

# DATA SHEET

## **PDIUSBH11** Universal Serial Bus Hub

Product specification  
Supersedes data of 1997 Apr 17

1997 Aug 01

# Universal Serial Bus Hub

# PDIUSBH11

## FEATURES

- Complies with the Universal Serial Bus specification Rev. 1.0
- Four downstream ports with per packet connectivity
- Embedded function with two endpoints (control and interrupt)
- Integrated FIFO memory for hub and embedded function
- Automatic protocol handling
- Versatile I<sup>2</sup>C interface
- Allows software control of monitor
- Compliant with USB Human Interface and Display Device Class
- Single 3.3V supply with 5V tolerant I/O

## DESCRIPTION

The Philips Semiconductors PDIUSBH11 is a compound USB hub IC (hub plus embedded function).

It is used in a microcontroller based system and communicates with the system microcontroller over the I<sup>2</sup>C serial bus. This modular approach to implementing a hub and embedded function allows the designer to maintain the system microcontroller of choice and retain existing architecture. This cuts down development time and offers the most cost-effective solution.

Ideal applications for the IC include computer monitors and keyboards.

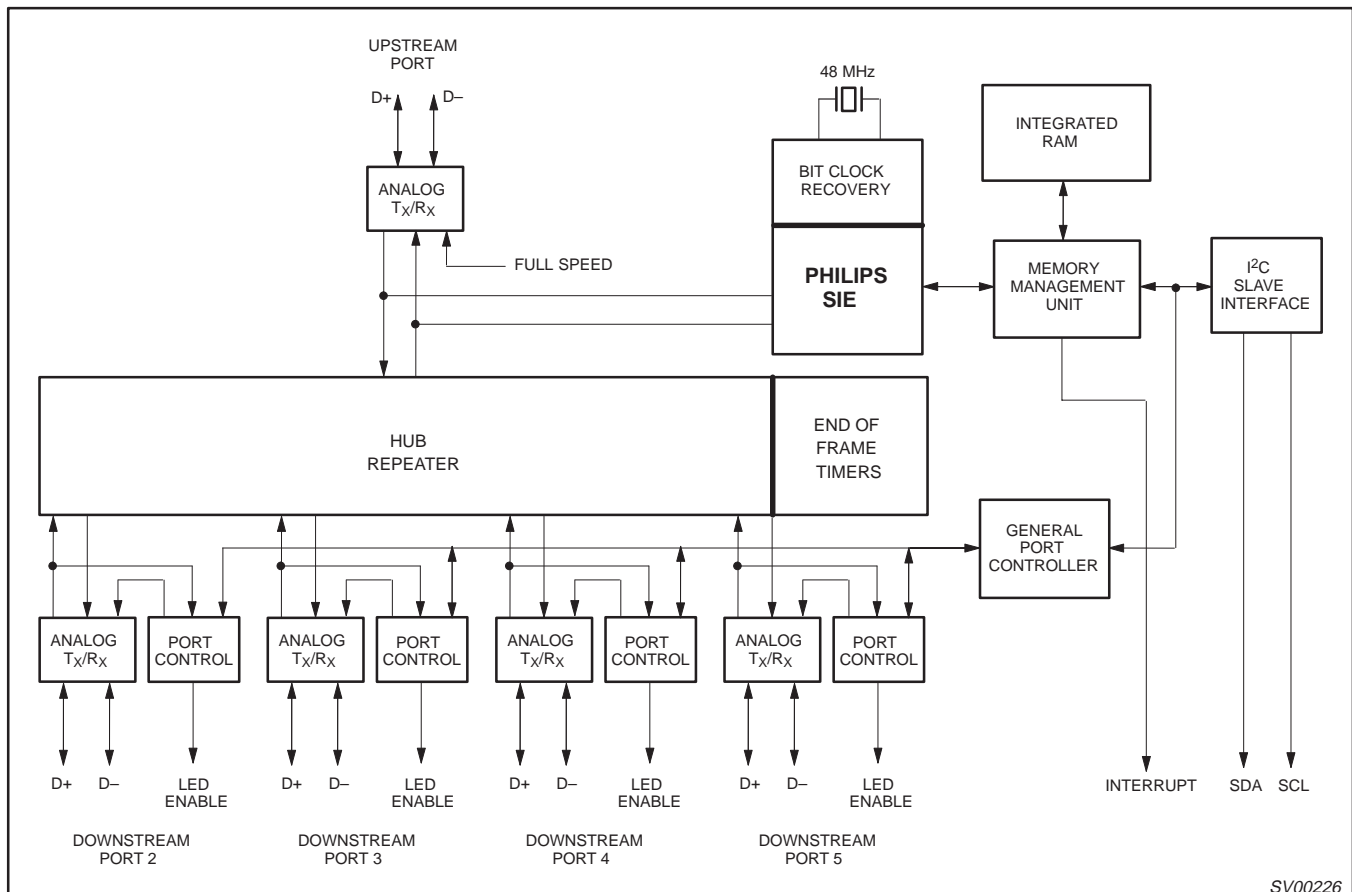
The PDIUSBH11 conforms to the USB specification 1.0 and I<sup>2</sup>C serial interface specification. It is also compliant with the USB Human Input Device and Monitor Control Class specifications.

The embedded function of the PDIUSBH11 appears as PORT1 to the host system and the four downstream ports are numbered 2 through 5.

## ORDERING INFORMATION

| PACKAGES            | TEMPERATURE RANGE | OUTSIDE NORTH AMERICA | NORTH AMERICA | PKG. DWG. # |
|---------------------|-------------------|-----------------------|---------------|-------------|
| 32-pin plastic SO   | 0°C to +70°C      | PDIUSBH11 D           | PDIUSBH11 D   | SOT287-1    |
| 32-pin plastic SDIP | 0°C to +70°C      | PDIUSBH11 NB          | PDIUSBH11 NB  | SOT232-1    |

## BLOCK DIAGRAM



### NOTE:

1. This is a conceptual block diagram and does not include each individual signal.

# Universal Serial Bus Hub

# PDIUSBH11

## Analog Transceivers

These transceivers interface directly to the USB cables through some termination resistors. They are capable of transmitting and receiving serial data at both "full speed" (12 Mbit/s) and "low speed" (1.5 Mbit/s) data rates.

## Hub Repeater

The hub repeater is responsible for managing connectivity on a per packet basis. It implements packet signaling connectivity and resume connectivity.

Low speed devices can be connected to downstream ports since the repeater will not propagate upstream packets to downstream ports, to which low speed devices are connected, unless they are preceded by a PREAMBLE PID.

## End of Frame Timers

This block contains the specified EOF1 and EOF2 timers which are used to detect loss-of-activity and babble error conditions in the hub repeater. The timers also maintain the low-speed keep-alive strobe which is sent at the beginning of a frame.

## General and Individual Port Controller

The general and individual port controllers together provide status and control of individual downstream ports. Via the I<sup>2</sup>C-interface a microcontroller can access the downstream ports and request or change the status of each individual port.

Any change in the status or settings of the individual port will result in an interrupt request. Via an interrupt register, the servicing microcontroller can look up the downstream port which generated

## ENDPOINT DESCRIPTIONS

The following table summarizes the endpoints supported by the PDIUSBH11.

| FUNCTION | ENDPOINT NUMBER | ENDPOINT TYPE | TRANSFER TYPE | DIRECTION | MAXIMUM PACKET SIZE (bytes) |
|----------|-----------------|---------------|---------------|-----------|-----------------------------|
| HUB      | 0               | Default       | Control       | IN, OUT   | 8                           |
|          | 1               | Status change | Interrupt     | IN        | 1                           |
| EMBEDDED | 0               | Default       | Control       | IN, OUT   | 8                           |
|          | 1               | Interrupt     | Interrupt     | IN        | 8                           |

## PIN DESCRIPTION

The PDIUSBH11 has two modes of operation. The first mode (Mode 0) enables the pins DN<sub>x</sub>\_EN\_N to power a LED indicating the port is enabled. The second mode (Mode 1) utilizes the LED enable pins as per port overcurrent condition pins.

the interrupt and request its new status. Any port status change can then be reported to the host via the hub status change (interrupt) endpoint.

## Bit Clock Recovery

The bit clock recovery circuit recovers the clock from the incoming USB data stream using (4X) over-sampling principle. It is able to track jitter and frequency drift specified by the USB spec.

## Philips Serial Interface Engine (PSIE)

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 / serial conversion, bit stuffing / destuffing, CRC checking / generation, PID verification / generation, address recognition, handshake evaluation / generation.

## Memory Management Unit (MMU) and Integrated RAM

The MMU and the integrated RAM is used to handle the large difference in data-rate between USB, running in burst of 12 Mbit/s and the I<sup>2</sup>C interface to the microcontroller, running at 100 kbit/s. This allows the microcontroller to read and write USB packets at its own (low) speed through I<sup>2</sup>C.

## I<sup>2</sup>C Slave Interface

This block implements the necessary I<sup>2</sup>C interface protocol. A slave I<sup>2</sup>C allows for simple micro-coding. An interrupt is used to alert the microcontroller whenever the PDIUSBH11 needs attention. As a slave I<sup>2</sup>C device, the PDIUSBH11 I<sup>2</sup>C clock: SCL is an input and is controlled by the microcontroller.

The voltage level at power up on the TEST1 and TEST2 pins determine the PDIUSBH11 mode of operation. When both of the pins are connected to Ground, Mode 0 is enabled. When pins TEST1 and TEST2 are connected to Vcc, Mode 1 is enabled. Note that in Mode 1 the pin DN<sub>2</sub>\_EN\_N remains an LED enable pin. Pin TEST3 should always be connected to Ground at all times.

## Universal Serial Bus Hub

## PDIUSBH11

## PIN DESCRIPTION (MODE 0)

| PIN NO | PIN SYMBOL       | I/O   | DRIVE | NAME AND FUNCTION                           |
|--------|------------------|-------|-------|---|
| 1      | TEST1            | I     |       | Connect to Ground                           |
| 2      | TEST2            | I     |       | Connect to Ground                           |
| 3      | TEST3            | I     |       | Connect to Ground                           |
| 4      | RESET_N          | I     | ST    | Power-on reset                              |
| 5      | GND              | POWER |       | Ground reference                            |
| 6      | XTAL1            | I/O   |       | Crystal connection 1 (48MHz)                |
| 7      | XTAL2            | I/O   |       | Crystal connection 2 (48MHz)                |
| 8      | CLK12MHZ         | O     | 2mA   | 12MHz output clock for external devices     |
| 9      | V <sub>CC</sub>  | POWER |       | Voltage supply 3.3V ± 0.3V                  |
| 10     | OCURRENT_N       | I     | ST    | Over-current notice to the device           |
| 11     | SWITCH_N         | O     | OD8   | Enables power to downstream ports           |
| 12     | SUSPEND          | O     | 4mA   | Device is in suspended state                |
| 13     | DN2_EN_N         | O     | OD8   | Downstream port 2 LED enable indicator      |
| 14     | DN3_EN_N         | O     | OD8   | Downstream port 3 LED enable indicator      |
| 15     | DN4_EN_N         | O     | OD8   | Downstream port 4 LED enable indicator      |
| 16     | DN5_EN_N         | O     | OD8   | Downstream port 5 LED enable indicator      |
| 17     | INT_N            | O     | OD4   | Connect to microcontroller interrupt        |
| 18     | SDA              | I/O   | OD4   | I <sup>2</sup> C bi-directional data        |
| 19     | SCL              | I/O   | OD4   | I <sup>2</sup> C bit-clock                  |
| 20     | GND              | POWER |       | Ground reference                            |
| 21     | DN5_DP           | AI/O  |       | Downstream port 5 D <sup>+</sup> connection |
| 22     | DN5_DM           | AI/O  |       | Downstream port 5 D <sup>-</sup> connection |
| 23     | DN4_DP           | AI/O  |       | Downstream port 4 D <sup>+</sup> connection |
| 24     | DN4_DM           | AI/O  |       | Downstream port 4 D <sup>-</sup> connection |
| 25     | DN3_DP           | AI/O  |       | Downstream port 3 D <sup>+</sup> connection |
| 26     | DN3_DM           | AI/O  |       | Downstream port 3 D <sup>-</sup> connection |
| 27     | DN2_DP           | AI/O  |       | Downstream port 2 D <sup>+</sup> connection |
| 28     | DN2_DM           | AI/O  |       | Downstream port 2 D <sup>-</sup> connection |
| 29     | AGND             | POWER |       | Analog Ground reference                     |
| 30     | AV <sub>CC</sub> | POWER |       | Analog voltage supply 3.3V ± 0.3V           |
| 31     | UP_DP            | AI/O  |       | Upstream D <sup>+</sup> connection          |
| 32     | UP_DM            | AI/O  |       | Upstream D <sup>-</sup> connection          |

## Universal Serial Bus Hub

## PDIUSBH11

## PIN DESCRIPTION (MODE 1)

| PIN NO | PIN SYMBOL       | I/O   | DRIVE | NAME AND FUNCTION                           |
|--------|------------------|-------|-------|---|
| 1      | TEST1            | I     |       | Connect to V <sub>CC</sub>                  |
| 2      | TEST2            | I     |       | Connect to V <sub>CC</sub>                  |
| 3      | TEST3            | I     |       | Connect to Ground                           |
| 4      | RESET_N          | I     | ST    | Power-on reset                              |
| 5      | GND              | POWER |       | Ground reference                            |
| 6      | XTAL1            | I/O   |       | Crystal connection 1 (48MHz)                |
| 7      | XTAL2            | I/O   |       | Crystal connection 2 (48MHz)                |
| 8      | CLK12MHZ         | O     | 2mA   | 12MHz output clock for external devices     |
| 9      | V <sub>CC</sub>  | POWER |       | Voltage supply 3.3V ± 0.3V                  |
| 10     | OCURRENT2_N      | I     | ST    | Downstream port 2 over-current notice       |
| 11     | SWITCH_N         | O     | OD8   | Enables power to downstream ports           |
| 12     | SUSPEND          | O     | 4mA   | Device is in suspended state                |
| 13     | DN2_EN_N         | O     | OD8   | Downstream port 2 LED enable indicator      |
| 14     | OCURRENT3_N      | I     | ST    | Downstream port 3 over-current notice       |
| 15     | OCURRENT4_N      | I     | ST    | Downstream port 4 over-current notice       |
| 16     | OCURRENT5_N      | I     | ST    | Downstream port 5 over-current notice       |
| 17     | INT_N            | O     | OD4   | Connect to microcontroller interrupt        |
| 18     | SDA              | I/O   | OD4   | I <sup>2</sup> C bi-directional data        |
| 19     | SCL              | I/O   | OD4   | I <sup>2</sup> C bit-clock                  |
| 20     | GND              | POWER |       | Ground reference                            |
| 21     | DN5_DP           | AI/O  |       | Downstream port 5 D <sup>+</sup> connection |
| 22     | DN5_DM           | AI/O  |       | Downstream port 5 D <sup>-</sup> connection |
| 23     | DN4_DP           | AI/O  |       | Downstream port 4 D <sup>+</sup> connection |
| 24     | DN4_DM           | AI/O  |       | Downstream port 4 D <sup>-</sup> connection |
| 25     | DN3_DP           | AI/O  |       | Downstream port 3 D <sup>+</sup> connection |
| 26     | DN3_DM           | AI/O  |       | Downstream port 3 D <sup>-</sup> connection |
| 27     | DN2_DP           | AI/O  |       | Downstream port 2 D <sup>+</sup> connection |
| 28     | DN2_DM           | AI/O  |       | Downstream port 2 D <sup>-</sup> connection |
| 29     | AGND             | POWER |       | Analog Ground reference                     |
| 30     | AV <sub>CC</sub> | POWER |       | Analog voltage supply 3.3V ± 0.3V           |
| 31     | UP_DP            | AI/O  |       | Upstream D <sup>+</sup> connection          |
| 32     | UP_DM            | AI/O  |       | Upstream D <sup>-</sup> connection          |

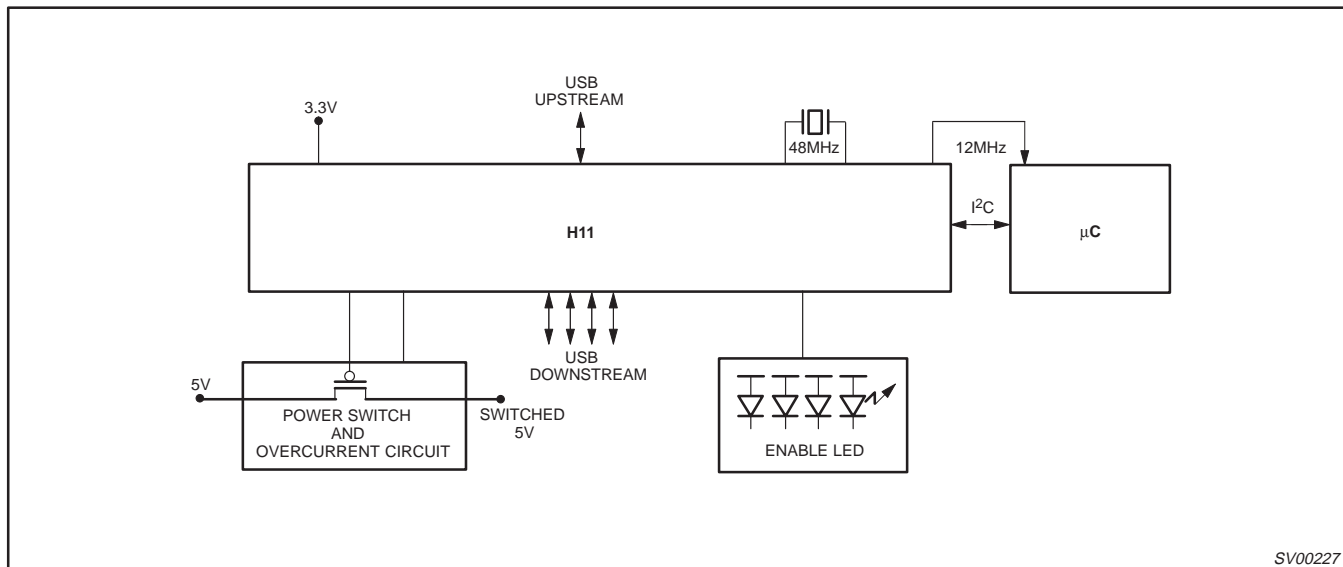
## NOTES:

- Signals ending in \_N indicate active low signals.  
ST: Schmitt Trigger  
OD4, OD8: Open Drain with 4 or 8 mA drive  
AI/O: Analog I/O

# Universal Serial Bus Hub

# PDIUSBH11

## APPLICATION DIAGRAM



SV00227

### I²C Interface.

The I²C bus is used to interface to an external microcontroller needed to control the operation of the hub. For cost consideration, the target system microcontroller can be shared and utilized for this purpose. The PDIUSBH11 implements a slave I²C interface. When the PDIUSBH11 needs to communicate with the microcontroller it asserts an interrupt signal. The microcontroller services this interrupt by reading the appropriate status register on the PDIUSBH11 through the I²C bus. (For more information about the I²C serial bus, refer to the I²C handbook, Philips order number 9397 750 00013).

The I²C interface on the PDIUSBH11 defines two types of transactions :

#### 1. command transaction

A command transaction is used to define which data (e.g., status byte, buffer data, ...) will be read from / written to the USB interface in the next data transaction. A data transaction usually follows a command transaction.

#### 2. data transaction

A data transaction reads data from / writes data to the USB interface. The meaning of the data is dependent on the command transaction which was sent before the data transaction.

Two addresses are used to differentiate between command and data transactions. Writing to the command address is interpreted as a command, while reading from / writing to the data address is used to transfer data between the PDIUSBH11 and the controller.

## ADDRESS TABLE

| TYPE OF ADDRESS | PHYSICAL ADDRESS (MSB to LSB) |
|-----------------|-------------------------------|
| Command         | 0011 011 (binary)             |
| Data            | 0011 010 (binary)             |

### Protocol

An I²C transaction starts with a 'Start Condition', followed by an address. When the address matches either the command or data address the transaction starts and runs until a 'Stop Condition' or another 'Start Condition' (repeated start) occurs.

The command address is write-only and is unable to do a read. The next bytes in the message are interpreted as commands. Several command bytes can be sent after one command address. Each of the command bytes is acknowledged and passed on to the Memory Management Unit inside the PDIUSBH11.

When the start condition address matches the data address, the next bytes are interpreted as data. When the RW bit in the address indicates a 'master writes data to slave' (= '0') the bytes are received, acknowledged and passed on to the Memory Management Unit. If the RW bit in the address indicates a 'master reads data from slave' (= '1') the PDIUSBH11 will send data to the master. The I²C-master must acknowledge all data bytes except the last one. In this way the I²C interface knows when the last byte has been transmitted and it then releases the SDA line so that the master controller can generate the STOP condition.

Repeated start support allows another packet to be sent without generating a Stop Condition.

### Timing

When the master writes data to the PDIUSBH11, the data is sampled 1 micro-second after the rising edge of SCL. When the PDIUSBH11 writes data to the master, the data is driven 1 micro-second after the falling edge of SCL.

## Universal Serial Bus Hub

## PDIUSBH11

**COMMAND SUMMARY**

Some commands have the same command code (e.g., Read Buffer and Write Buffer). In these cases, the direction of the Data Phase (read or write) indicates which command is executed.

| COMMAND NAME                   | RECIPIENT                     | CODING | DATA PHASE             |
|--------------------------------|-------------------------------|--------|------------------------|
| <b>Initialization Commands</b> |                               |        |                        |
| Set Address / Enable           | Hub                           | D0h    | Write 1 byte           |
|                                | Embedded Function             | D1h    | Write 1 byte           |
| Set Endpoint Enable            | Hub + Embedded Function       | D8h    | Write 1 byte           |
| <b>Data Flow Commands</b>      |                               |        |                        |
| Read Interrupt Register        |                               | F4h    | Read 1 byte            |
| Select Endpoint                | Hub Control OUT               | 00h    | Read 1 byte (optional) |
|                                | Hub Control IN                | 01h    | Read 1 byte (optional) |
|                                | Embedded Function Control OUT | 02h    | Read 1 byte (optional) |
|                                | Embedded Function Control IN  | 03h    | Read 1 byte (optional) |
|                                | Embedded Function Interrupt   | 04h    | Read 1 byte (optional) |
| Read Last Transaction Status   | Hub Control OUT               | 40h    | Read 1 byte            |
|                                | Hub Control IN                | 41h    | Read 1 byte            |
|                                | Embedded Function Control OUT | 42h    | Read 1 byte            |
|                                | Embedded Function Control IN  | 43h    | Read 1 byte            |
|                                | Embedded Function Interrupt   | 44h    | Read 1 byte            |
| Read Endpoint Status           | Hub Control OUT               | 80h    | Read 1 byte            |
|                                | Hub Control IN                | 81h    | Read 1 byte            |
|                                | Embedded Function Control OUT | 82h    | Read 1 byte            |
|                                | Embedded Function Control IN  | 83h    | Read 1 byte            |
|                                | Embedded Function Interrupt   | 84h    | Read 1 byte            |
| Read Buffer                    | Selected Endpoint             | F0h    | Read n bytes           |
| Write Buffer                   | Selected Endpoint             | F0h    | Write n bytes          |
| Set Endpoint Status            | Hub Control OUT               | 40h    | Write 1 byte           |
|                                | Hub Control IN                | 41h    | Write 1 byte           |
|                                | Embedded Function Control OUT | 42h    | Write 1 byte           |
|                                | Embedded Function Control IN  | 43h    | Write 1 byte           |
|                                | Embedded Function Interrupt   | 44h    | Write 1 byte           |
| Acknowledge Setup              | Selected Endpoint             | F1h    | None                   |
| Clear Buffer                   | Selected Endpoint             | F2h    | None                   |
| Validate Buffer                | Selected Endpoint             | FAh    | None                   |
| <b>Hub Commands</b>            |                               |        |                        |
| Clear Port Feature             | Port 2                        | E0h    | Write 1 byte           |
|                                | Port 3                        | E1h    | Write 1 byte           |
|                                | Port 4                        | E2h    | Write 1 byte           |
|                                | Port 5                        | E3h    | Write 1 byte           |
| Set Port Feature               | Port 2                        | E8h    | Write 1 byte           |
|                                | Port 3                        | E9h    | Write 1 byte           |
|                                | Port 4                        | EAh    | Write 1 byte           |
|                                | Port 5                        | EBh    | Write 1 byte           |
| Get Port Status                | Port 2                        | E0h    | Read 1 or 2 bytes      |
|                                | Port 3                        | E1h    | Read 1 or 2 bytes      |
|                                | Port 4                        | E2h    | Read 1 or 2 bytes      |
|                                | Port 5                        | E3h    | Read 1 or 2 bytes      |
| Set Status Change Bits         |                               | F7h    | Write 1 byte           |
| <b>General Commands</b>        |                               |        |                        |
| Send Resume                    |                               | F6h    | None                   |
| Read Current Frame Number      |                               | F5h    | Read 1 or 2 bytes      |

# Universal Serial Bus Hub

# PDIUSBH11

## COMMAND DESCRIPTIONS

### Command Procedure

There are four basic types of commands: Initialization, Data, Hub Specific and General commands. Respectively, these are used to initialize the hub and embedded function; for data flow between the hub, embedded function and the host; some hub specific commands for controlling individual downstream ports; and some general commands.

### Initialization Commands

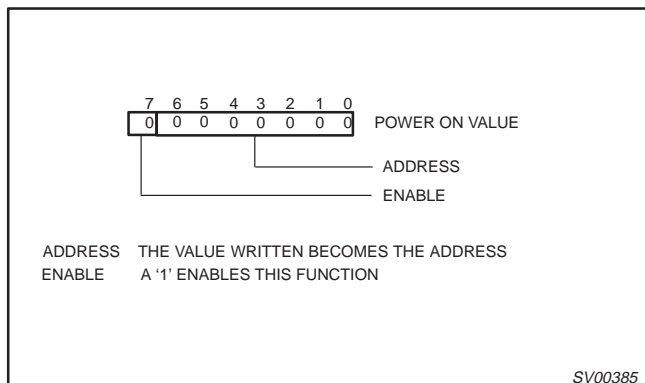
Initialization commands are used during the enumeration process of the USB network. These commands are used to enable the hub and embedded function endpoints. They are also used to set the USB assigned address.

#### Set Address / Enable

**Command** : D0h (Hub), D1h (Embedded Function)

**Data** : Write 1 byte

This command is used to set the USB assigned address and enable the hub or embedded function respectively. The hub always powers up disabled and should be enabled after a bus RESET.

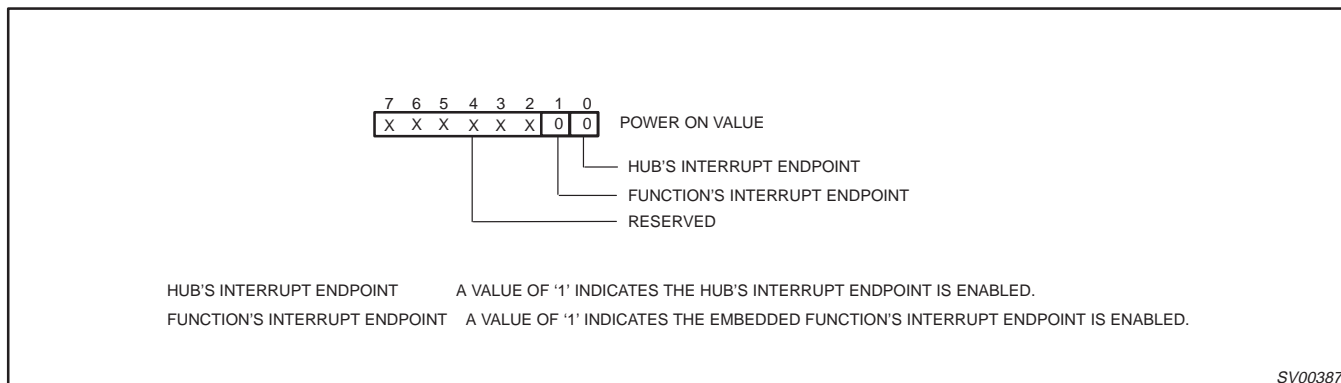


#### Set Endpoint Enable

**Command** : D8h

**Data** : Write 1 byte

Interrupt endpoints can only be enabled when the hub/function is enabled via the Set Address/Enable command.





# Universal Serial Bus Hub

# PDIUSBH11

### Data Flow Commands

Data flow commands are used to manage the data transmission between the USB endpoints and the monitor. Much of the data flow is initiated via an interrupt to the microcontroller. The microcontroller utilizes these commands to access and determine whether the endpoint FIFOs have valid data.

### Read Interrupt Register

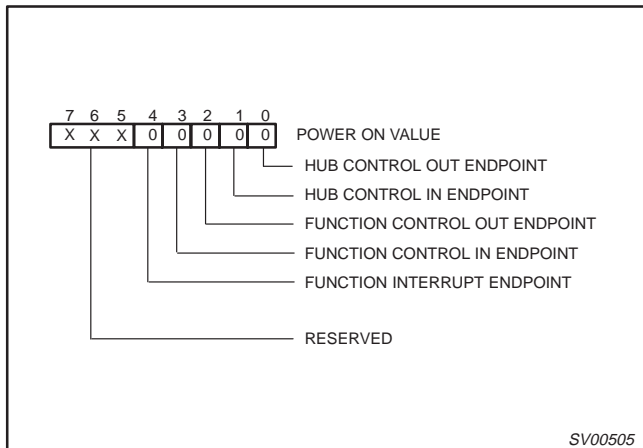
**Command** : F4h

**Data** : Read 1 byte

This command indicates the origin of an interrupt. A "1" indicates an interrupt occurred at this endpoint. The bits are cleared by reading the endpoint status register through Read Endpoint Status command.

After a bus reset an interrupt will be generated, however all bits in the interrupt register will be 0. The interrupt is internally cleared by reading the interrupt register. A bus reset is completely identical to the hardware reset through the RESET\_N pin with the sole difference of interrupt notification.

The hub interrupt endpoint is handled internally by the PDIUSBH11 hardware without the need of microcontroller intervention.

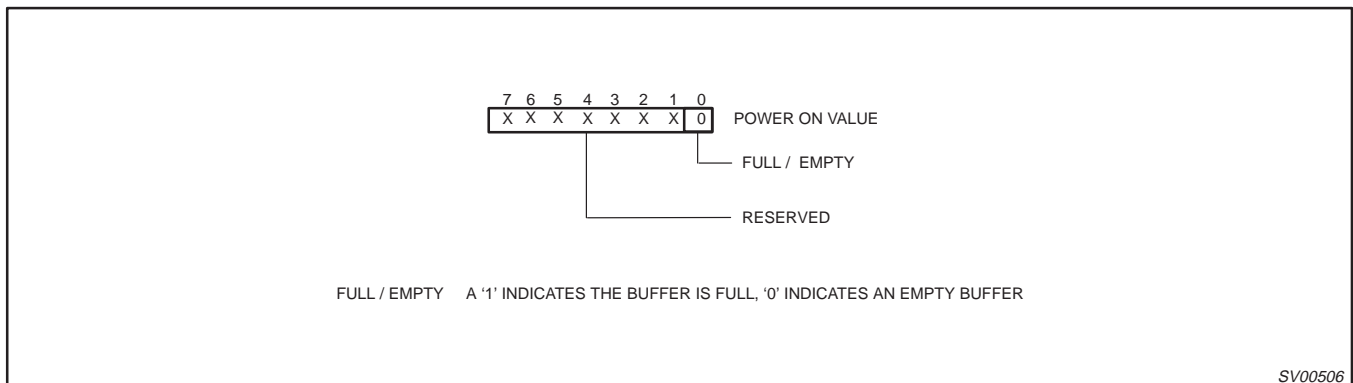


### Select Endpoint

**Command** : 00–04h

**Data** : Optional Read 1 byte

The Select Endpoint command initializes an internal pointer to the start of the Selected buffer. Optionally, this command can be followed by a data read, which returns 0 if the buffer is empty and 1 if the buffer is full.



# Universal Serial Bus Hub

# PDIUSBH11

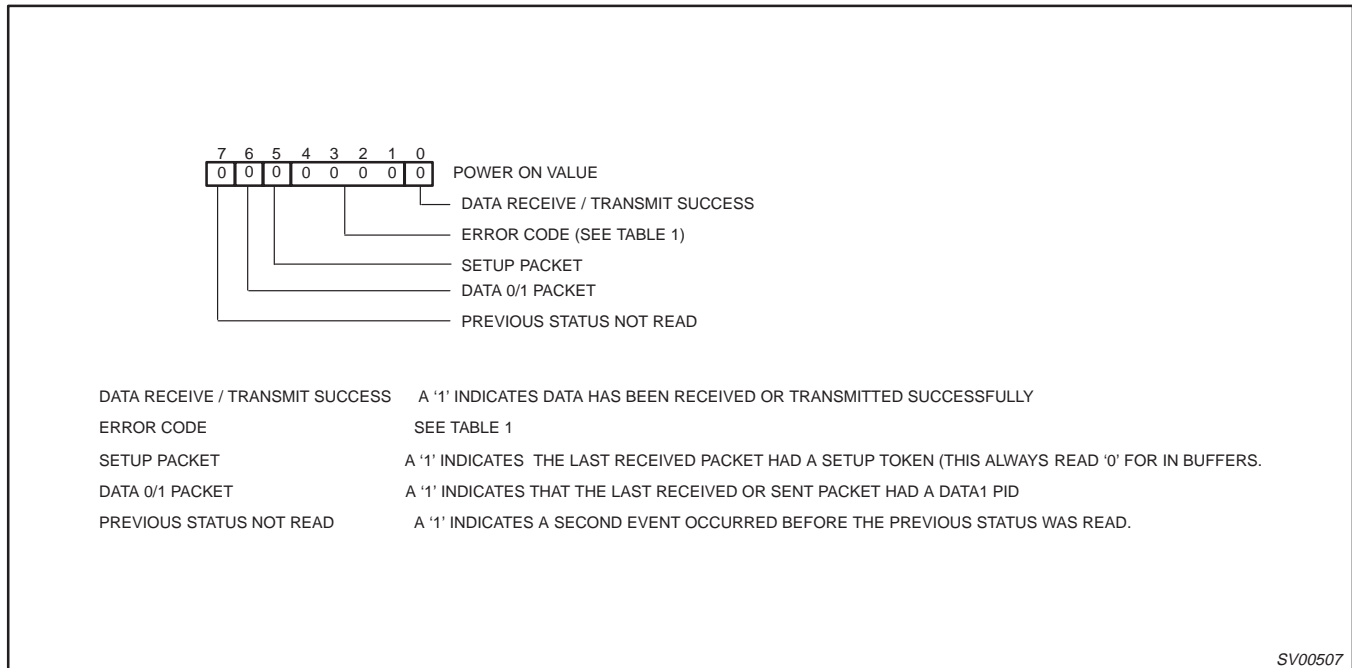
## Read Last Transaction Status

**Command** : 40–44h

**Data** : Read 1 byte

The *Read Last Transaction Status* command is followed by one data read that returns the status of the last transaction of the endpoint. This command also resets the corresponding interrupt flag in the interrupt register, and clears the status, indicating that it was read.

This command is useful for debugging purposes. Since it keeps track of every transaction, the status information is overwritten for each new transaction.



**Table 1.**

| ERROR CODE | RESULT   |
|------------|--|
| 0000       | No Error   |
| 0001       | PID Encoding Error, Bits 7–4 are not the inversion of bits 3–0   |
| 0010       | PID Unknown, encoding is valid, but PID does not exist   |
| 0011       | Unexpected Packet, Packet is not of the type expected (= token, data or acknowledge), or SETUP token to a non-control endpoint |
| 0100       | Token CRC Error  |
| 0101       | Data CRC Error   |
| 0110       | Time Out Error   |
| 0111       | Babble Error   |
| 1000       | Unexpected End of Packet   |
| 1001       | Sent or Received NAK   |
| 1010       | Sent Stall, a token was received, but the endpoint was stalled   |
| 1011       | Overflow Error, the received packet was longer than the available buffer space   |
| 1101       | Bitstuff Error   |
| 1111       | Wrong DATA PID, the received DATA PID was not the expected one   |

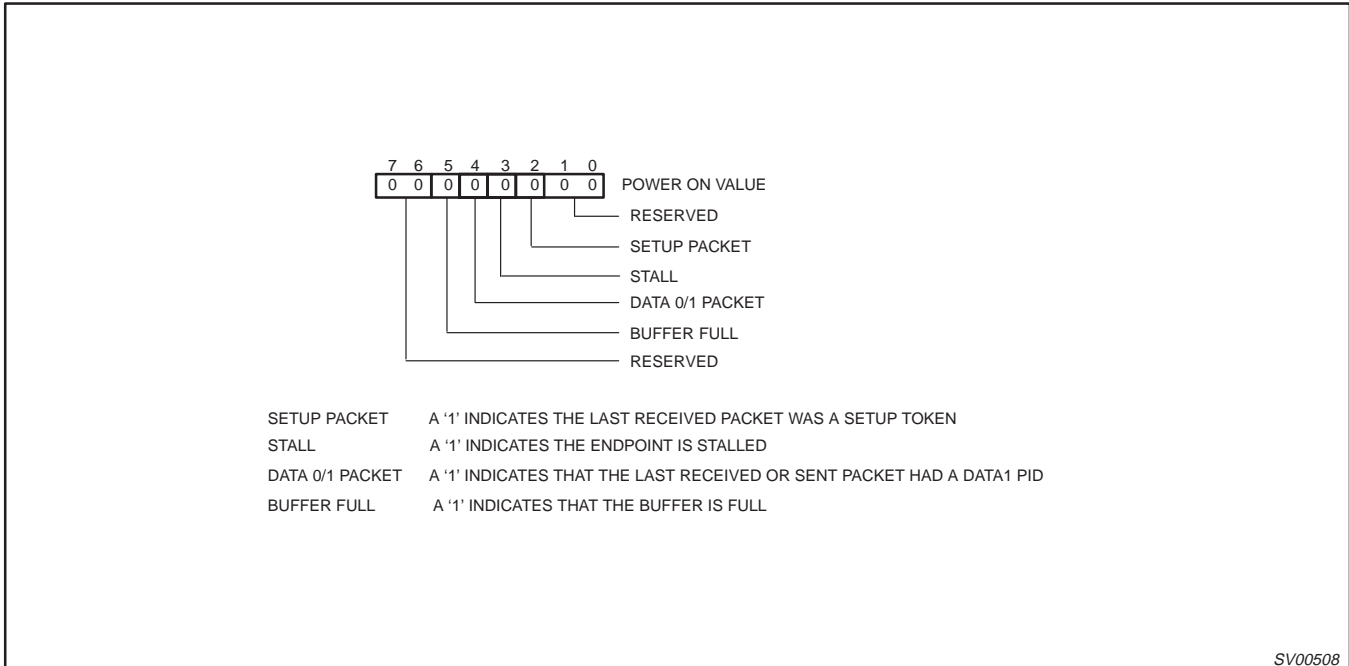
# Universal Serial Bus Hub

# PDIUSBH11

## Read Endpoint Status

**Command** : 80–84h

**Data** : Read 1 byte



## Read Buffer

**Command** : F0h

**Data** : Read multiple bytes (max 10)

The Read Buffer command is followed by a number of data reads, which return the contents of the selected endpoint data buffer. After each read, the internal buffer pointer is incremented by 1.

The buffer pointer is not reset to the buffer start by the Read Buffer command. This means that reading or writing a buffer can be interrupted by any other command (except for Select Endpoint), or can be done by more than one I2C transaction (read the first 2 bytes to get the number of data bytes, then read the rest in other transactions).

The data in the buffer are organized as follows:

- byte 0: reserved: can have any value
- byte 1: Number / length of data bytes
- byte 2: Data byte 1
- byte 3: Data byte 2

## Write Buffer

**Command** : F0h

**Data** : Write multiple bytes (max 10)

The Write Buffer command is followed by a number of data writes, which load the endpoints buffer. The data must be organized in the same way as described in the Read Buffer command. The first byte (reserved) should always be 0. As in the Read Buffer command, the data can be split up into different I2C data transactions.

## WARNING

There is no protection against writing or reading over a buffer's boundary or against writing into an OUT buffer or reading from an IN buffer. Any of these actions could cause an incorrect operation. Data in an OUT buffer are only meaningful after a successful transaction.

# Universal Serial Bus Hub

# PDIUSBH11

### Clear Buffer

**Command** : F2h

**Data** : None

When a packet is received completely, an internal endpoint buffer full flag is set. All subsequent packets will be refused by returning a NACK. When the microcontroller has read the data, it should free the buffer by the Clear Buffer command. When the buffer is cleared new packets will be accepted.

### Validate Buffer

**Command** : FAh

**Data** : None

When the microprocessor has written data into an IN buffer, it should set the buffer full flag by the Validate Buffer command. This indicates that the data in the buffer are valid and can be sent to the host when the next IN token is received.

### Set Endpoint Status

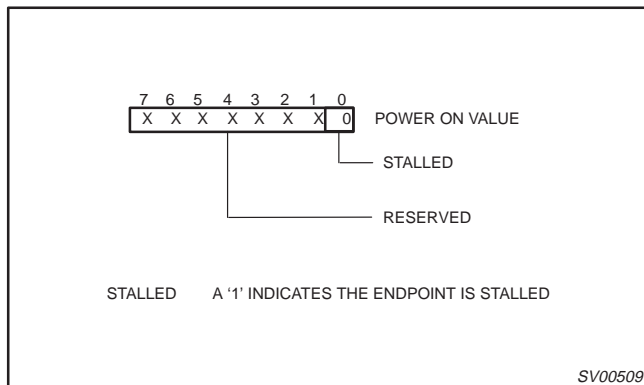
**Command** : 40–44h

**Data** : Write 1 byte

A stalled control endpoint is automatically unstalled when it receives a SETUP token, regardless of the content of the packet. If the endpoint should stay in its stalled state, the microcontroller can re–stall it.

When a stalled endpoint is unstalled (either by the Set Endpoint Status command or by receiving a SETUP token), it is also re–initialized. This flushes the buffer and if it is an OUT buffer it waits for a DATA 0 PID, if it is an IN buffer it writes a DATA 0 PID.

Even when unstalled, writing Set Endpoint Status to '0' initializes the endpoint.



### Acknowledge Setup

**Command** : F1h

**Data** : None

The arrival of a SETUP packet flushes the IN buffer and disables the Validate Buffer and Clear Buffer commands for both IN and OUT endpoints.

The microcontroller needs to re–enable these commands by the Acknowledge Setup command. This ensures that the last SETUP packet stays in the buffer and no packet can be sent back to the host until the microcontroller has acknowledged explicitly that it has seen the SETUP packet.

The microcontroller must send the Acknowledge Setup command to both the IN and OUT endpoints.

# Universal Serial Bus Hub

# PDIUSBH11

## Hub Commands

Hub commands are used to report connectivity and power status between the hub and the host. These commands allow the host to enable each port individually and get any change of status such as new connectivity information.

### Clear/Set Port Feature

**Command** : E0–E3h (Clear) and E8h–EBh (Set)

**Data** : Write 1 byte

When the controller receives a Set Feature or a Clear Feature request, there are two possibilities:

- The request applies to port 1, the embedded port. In this case the request should be handled internally by the controller.
- If the request applies to ports 2 through 5, the controller should translate the request into a Set Feature or Clear Feature command towards the PDIUSBH11.

When the PDIUSBH11 is configured in mode 0, there is only one power switch output and one overcurrent input. This means that the F\_PORT\_POWER and C\_PORT\_OVERCURRENT features are not port specific. For these features, any of the Set / Clear Feature commands can be used. The specific port assignment is ignored.

When the PDIUSBH11 is configured in mode 1, there is still only one power switch output but there are four individual overcurrent input pins corresponding to each port. This means that the F\_PORT\_POWER feature is port specific and the C\_PORT\_OVERCURRENT feature is not port specific.

Setting the F\_PORT\_POWER feature turns the power on when it is off and turns the overcurrent detection on only when the power is already on. This allows to have a short period of overcurrent condition at the moment that power is switched on. For this reason, the F\_PORT\_POWER feature needs to be set twice. Clearing this feature turns both the power and the overcurrent detection off.

The data written in the data phase is the feature code described in Table 2.

**Table 2.**

| FEATURE            | FEATURE CODE | SET              | CLEAR   |
|--------------------|--------------|------------------|---|
| F_PORT_ENABLE      | 0            | Enables a port   | Disables a port   |
| F_PORT_SUSPEND     | 1            | Suspends a port  | Resumes a port  |
| FC_PORT_RESET      | 2            | Resets a port    | Clears a port Reset Change bit                                |
| F_PORT_POWER       | 3            | Powers all ports | Unpowers all ports  |
| C_PORT_CONNECTION  | 4            | –                | Clears a port Connection Change bit                           |
| C_PORT_ENABLE      | 5            | –                | Clears a port Enable Change bit                               |
| C_PORT_SUSPEND     | 6            | –                | Clears a port Suspend Change bit                              |
| C_PORT_OVERCURRENT | 7            | –                | Clears a port (Mode 1) or hub (Mode 0) Overcurrent Change bit |

# Universal Serial Bus Hub

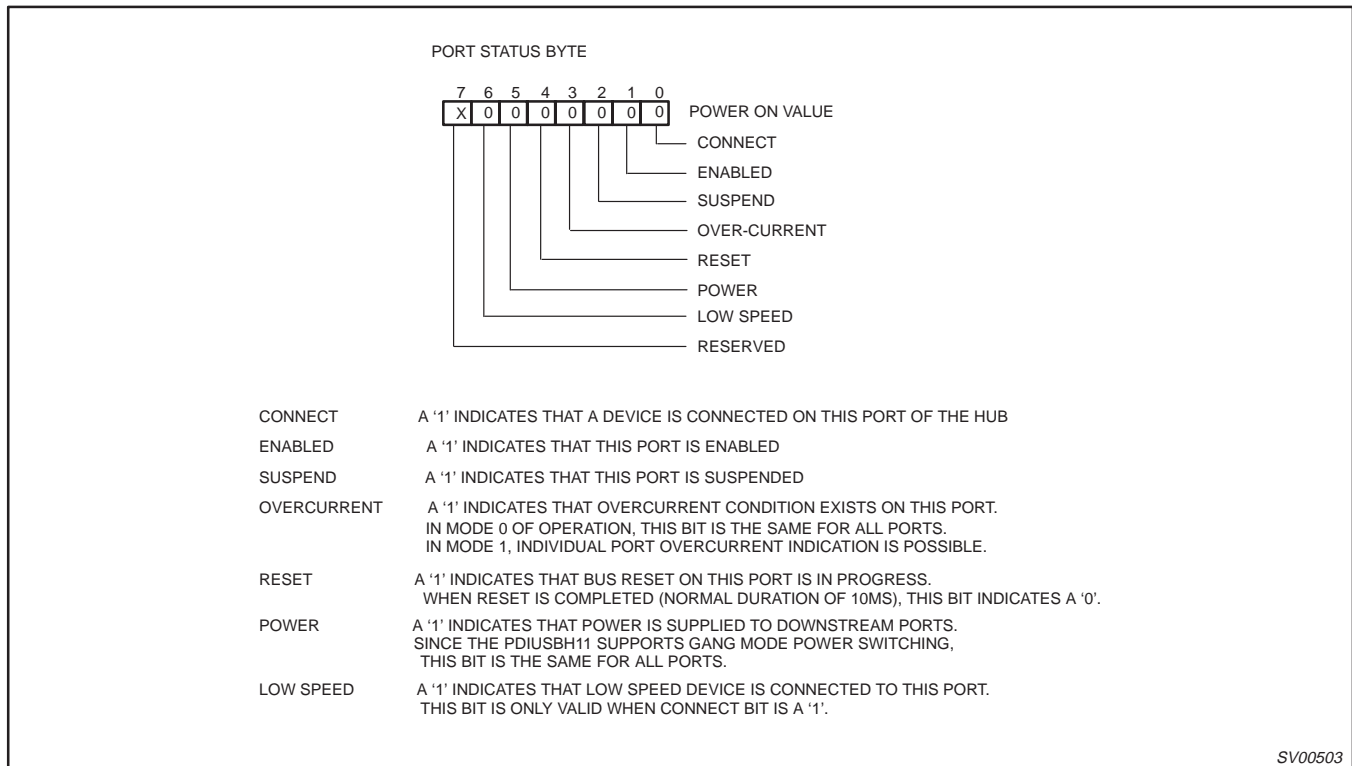
# PDIUSBH11

## Get Port Status

**Command** : E0h–E3h

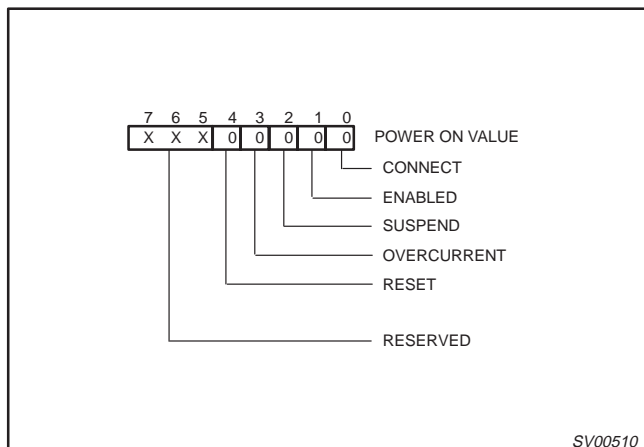
**Data** : Read 1 or 2 bytes

The Get Port Status Command can be followed by one or two data reads. The first byte returned contains the port status. The second byte returned is the port status change byte.



## Port Status Change Byte

The description for the Port Status Change Byte is similar to the Port Status Byte except that the value of the bits are '1' only when a change has occurred.



# Universal Serial Bus Hub

# PDIUSBH11

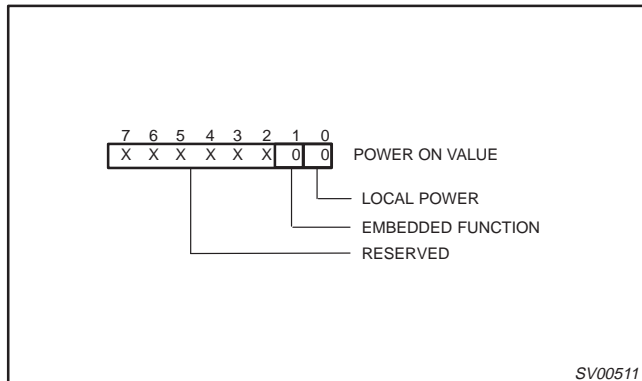
## Set Status Change Bits

**Command** : F7h

**Data** : Write 1 byte

For assembling the hub's status change register, the device needs some additional information from the controller, i.e. the Local Power Status Change bit and the embedded function Status Change bit.

These are provided by the Set Status Change Bits command. This command is always followed by one data write which contains the Local Power Status Change bit at the LSB and the embedded function Status Change bit at position 1. All other bits should be 0.



## GENERAL COMMANDS

### Send Resume

**Command** : F6h

**Data** : None

Sends an upstream resume signal for 10 ms. This command is normally issued when the device is in suspend. The RESUME command is not followed by a data read or write.

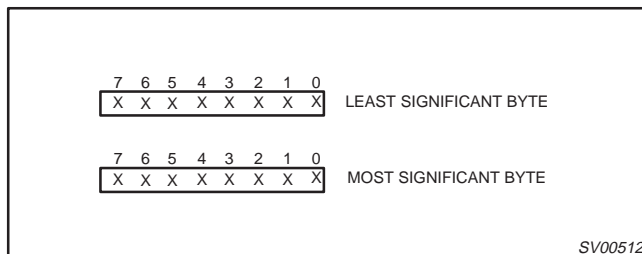
The PDIUSBH11 automatically sends a RESUME command when an event occurs downstream.

### Read Current Frame Number

**Command** : F5h

**Data** : Read 1 or 2 bytes

This command is followed by one or two data reads and returns the frame number of the last successfully received SOF. The frame number is returned Least Significant Byte first.



## EMBEDDED FUNCTION

The USB host sees no difference between the embedded function and a function connected to one of the downstream ports. Some of the port commands sent by the host must be handled appropriately by the embedded function to appear as any other downstream port.

The micro controller maintains a series of status and status change bits for the embedded function as described in the Get Port Status command section. From these bits, the Status Change bit for the embedded function is derived (i.e. the port specific Status Change bits). This Status Change bit is then provided to the PDIUSBH11 by the Set Status Change Bits command.

# Universal Serial Bus Hub

# PDIUSBH11

## Host Requests

### SetFeature PORT\_RESET

Reinitialize the embedded function and set the Reset Change bit to indicate that the reset has completed. Reset the Enable Status bit, enable the embedded function and set its address to 0 by the Set embedded function Address / Enable command. Disable the embedded function interrupt endpoint by the Set Endpoint Enable command.

### SetFeature PORT\_ENABLE

Enable the function by the Set embedded function Address / Enable command. Set the Enable Status bit.

### SetFeature PORT\_SUSPEND

Disable the function by the Set embedded function Address / Enable command. Reset the Enable Status bit and set the Suspend Status bit.

### ClearFeature PORT\_ENABLE

Disable the function by the Set embedded function Address / Enable command. Reset the Enable Status bit.

### ClearFeature PORT\_SUSPEND

Enable the function by the Set embedded function Address / Enable command. Set the Enable Status bit, reset the Suspend Status bit; set the Resume Status Change bit to indicate that the resume has completed.

### ClearFeature any Change Indicator

Clear the corresponding status change bit.

## Babbling Condition

When the embedded function causes a babbling condition, the function is automatically disabled by the PDIUSBH11. As soon as the micro controller detects the babbling error, it must set the Enable Status Change bit and reset the Enable Status bit.

## Remote WakeUp

There are three scenarios a remote wakeup can occur. The following describes the course of actions for each of the cases:

1. The device is not suspended and the embedded port is suspended
  - Enable back the function by setting the enable bit in the Set Address/Enable register and update the following status bits in the micro-controller program: reset the Suspend Status bit, set the Enable Status bit and set the Suspend Status Change bit.
2. The device is suspended and the embedded port is suspended.
  - Send an upstream Resume using the Send Resume command, enable back the function by setting the enable bit in the Set Address/Enable register and update the following status bits in the micro-controller program: reset the Suspend Status bit, set the Enable Status bit and set the Suspend Status Change bit.
3. The device is suspended and the embedded port is enabled
  - Send an upstream resume using the Send Resume command

## RECOMMENDED OPERATING CONDITIONS

| SYMBOL      | PARAMETER                                       | CONDITIONS                               | LIMITS |          | UNIT |
|-------------|---|--|--------|----------|------|
|             |   |  | MIN.   | MAX.     |      |
| $V_{CC}$    | DC supply voltage                               |  | 3.0    | 3.6      | V    |
| $V_I$       | DC Input voltage range                          |  | 0      | 5.5      | V    |
| $V_{I/O}$   | DC input range for I/O                          |  | 0      | 5.5      | V    |
| $V_{A/I/O}$ | DC input range for analog I/O                   |  | 0      | $V_{CC}$ | V    |
| $V_O$       | DC output voltage range                         |  | 0      | $V_{CC}$ | V    |
| $T_{amb}$   | Operating ambient temperature range in free air | See DC and AC characteristics per device | 0      | +70      | °C   |



## Universal Serial Bus Hub

## PDIUSBH11

**ABSOLUTE MAXIMUM RATINGS<sup>1</sup>**

In accordance with the Absolute Maximum Rating System (IEC 134) Voltages are referenced to GND (ground = 0V)

| SYMBOL            | PARAMETER   | CONDITIONS                  | LIMITS |                | UNIT |
|-------------------|---|-----------------------------|--------|----------------|------|
|                   |   |                             | MIN    | MAX            |      |
| $V_{CC}$          | DC supply voltage                                 |                             | -0.5   | +4.6           | V    |
| $I_{IK}$          | DC input diode current                            | $V_I < 0$                   | -      | -50            | mA   |
| $V_I$             | DC input voltage                                  | Note 2                      | -0.5   | +5.5           | V    |
| $V_{I/O}$         | DC input voltage range for I/O's                  |                             | -0.5   | $V_{CC} + 0.5$ | V    |
| $I_{OK}$          | DC output diode current                           | $V_O > V_{CC}$ or $V_O < 0$ | -      | $\pm 50$       | mA   |
| $V_O$             | DC output voltage                                 | Note 2                      | -0.5   | $V_{CC} + 0.5$ | V    |
| $I_O$             | DC output source or sink current for digital pins | $V_O = 0$ to $V_{CC}$       | -      | $\pm 15$       | mA   |
| $I_O$             | DC output source or sink current for D+/D- pins   | $V_O = 0$ to $V_{CC}$       | -      | $\pm 50$       | mA   |
| $I_{GND}, I_{CC}$ | DC $V_{CC}$ or GND current                        |                             | -      | $\pm 100$      | mA   |
| $T_{stg}$         | Storage temperature range                         |                             | -60    | +150           | °C   |
| $P_{tot}$         | Power dissipation per package                     |                             |        |                | mW   |

**NOTES:**

1. Stresses beyond those listed may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
2. The input and output voltage ratings may be exceeded if the input and output clamp current ratings are observed.

# Universal Serial Bus Hub

# PDIUSBH11

## DC CHARACTERISTICS (DIGITAL PINS)

|                         | PARAMETER                     |                               | LIMITS |     |                       |                  |
|-------------------------|-------------------------------|-------------------------------|--------|-----|-----------------------|------------------|
|                         |                               |                               | MIN    | TYP | MAX                   |                  |
| <b>Input Levels:</b>    |                               |                               |        |     |                       |                  |
| V <sub>IL</sub>         | LOW level input voltage       |                               |        |     | 0.9                   | V                |
| V <sub>IH</sub>         | HIGH level input voltage      |                               | 2.5    |     |                       | V                |
| V <sub>TLH</sub>        | LOW to HIGH threshold voltage | ST (Schmitt Trigger) pins     |        |     | 80                    | %V <sub>CC</sub> |
| V <sub>THL</sub>        | HIGH to LOW threshold voltage | ST (Schmitt Trigger) pins     | 20     |     |                       | %V <sub>CC</sub> |
| V <sub>HYS</sub>        | Hysteresis voltage            | ST (Schmitt Trigger) pins     |        | 1.1 |                       | V                |
| <b>Output Levels:</b>   |                               |                               |        |     |                       |                  |
| V <sub>OL</sub>         | LOW level output              | I <sub>OL</sub> = rated drive | 0.4    |     |                       | V                |
|                         |                               | I <sub>OL</sub> = 20µA        | 0.1    |     |                       |                  |
| V <sub>OH</sub>         | HIGH level output             | I <sub>OH</sub> = rated drive |        |     | V <sub>CC</sub> - 0.4 | V                |
|                         |                               | I <sub>OH</sub> = 20µA        |        |     | V <sub>CC</sub> - 0.1 |                  |
| <b>Leakage Current:</b> |                               |                               |        |     |                       |                  |
| I <sub>OZ</sub>         | OFF-state current             | OD (Open Drain) pins          |        |     | ± 5                   | µA               |
| I <sub>I</sub>          | Input leakage current         |                               |        |     | ± 1                   | µA               |

## DC CHARACTERISTICS (AI/O PINS)

|                           | PARAMETER                       |                             | LIMITS |      |    |
|---------------------------|---------------------------------|-----------------------------|--------|------|----|
|                           |                                 |                             | MIN    | MAX  |    |
| <b>Leakage Current:</b>   |                                 |                             |        |      |    |
| I <sub>LO</sub>           | Hi-Z state data line leakage    | 0V < V <sub>IN</sub> < 3.3V |        | ± 10 | µA |
| <b>Input Levels:</b>      |                                 |                             |        |      |    |
| VDI                       | Differential input sensitivity  | ((D+) - (D-))  <sup>1</sup> | 0.2    |      | V  |
| VCM                       | Differential common mode range  | Includes VDI range          | 0.8    | 2.5  | V  |
| VSE                       | Single ended receiver threshold |                             | 0.8    | 2.0  | V  |
| <b>Output Levels:</b>     |                                 |                             |        |      |    |
| V <sub>OL</sub>           | Static output LOW               | RL of 1.5KΩ to 3.6V         |        | 0.3  | V  |
| V <sub>OH</sub>           | Static output HIGH              | RL of 15KΩ to GND           | 2.8    | 3.6  | V  |
| <b>Capacitance:</b>       |                                 |                             |        |      |    |
| C <sub>IN</sub>           | Transceiver capacitance         | Pin to GND                  |        | 20   | pF |
| <b>Output Resistance:</b> |                                 |                             |        |      |    |
| ZDRV <sup>2</sup>         | Driver output resistance        | Steady state drive          | 28     | 43   | Ω  |

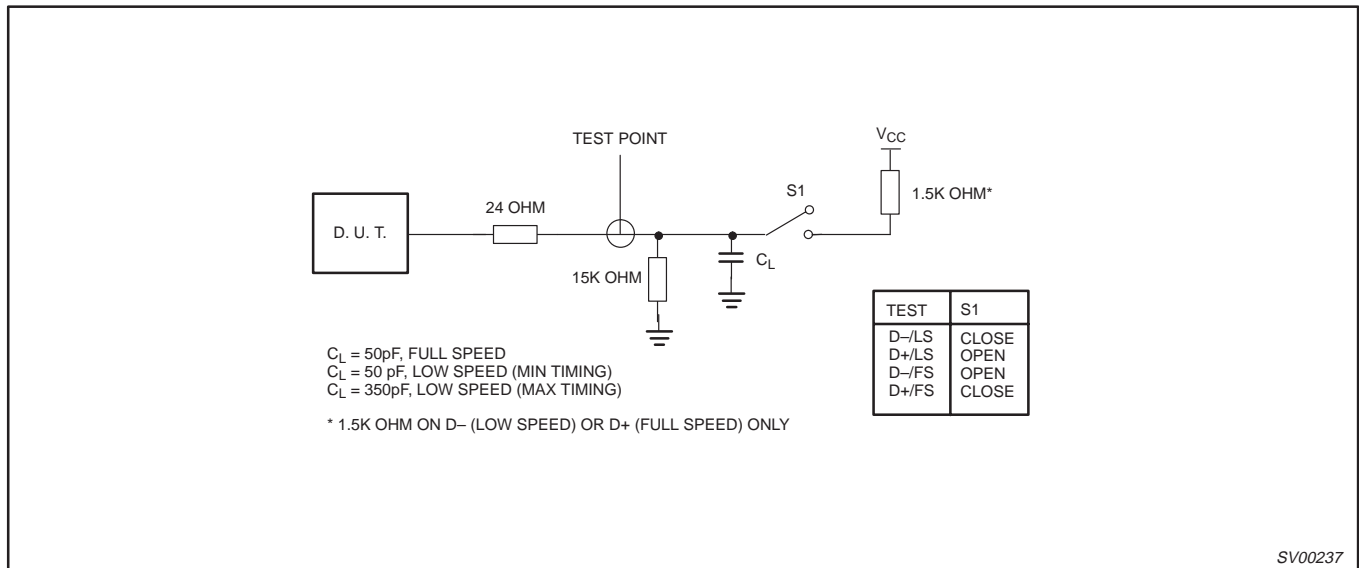
**NOTES:**

1. D+ is the generic symbol for the USB positive data pins: UP\_DP, DN2\_DP, DN3\_DP, DN4\_DP, DN5\_DP. D- is the generic symbol for the USB negative data pins: UP\_DM, DN2\_DM, DN3\_DM, DN4\_DM, DN5\_DM.
2. Includes external resistors of 24Ω ± 1% each on D+ and D-.

# Universal Serial Bus Hub

# PDIUSBH11

## LOAD FOR D+/D-



## AC CHARACTERISTICS (A/I/O PINS. FULL SPEED)

| SYMBOL                         | PARAMETER  | TEST CONDITIONS   | LIMITS      |           | UNIT |
|--------------------------------|--|---|-------------|-----------|------|
|                                |  |   | MIN         | MAX       |      |
| <b>Driver Characteristics:</b> |  | $C_L = 50\text{pF}$ ;<br>$R_{pu} = 1.5\text{K}\Omega$ on D+ to $V_{CC}$ |             |           |      |
| $T_R$<br>$T_F$                 | Transition time:<br>Rise time<br>Fall time                                     | Between 10% and 90%   | 4<br>4      | 20<br>20  | ns   |
| $T_{RFM}$                      | Rise/Fall time matching  | $(T_R/T_F)$   | 90          | 110       | %    |
| $V_{CRS}$                      | Output signal crossover voltage  |   | 1.3         | 2.0       | V    |
| <b>Driver Timings:</b>         |  |   |             |           |      |
| $T_{EOPT}$                     | Source EOP width   | Figure 1  | 160         | 175       | ns   |
| $T_{DEOP}$                     | Differential data to EOP transition skew                                       | Figure 1  | -2          | 5         | ns   |
| <b>Receiver Timings:</b>       |  |   |             |           |      |
| $T_{JR1}$<br>$T_{JR2}$         | Receiver data jitter tolerance<br>To next transition<br>For paired transitions | Characterized and not Tested.<br>Guaranteed by Design.                  | -18.5<br>-9 | 18.5<br>9 | ns   |
| $T_{EOPR1}$<br>$T_{EOPR2}$     | EOP width at receiver<br>Must reject as EOP<br>Must accept                     | Figure 1  | 40<br>82    |           | ns   |
| <b>Hub Timings:</b>            |  | $C_L = 50\text{pF}$ ;<br>$R_{pu} = 1.5\text{K}\Omega$ on D+ to $V_{CC}$ |             |           |      |
| $T_{HDD}$                      | Hub differential data delay  | Figure 2  |             | 40        | ns   |
| $T_{SOP}$                      | Data bit width distortion after SOP  | Figure 2  | -5          | 3         | ns   |
| $T_{EOPDR}$                    | Hub EOP delay relative to $T_{HDD}$  | Figure 3  | 0           | 15        | ns   |
| $T_{HESK}$                     | Hub EOP output width skew  | Figure 3  | -15         | +15       | ns   |

# Universal Serial Bus Hub

# PDIUSBH11

## AC CHARACTERISTICS (A/I/O PINS. LOW SPEED)

| SYMBOL                         | PARAMETER  | TEST CONDITIONS  | LIMITS     |      | UNIT |
|--------------------------------|--|--|------------|------|------|
|                                |  |  | MIN        | MAX  |      |
| <b>Driver Characteristics:</b> |  | $C_L = 50\text{pF}$ and $350\text{pF}$ ;<br>$R_{pu} = 1.5\text{K}\Omega$ on D- to $V_{CC}$ |            |      |      |
| $T_{LR}$                       | Transition time:<br>Rise time                              | Between 10% and 90%  | 75         | 300  | ns   |
| $T_{LF}$                       | Fall time  | $C_L = 50\text{pF}$<br>$C_L = 350\text{pF}$  | 75         | 300  | ns   |
| $V_{LCRS}$                     | Output signal crossover voltage                            |  | 1.3        | 2.0  | V    |
| <b>Driver Timings:</b>         |  |  |            |      |      |
| $T_{LEOPT}$                    | Source EOP width   | Figure 1   | 1.25       | 1.50 | ns   |
| $T_{LDEOP}$                    | Differential data to EOP transition skew                   | Figure 1   | -40        | 100  | ns   |
| <b>Receiver Timings:</b>       |  |  |            |      |      |
| $T_{LEOPR1}$<br>$T_{LEOPR2}$   | EOP width at receiver<br>Must reject as EOP<br>Must accept | Figure 1   | 330<br>675 |      | ns   |
| <b>Hub Timings:</b>            |  | $C_L = 50\text{pF}$ and $350\text{pF}$ ;<br>$R_{pu} = 1.5\text{K}\Omega$ on D- to $V_{CC}$ |            |      |      |
| $T_{LHDD}$                     | Hub differential data delay                                | Figure 2   |            | 300  | ns   |
| $T_{LSOP}$                     | Data bit width distortion after SOP                        | Figure 2   | -65        | 45   | ns   |
| $T_{LEOPDR}$                   | Hub EOP delay relative to $T_{HDD}$                        | Figure 3   | 0          | 200  | ns   |
| $T_{LHESK}$                    | Hub EOP output width skew                                  | Figure 3   | -300       | +300 | ns   |

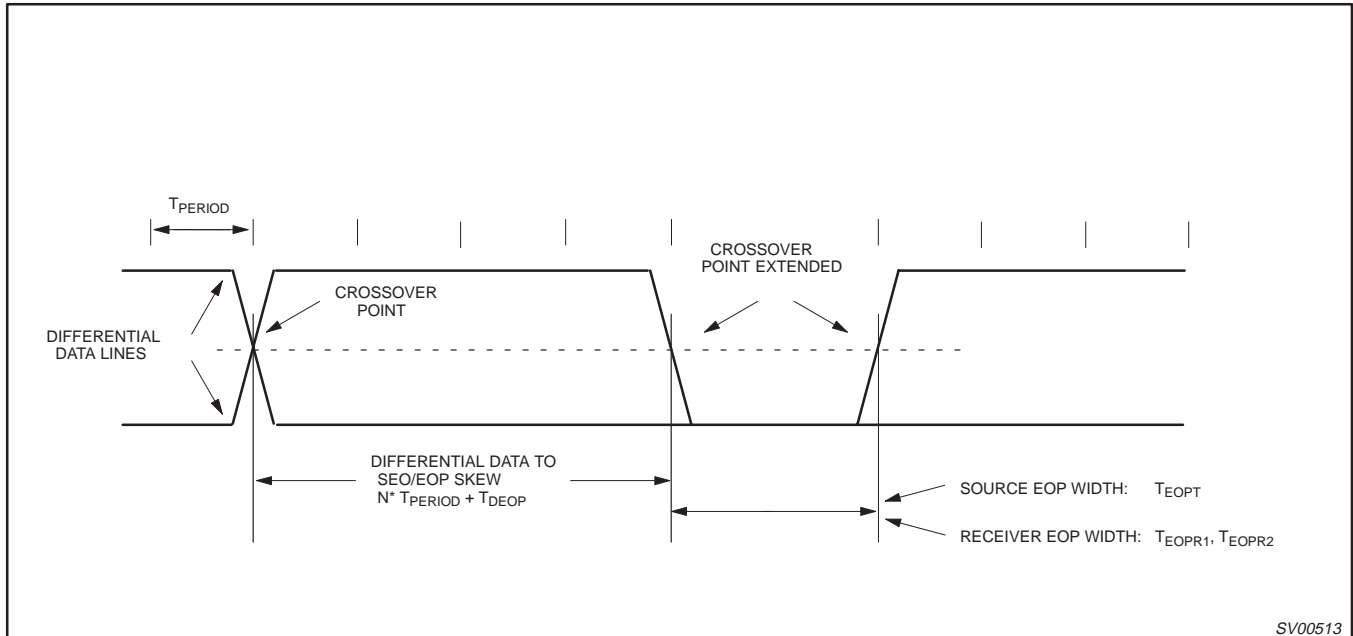


Figure 1. Differential Data to EOP Transition Skew and EOP Width

SV00513

Universal Serial Bus Hub

PDIUSBH11

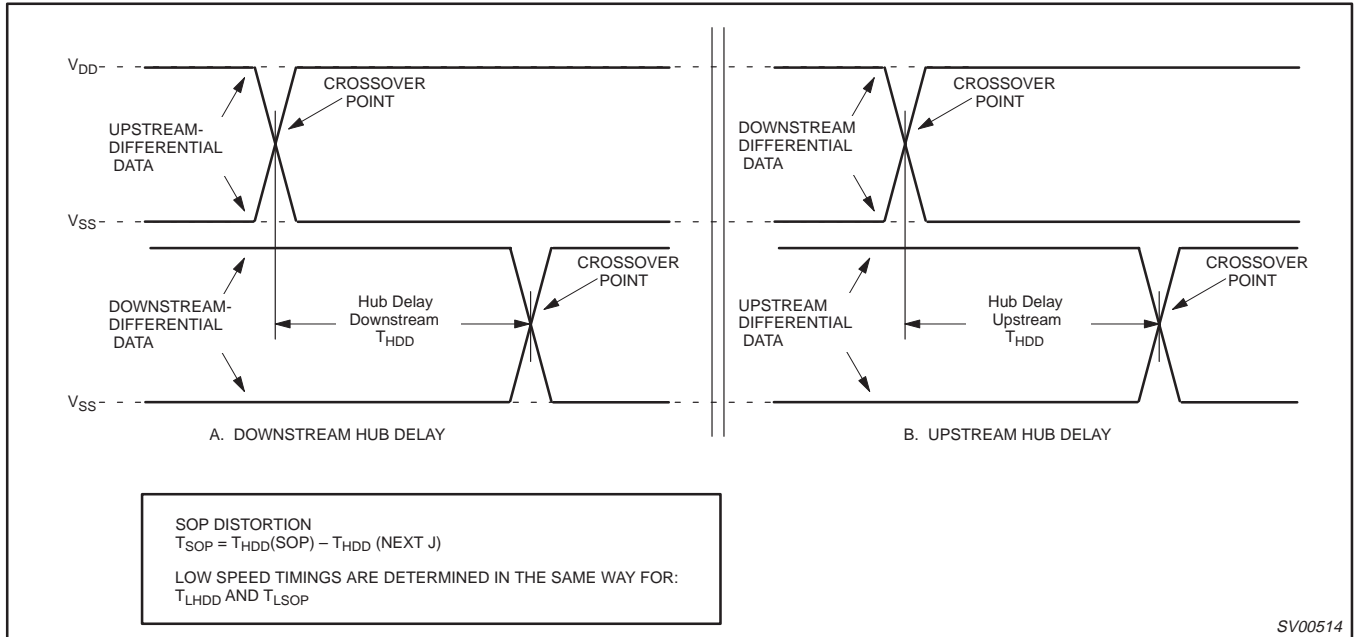


Figure 2. Hub Differential Data Delay and SOP Distortion

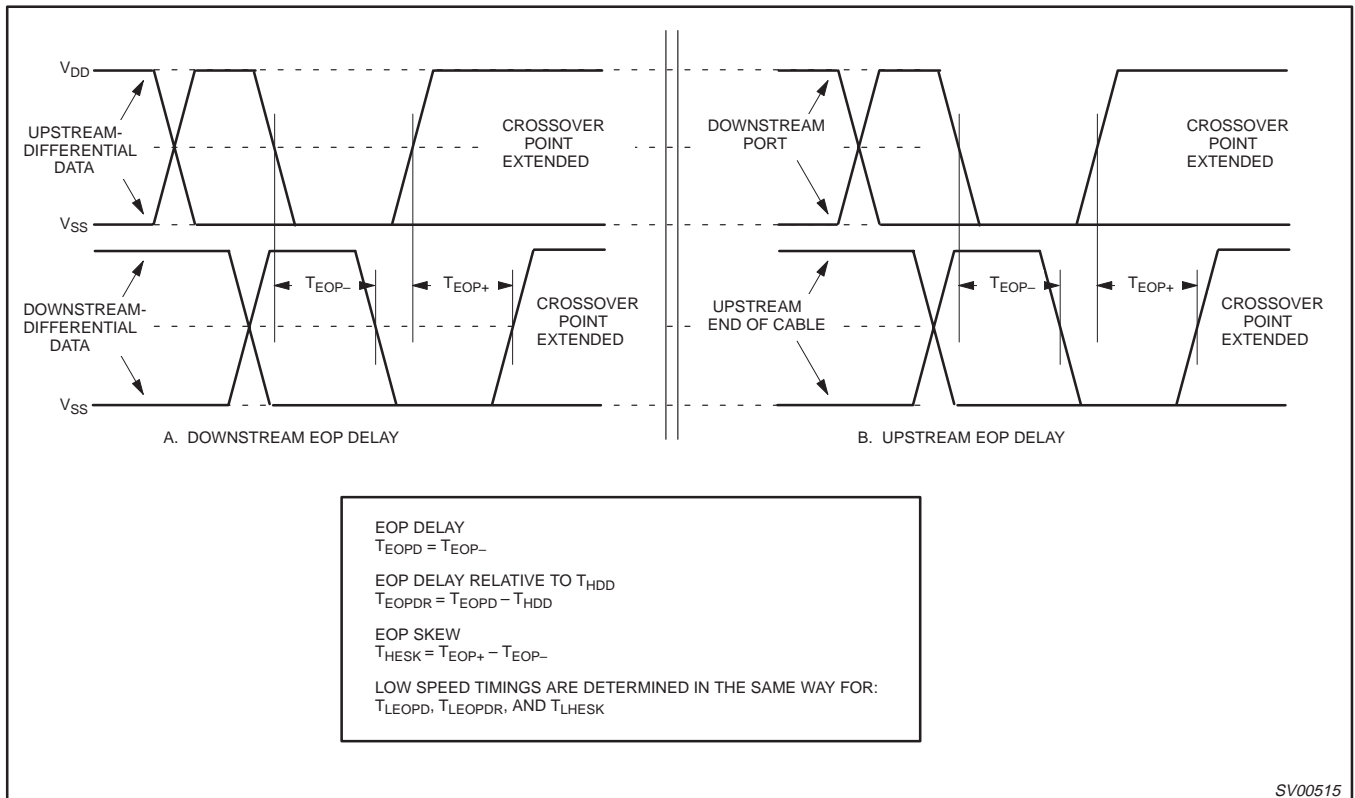


Figure 3. Hub EOP Delay and EOP Skew

# Universal Serial Bus Hub

# PDIUSBH11

## AC CHARACTERISTICS (I<sup>2</sup>C)

All timing values are valid within the operating supply voltage and ambient temperature range and reference to  $V_{IL}$  and  $V_{IH}$  with an input voltage swing of  $V_{SS}$  and  $V_{DD}$ .

| SYMBOL  | PARAMETER                    | LIMITS |     |     | UNIT    |
|---|------------------------------|--------|-----|-----|---------|
|   |                              | MIN    | TYP | MAX |         |
| <b>I<sup>2</sup>C-bus timing (see Figure ; Note )</b> |                              |        |     |     |         |
| $f_{SCL}$   | SCL clock frequency          | –      | –   | 100 | kHz     |
| $t_{SP}$  | Tolerable spike width on bus | –      | –   | 100 | ns      |
| $t_{BUF}$   | Bus free time                | 4.7    | –   | –   | $\mu$ s |
| $t_{SU;STA}$  | Start condition set-up time  | 4.7    | –   | –   | $\mu$ s |
| $t_{HD;STA}$  | Start condition hold time    | 4.0    | –   | –   | $\mu$ s |
| $t_{LOW}$   | SCL LOW time                 | 4.7    | –   | –   | $\mu$ s |
| $t_{HIGH}$  | SCL HIGH time                | 4.0    | –   | –   | $\mu$ s |
| $t_r$   | SCL and SDA rise times       | –      | –   | 1.0 | $\mu$ s |
| $t_f$   | SCL and SDA fall times       | –      | –   | 0.3 | $\mu$ s |
| $t_{SU;DAT}$  | Data set-up time             | 250    | –   | –   | ns      |
| $t_{HD;DAT}$  | Data hold time               | 0      | –   | –   | ns      |
| $t_{VD;DAT}$  | SCL LOW to data out valid    | –      | –   | 3.4 | $\mu$ s |
| $t_{SU;STO}$  | Stop condition set-up time   | 4.0    | –   | –   | $\mu$ s |

1. A detailed description of the I<sup>2</sup>C-bus specification, with applications, is given in brochure "The I<sup>2</sup>C-bus and how to use it". This brochure may be ordered using the code 9398 393 40011.

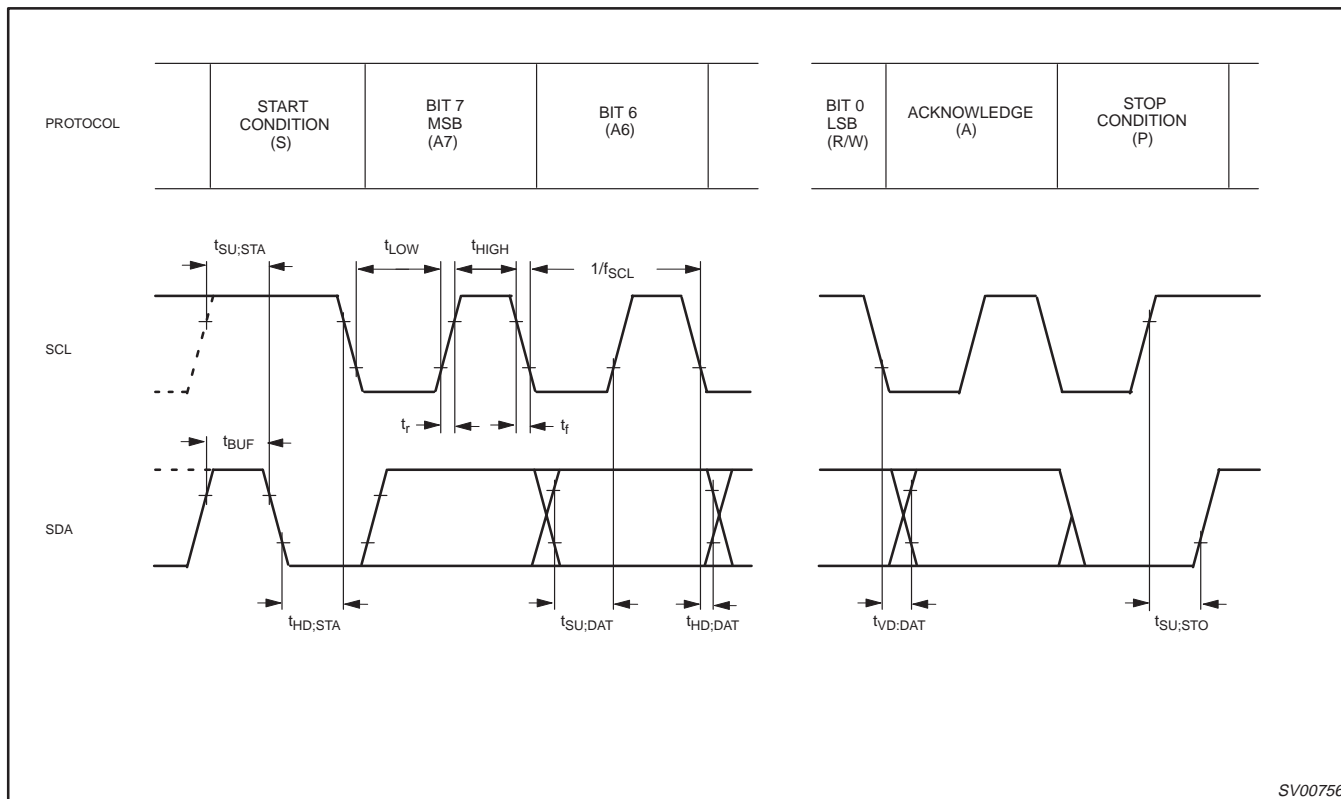


Figure 4. I<sup>2</sup>C-bus timing diagram; rise and fall times refer to  $V_{IL}$  and  $V_{IH}$

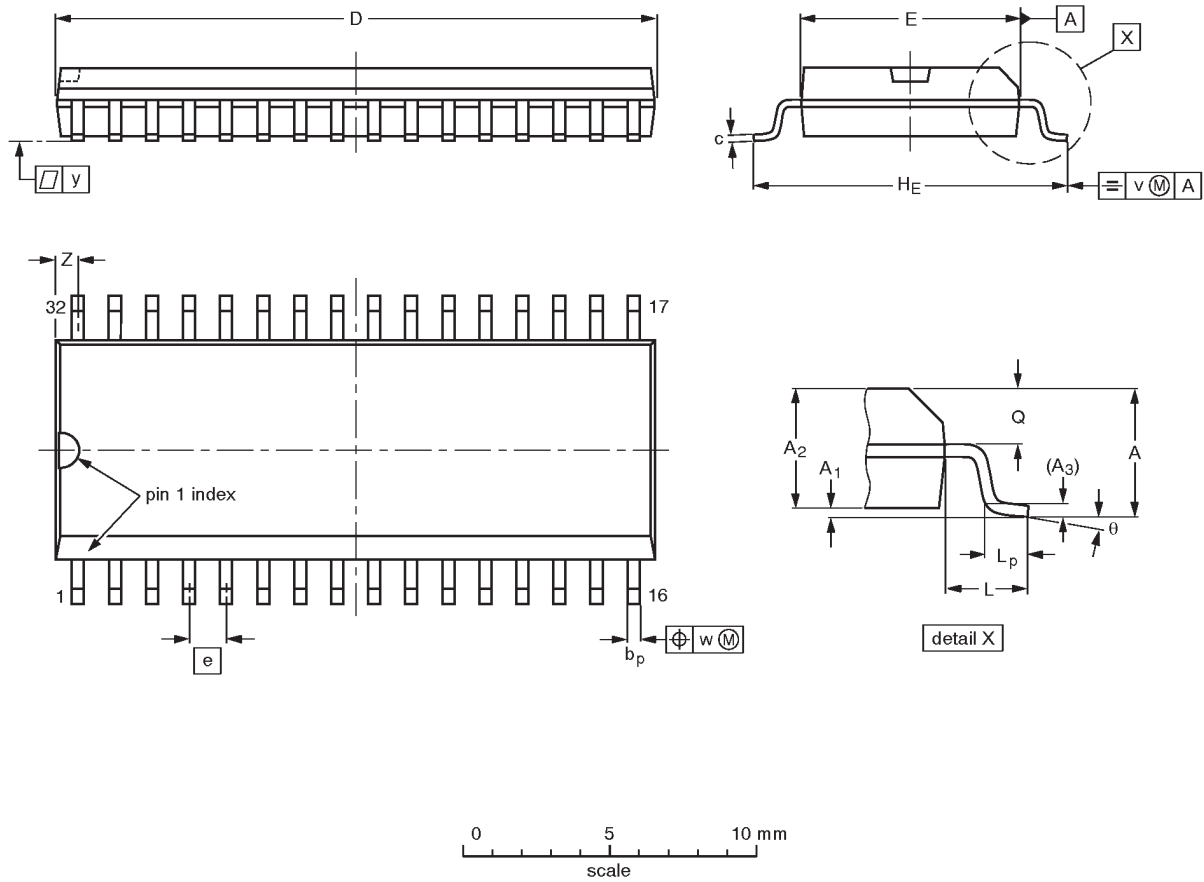
SV00756

Universal Serial Bus Hub

PDIUSBH11

SO32: plastic small outline package; 32 leads; body width 7.5mm

SOT287-1



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

| UNIT   | A max. | A <sub>1</sub> | A <sub>2</sub> | A <sub>3</sub> | b <sub>p</sub> | c              | D <sup>(1)</sup> | E <sup>(1)</sup> | e     | H <sub>E</sub> | L     | L <sub>p</sub> | Q              | v    | w    | y     | Z <sup>(1)</sup> | θ        |
|--------|--------|----------------|----------------|----------------|----------------|----------------|------------------|------------------|-------|----------------|-------|----------------|----------------|------|------|-------|------------------|----------|
| mm     | 2.65   | 0.3<br>0.1     | 2.45<br>2.25   | 0.25           | 0.49<br>0.36   | 0.27<br>0.18   | 20.7<br>20.3     | 7.6<br>7.4       | 1.27  | 10.65<br>10.00 | 1.4   | 1.1<br>0.4     | 1.2<br>1.0     | 0.25 | 0.25 | 0.1   | 0.95<br>0.55     | 8°<br>0° |
| inches | 0.10   | 0.012<br>0.004 | 0.096<br>0.086 | 0.01           | 0.02<br>0.01   | 0.011<br>0.007 | 0.81<br>0.80     | 0.30<br>0.29     | 0.050 | 0.42<br>0.39   | 0.055 | 0.043<br>0.016 | 0.047<br>0.039 | 0.01 | 0.01 | 0.004 | 0.037<br>0.022   |          |

Note

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.

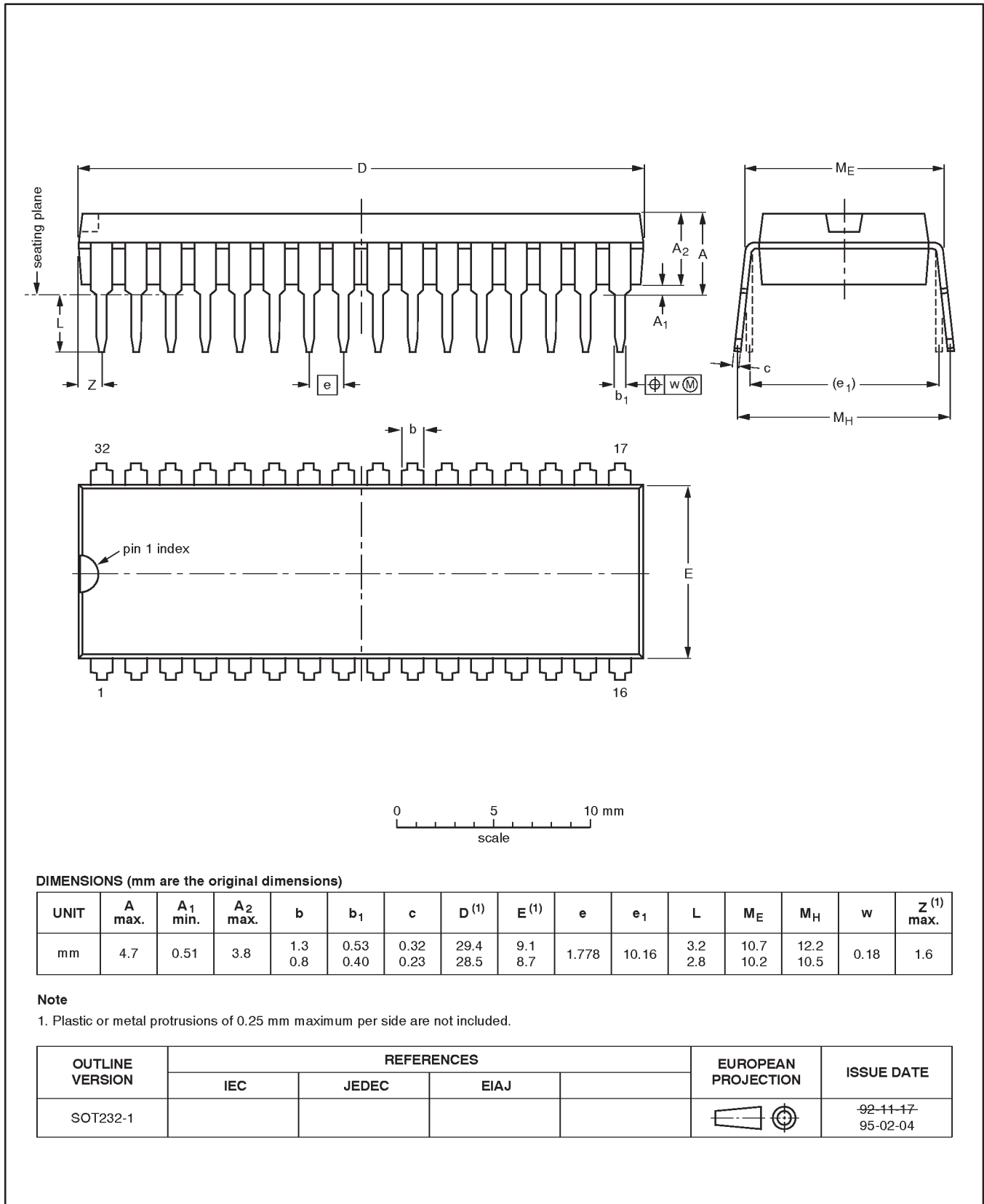
| OUTLINE VERSION | REFERENCES |       |      |  | EUROPEAN PROJECTION | ISSUE DATE           |
|-----------------|------------|-------|------|--|---------------------|----------------------|
|                 | IEC        | JEDEC | EIAJ |  |                     |                      |
| SOT287-1        |            |       |      |  |                     | 92-11-17<br>95-01-25 |

Universal Serial Bus Hub

PDIUSBH11

SDIP32: plastic shrink dual in-line package; 32 leads (400 mil)

SOT232-1



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

| UNIT | A max. | A <sub>1</sub> min. | A <sub>2</sub> max. | b          | b <sub>1</sub> | c            | D <sup>(1)</sup> | E <sup>(1)</sup> | e     | e <sub>1</sub> | L          | M <sub>E</sub> | M <sub>H</sub> | w    | Z <sup>(1)</sup> max. |
|------|--------|---------------------|---------------------|------------|----------------|--------------|------------------|------------------|-------|----------------|------------|----------------|----------------|------|-----------------------|
| mm   | 4.7    | 0.51                | 3.8                 | 1.3<br>0.8 | 0.53<br>0.40   | 0.32<br>0.23 | 29.4<br>28.5     | 9.1<br>8.7       | 1.778 | 10.16          | 3.2<br>2.8 | 10.7<br>10.2   | 12.2<br>10.5   | 0.18 | 1.6                   |

**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 | EIAJ |  |                     |                      |
| SOT232-1        |            |       |      |  |                     | 92-11-17<br>95-02-04 |



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# Universal Serial Bus Hub

# PDIUSBH11

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## NOTES

## Universal serial bus hub

## PDIUSBH11

## DEFINITIONS

| Data Sheet Identification        | Product Status                | Definition   |
|----------------------------------|-------------------------------|--|
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