure 22; unless otherwise specified.

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|--------|-----------|-----------|---|-----|-----|-----|------|
| **Driver characteristics** | | | | | | | |
| $t_{FR}$ | rise time | $C_L$ = 50 pF; 10 % to 90 % of $|V_{OH} - V_{OL}|$ | | 4 | - | 20 | ns |
| $t_{FF}$ | fall time | $C_L$ = 50 pF; 90 % to 10 % of $|V_{OH} - V_{OL}|$ | | 4 | - | 20 | ns |
| $t_{FRFM}$ | differential rise and fall time matching | | [1] | 90 | - | 111.1 | % |
| $V_{CRS}$ | output signal crossover voltage | | [1][2] | 1.3 | - | 2.0 | V |
| **Data source timing[2]** | | | | | | | |
| $t_{DJ1}$ | source jitter total (including frequency tolerance) to next transition | see Figure 10 | [1] | −3.5 | - | +3.5 | ns |
| $t_{DJ2}$ | source jitter total (including frequency tolerance) 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 jitter for differential transition to SE0 transition | see Figure 11 | | −2 | - | +5 | ns |
| **Receiver timing[2]** | | | | | | | |
| $t_{JR1}$ | receiver jitter to next transition | see Figure 12 | | −18.5 | - | +18.5 | ns |
| $t_{JR2}$ | receiver jitter for paired transitions | see Figure 12 | | −9 | - | +9 | ns |
| $t_{FEOPR}$ | receiver SE0 interval of EOP | accepted as EOP; see Figure 11 | | 82 | - | - | ns |
| $t_{FST}$ | width of SE0 interval during differential transition | rejected as EOP; see Figure 13 | | - | - | 14 | ns |

**Table 44. Dynamic characteristics: full-speed source electrical characteristics** *…continued*
$V_{CC}$ = 3.0 V to 3.6 V; $T_{amb}$ = −40 °C to +70 °C; test circuit Figure 22; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Hub timing (downstream ports configured as full-speed)[2]** | | | | | | |
| $t_{FHDD}$ | hub differential data delay (without cable) | see Figure 14; $C_L$ = 0 pF | - | - | 44 | ns |
| $t_{FSOP}$ | 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 the idle state.

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

**Table 45. Dynamic characteristics: low-speed source electrical characteristics**
$V_{CC}$ = 3.0 V to 3.6 V; $T_{amb}$ = −40 °C to +70 °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 |
| $t_{LRFM}$ | 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 the idle state.

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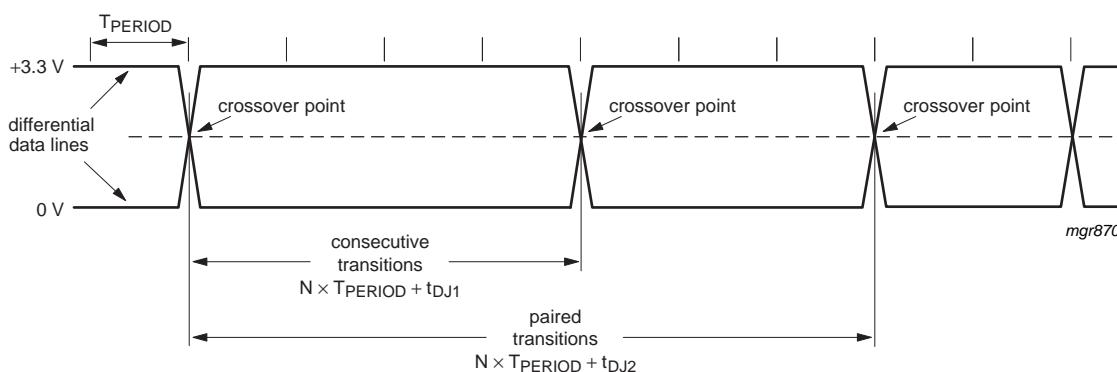


$T_{PERIOD}$ is the bit duration corresponding with the USB data rate.

**Fig 10. Source differential data jitter**
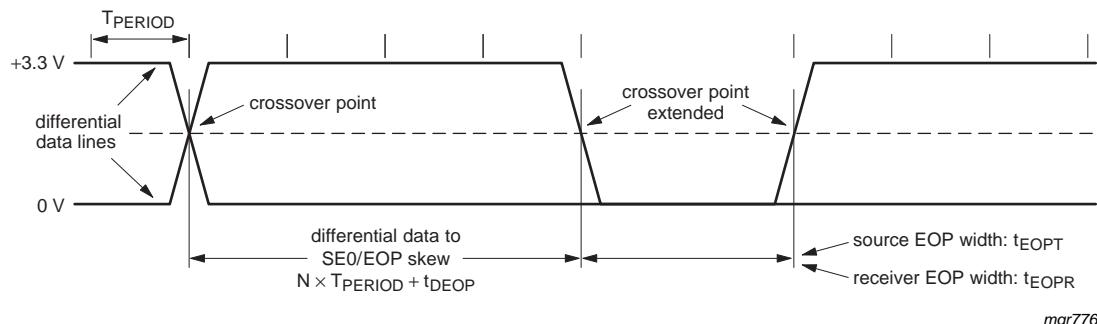
$T_{PERIOD}$ is the bit duration corresponding with the USB data rate.

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**
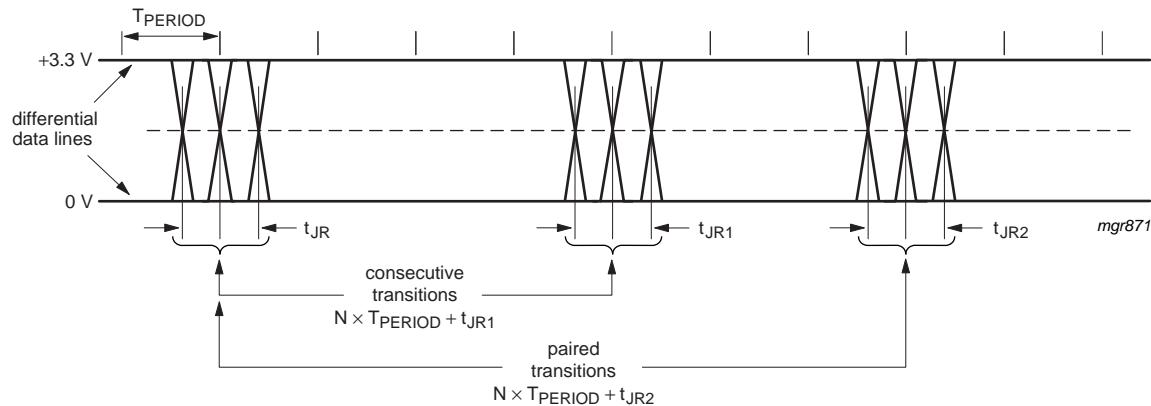


$T_{PERIOD}$ is the bit duration corresponding with the USB data rate.

$t_{JR}$ is the jitter reference point.

**Fig 12.  Receiver differential data jitter**
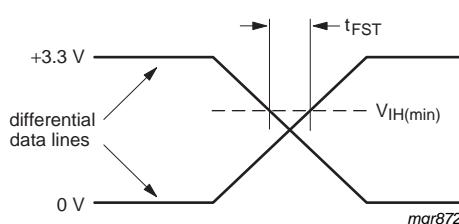


**Fig 13.  Receiver SE0 width tolerance**

SOP distortion:
$t_{SOP} = t_{HDD\ (next\ J)} - t_{HDD(SOP)}$
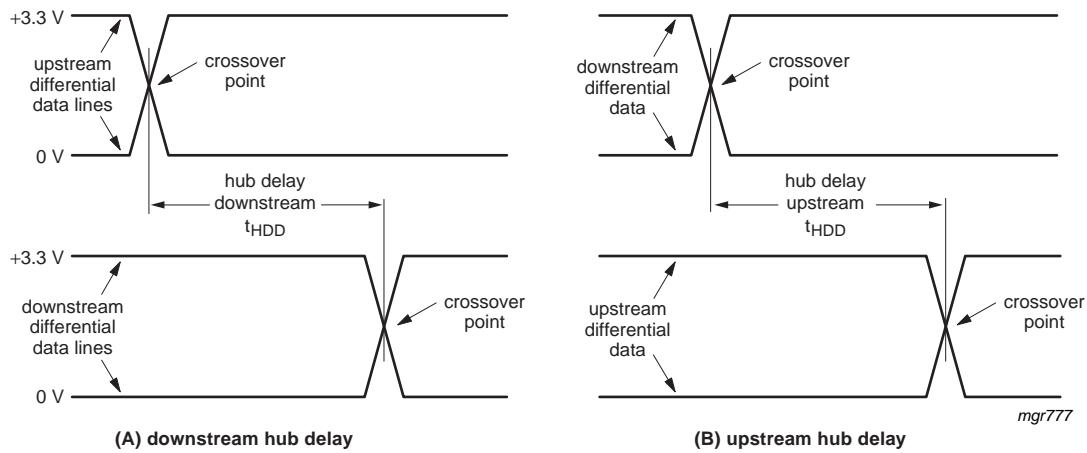
Full-speed timing symbols have a subscript prefix 'F', low-speed timing a prefix 'L'.

**Fig 14. Hub differential data delay and SOP distortion**
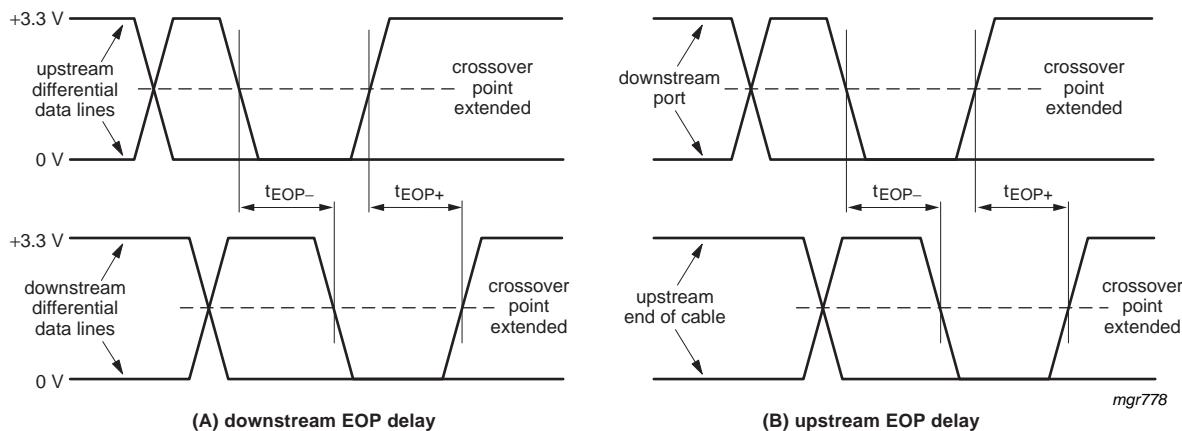


EOP delay:
$t_{EOP} = \max(t_{EOP-}, t_{EOP+})$

EOP delay relative to $t_{HDD}$:
$t_{EOPD} = t_{EOP} - t_{HDD}$

EOP skew:
$t_{HESK} = t_{EOP+} - t_{EOP-}$

Full-speed timing symbols have a subscript prefix 'F', low-speed timing a prefix 'L'.

**Fig 15. Hub EOP delay and EOP skew**

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

$V_{CC}$ and $T_{amb}$ within recommended operating range; $V_{DD} = 5$ 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 | $f_{XTAL} = 12$ MHz | [1] | 0 | 93.75 | 100 | kHz |
| **General timing** | | | | | | | |
| $t_{(SCL)L}$ | LOW period of the SCL clock | | | 4.7 | - | - | µs |
| $t_{(SCL)H}$ | HIGH period of the SCL clock | | | 4.0 | - | - | µs |
| $t_r$ | rise time | SDA and SCL signals | [2] | - | - | 1000 | ns |
| $t_f$ | fall time | SDA and SCL signals | | - | - | 300 | ns |
| $C_b$ | capacitive load for each bus line | | | - | - | 400 | pF |
| **SDA timing** | | | | | | | |
| $t_{BUF}$ | bus free time between a STOP and START condition | | | 4.7 | - | - | µs |
| $t_{SU;STA}$ | setup time for the START condition | | [3] | 4.7 | - | - | µs |
| $t_{HD;STA}$ | hold time for the START condition | | [4] | 4.0 | - | - | µs |
| $t_{SU;DAT}$ | data setup time | | | 250 | - | - | ns |
| $t_{HD;DAT}$ | data hold time | | | 0 | - | - | µs |
| $t_{SU;STO}$ | STOP condition setup time | | | 4.0 | - | - | µs |
| **Additional I2C-bus timing** | | | | | | | |
| $t_{VD;DAT}$ | data valid time | | [5] | - | - | 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 kΩ).

[3]    Set-up time for (repeated) START condition.

[4]    Hold time for (repeated) START condition.

[5]    SCL LOW to data-out valid time.
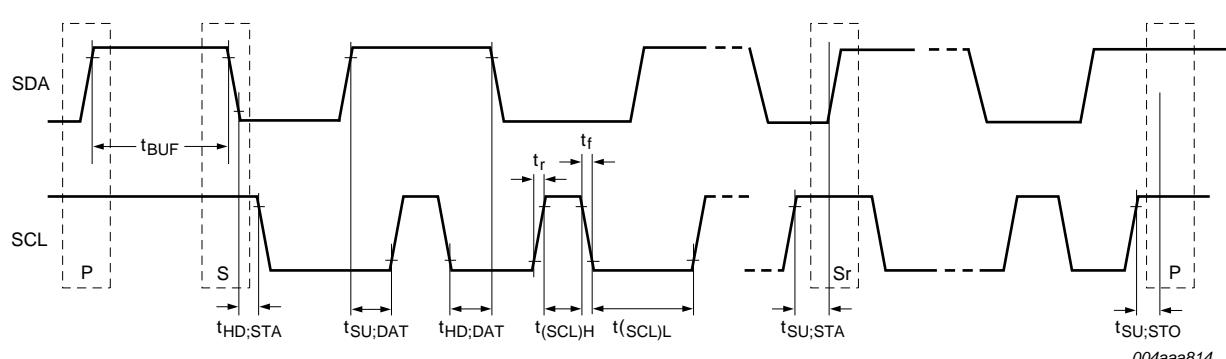


**Fig 16.   I2C-bus timing**

# 16. Application information

## 16.1 Descriptor configuration selection
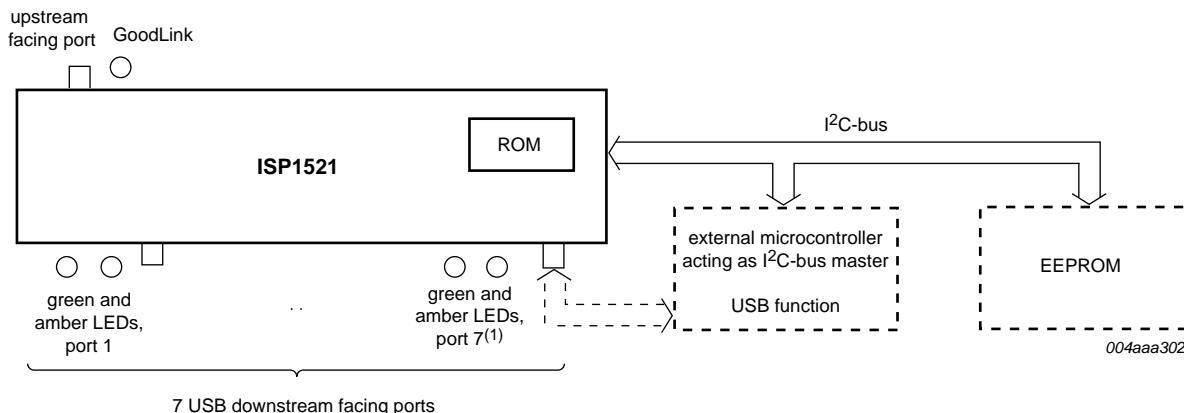


The I²C-bus cannot be shared between the EEPROM and the external microcontroller; see Table 11.

(1) The function on port 7, which is a nonremovable port, is optional.

**Fig 17.  Descriptors configuration selection application diagram**

## 16.2 Overcurrent detection limit adjustment

For an overcurrent limit of 500 mA per port, a PMOS with $R_{DSon}$ of approximately 100 m$\Omega$ is required. If a PMOS with a lower $R_{DSon}$ is used, analog overcurrent detection can be adjusted by using a series resistor; see Figure 18.

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

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

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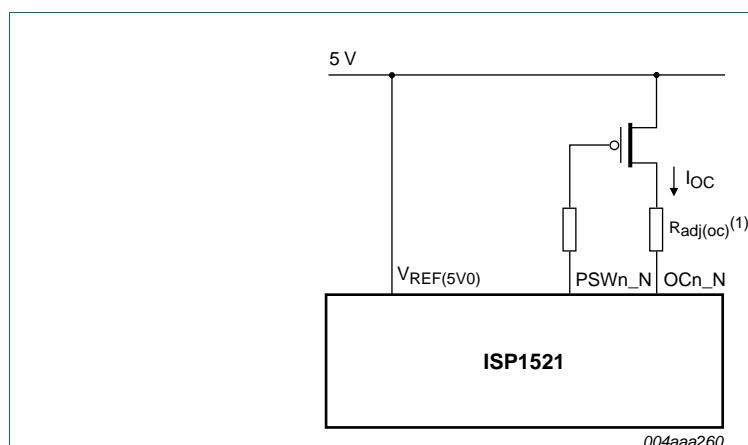


(1)  $R_{adj(oc)}$ is optional.

**Fig 18.  Adjusting analog overcurrent detection limit (optional)**

## 16.3   Self-powered hub configurations
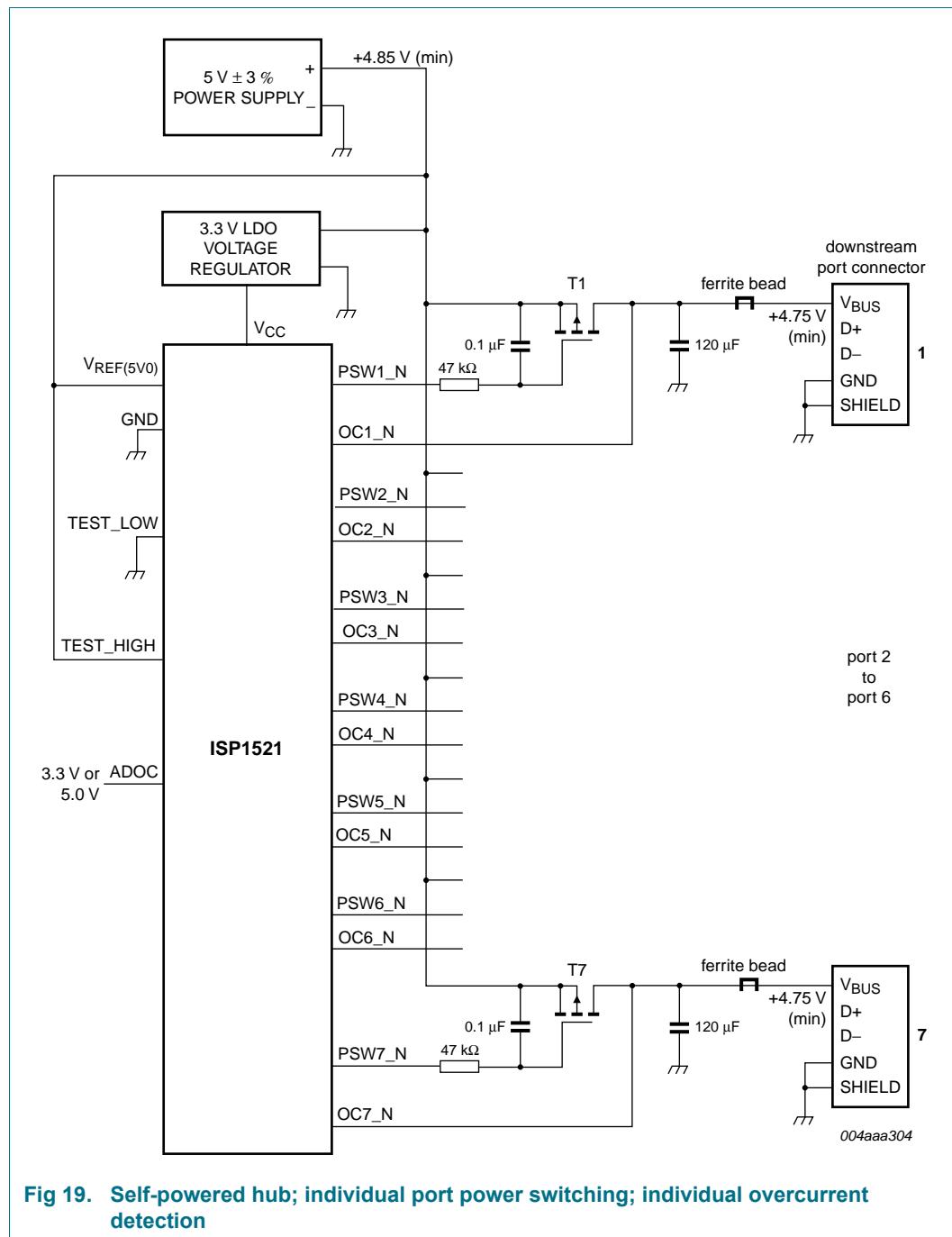


**Fig 19.   Self-powered hub; individual port power switching; individual overcurrent detection**
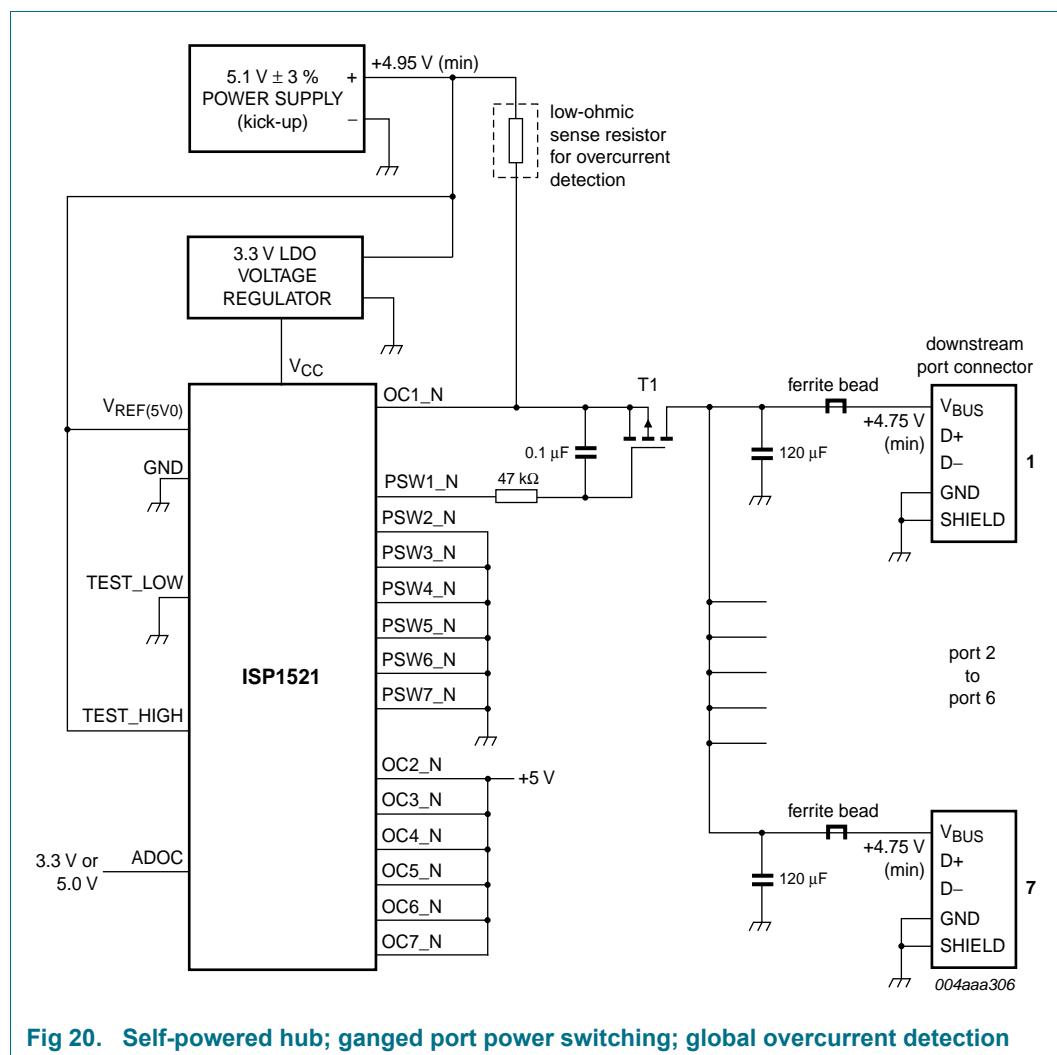
**Fig 20. Self-powered hub; ganged port power switching; global overcurrent detection**

# 17. Test information



(1) Transmitter: connected to 50 Ω inputs of a high-speed differential oscilloscope.

Receiver: connected to 50 Ω outputs of a high-speed differential data generator.

**Fig 21.  High-speed transmitter and receiver test circuit**



(1) $C_L$ = 50 pF for full-speed.

**Fig 22.  Full-speed test circuit**
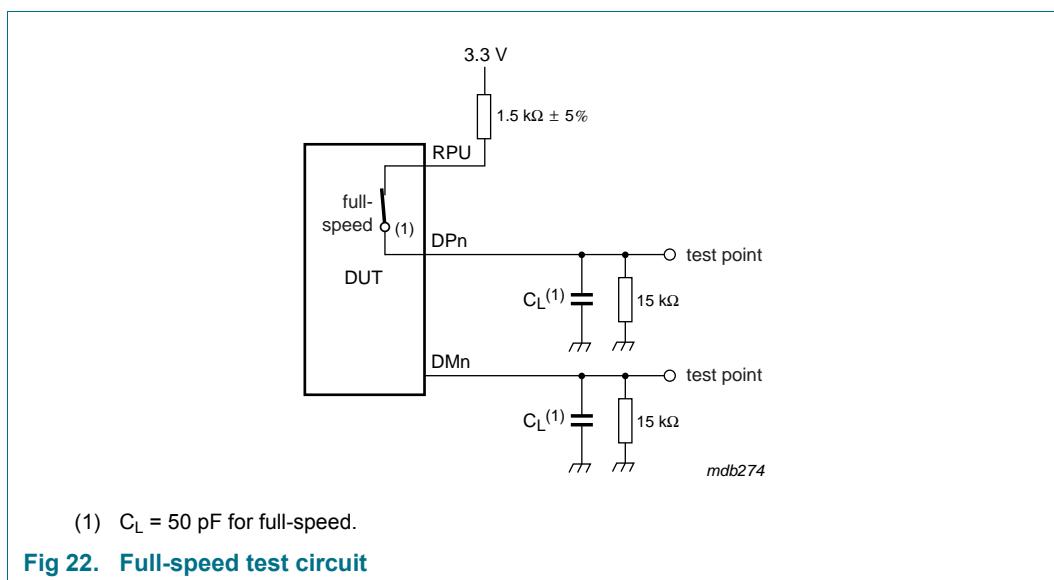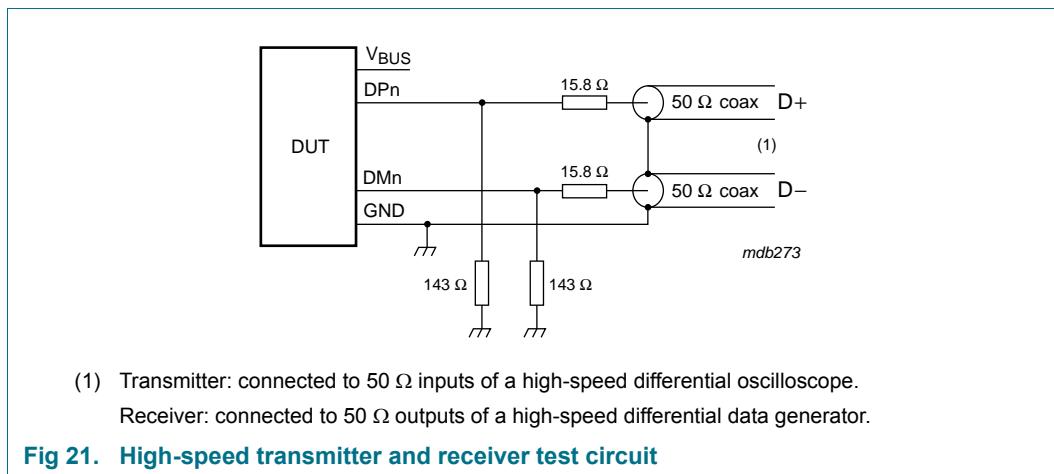
## 18. Package outline

**LQFP80: plastic low profile quad flat package; 80 leads; body 12 x 12 x 1.4 mm**　　　　**SOT315-1**



**DIMENSIONS (mm are the original dimensions)**

| UNIT | A max. | A₁ | A₂ | A₃ | bₚ | c | D(1) | E(1) | e | H_D | H_E | L | Lₚ | v | w | y | Z_D(1) | Z_E(1) | θ |
|------|--------|----|----|----|----|----|------|------|---|-----|-----|---|-----|---|---|---|--------|--------|---|
| mm | 1.6 | 0.16 0.04 | 1.5 1.3 | 0.25 | 0.27 0.13 | 0.18 0.12 | 12.1 11.9 | 12.1 11.9 | 0.5 | 14.15 13.85 | 14.15 13.85 | 1 | 0.75 0.30 | 0.2 | 0.15 | 0.1 | 1.45 1.05 | 1.45 1.05 | 7° 0° |

**Note**

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|-----------------|------------|------|-------|---|---------------------|------------|
| | IEC | JEDEC | JEITA | | | |
| SOT315-1 | 136E15 | MS-026 | | | | 00-01-19 03-02-25 |

**Fig 23.　Package outline SOT315-1 (LQFP80)**

# 19. Abbreviations

**Table 47.    Abbreviations**

| Acronym | Description |
| --- | --- |
| ACPI | Advanced Configuration and Power Interface |
| CRC | Cyclical Redundancy Check |
| EEPROM | Electronically Erasable Programmable Read-Only Memory |
| EMI | ElectroMagnetic Interference |
| EOP | End-of-Packet |
| ESD | ElectroStatic Discharge |
| FET | Field-Effect Transistor |
| HS | High-Speed |
| LSB | Least Significant Bit |
| MSB | Most Significant Bit |
| MOSFET | Metal Oxide Silicon Field Effect Transistor |
| NAK | Not AcKnowledge |
| PCB | Printed-Circuit Board |
| PID | Packet IDentifier |
| PLL | Phase-Locked Loop |
| SIE | Serial Interface Engine |
| SOP | Start-of-Packet |
| TT | Transaction Translator |
| TTL | Transistor-Transistor Logic |
| USB | Universal Serial Bus |

# 20. References

[1]    Universal Serial Bus Specification Rev. 2.0

[2]    The I$^2$C-bus specification

[3]    ISP1521 Hi-Speed USB hub demo board user manual (UM10011)

CD00222695

**Product data sheet**                    **Rev. 07 — 4 February 2010**                    **48 of 53**

# 21. Revision history

**Table 48.   Revision history**

| Revision | Release date | Data sheet status | Change notice |
|---|---|---|---|
| 7 | 20100204 | Product data sheet | - |
| Modifications: | • Updated the filename according to the latest corporate standards. | | |
| | • Table 37 "Static characteristics: digital input and output": updated $\Delta V_{trip}$. | | |
| | • Figure 9 "Overcurrent trip response timing": changed $V_{CC}$ to $V_{BUS}$. | | |
| | • Figure 21 "High-speed transmitter and receiver test circuit": changed $V_{CC}$ to $V_{BUS}$. | | |
| 6 | 20090929 | Product data sheet | - |
| 5 | 20090129 | Product data sheet | - |
| 4 | 20060330 | Product data sheet | - |
| 3 (9397 750 13702) | 20041124 | Product data | - |
| 2 (9397 750 11691) | 20040212 | Product data | - |
| 1 (9397 750 10691) | 20030625 | Preliminary data | - |

# 22. Tables

# 23. Figures

# 24. Contents

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