DATA SHEET

PDIUSBH11
Universal Serial Bus hub

Preliminary specification

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Philips
Semiconductors

PHILIPS

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^2C interface
- Compliant with USB Human Interface and Display Device Class
- Single 3.3V supply and SDIP32 package

DESCRIPTION

The Philips Semiconductors Universal Serial Bus (USB) hub is designed to provide USB expandability in a PC system and plug-and-play control of the embedded function, for example, monitor. The PDIUSBH11 is used in a microcontroller based system and communicates with the system microcontroller over the I^2C serial bus.

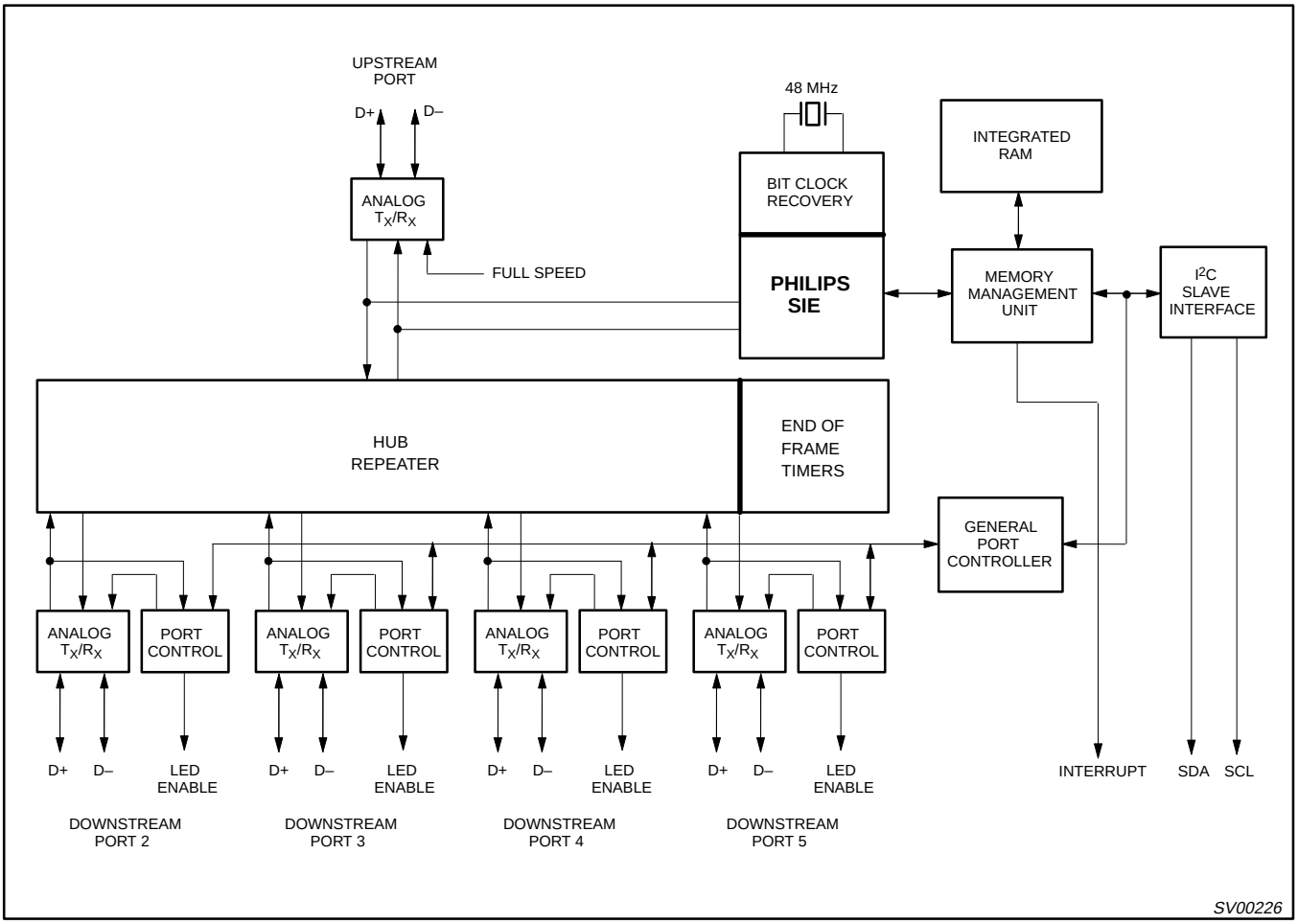
This modular approach to implementing a hub and embedded function allows the designer to either use a low cost dedicated microcontroller or adapt the existing system microcontroller. The PDIUSBH11 conforms to the USB specification 1.0 and the I^2C serial interface specification.

Since the device is a compound USB device (hub function plus embedded function), the embedded function appears as PORT1 to the host system. The four expansion 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.

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^2C–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 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: synchronisation 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^2C 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^2C.

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

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 DNx_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 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 DN2_EN_N remains an LED enable pin. Pin TEST3 should always be connected to Ground at all times.

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		Crystal connection 1 (48MHz)
7	XTAL2	O		Crystal connection 2 (48MHz)
8	CLK12MHZ	O	2mA	12MHz output clock for external devices
9	V_{CC}	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^2C bi-directional data
19	SCL	I/O	OD4	I^2C bit-clock
20	GND	POWER		Ground reference
21	DN5_DP	AI/O		Downstream port 5 D^+ connection
22	DN5_DM	AI/O		Downstream port 5 D^- connection
23	DN4_DP	AI/O		Downstream port 4 D^+ connection
24	DN4_DM	AI/O		Downstream port 4 D^- connection
25	DN3_DP	AI/O		Downstream port 3 D^+ connection
26	DN3_DM	AI/O		Downstream port 3 D^- connection
27	DN2_DP	AI/O		Downstream port 2 D^+ connection
28	DN2_DM	AI/O		Downstream port 2 D^- connection
29	AGND	POWER		Analog Ground reference
30	AV_{CC}	POWER		Analog voltage supply 3.3V 0.3V
31	UP_DP	AI/O		Upstream D^+ connection
32	UP_DM	AI/O		Upstream D^- connection

PIN DESCRIPTION (MODE 1)

PIN NO	PIN SYMBOL	I/O	DRIVE	NAME AND FUNCTION
1	TEST1	I		Connect to V_{CC}
2	TEST2	I		Connect to V_{CC}
3	TEST3	I		Connect to Ground
4	RESET_N	I	ST	Power-on reset
5	GND	POWER		Ground reference
6	XTAL1	I		Crystal connection 1 (48MHz)
7	XTAL2	O		Crystal connection 2 (48MHz)
8	CLK12MHZ	O	2mA	12MHz output clock for external devices
9	V_{CC}	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^2C bi-directional data
19	SCL	I/O	OD4	I^2C bit-clock
20	GND	POWER		Ground reference
21	DN5_DP	AI/O		Downstream port 5 D^+ connection
22	DN5_DM	AI/O		Downstream port 5 D^- connection
23	DN4_DP	AI/O		Downstream port 4 D^+ connection
24	DN4_DM	AI/O		Downstream port 4 D^- connection
25	DN3_DP	AI/O		Downstream port 3 D^+ connection
26	DN3_DM	AI/O		Downstream port 3 D^- connection
27	DN2_DP	AI/O		Downstream port 2 D^+ connection
28	DN2_DM	AI/O		Downstream port 2 D^- connection
29	AGND	POWER		Analog Ground reference
30	AV_{CC}	POWER		Analog voltage supply 3.3V 0.3V
31	UP_DP	AI/O		Upstream D^+ connection
32	UP_DM	AI/O		Upstream D^- connection

NOTES:
1. 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

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
$V_{AI/O}$	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 for individual device	0	+70	°C

ABSOLUTE MAXIMUM RATINGS[1]

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 $V_O < 0$	–	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 VP/VM, RCV pins	V_O = 0 to V_{CC}	–	15	mA
I_O	DC output source or sink current for D+/D– pins	V_O = 0 to V_{CC}	–	50	mA
I_{GND}, I_{CC}	DC V_{CC} or GND current		–	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.

DC ELECTRICAL CHARACTERISTICS (DIGITAL PINS)

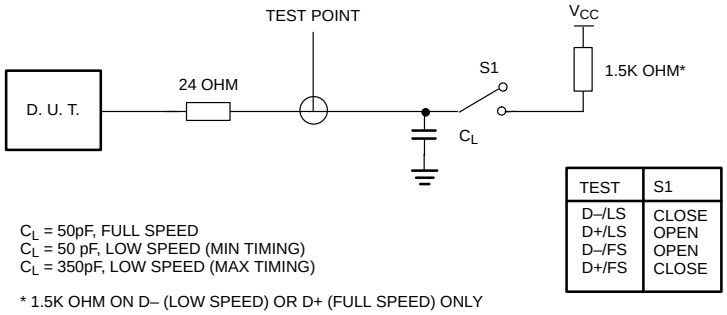
SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			Temp = 0°C to +70°C			
			MIN	TYP	MAX	
Input Levels:						
V_{IH}	HIGH level input voltage				0.9	V
V_{IL}	LOW level input voltage		2.5			V
VTLH	LOW to HIGH threshold voltage	ST (Schmitt Trigger) pins			80	$\%V_{CC}$
VTHL	HIGH to LOW threshold voltage	ST (Schmitt Trigger) pins	20			$\%V_{CC}$
VHYS	Hysteresis voltage	ST (Schmitt Trigger) pins		1.1		V
Output Levels:						
V_{OH}	HIGH level output	I_{OL} = rated drive	0.4			V
		I_{OL} = 20µA	0.1			
V_{OL}	LOW level output	I_{OH} = rated drive			V_{CC} –0.4	V
		I_{OH} = 20µA			V_{CC} –0.1	
Leakage Current:						
I_{CCS}	Supply current in Suspend	Oscillator stopped			100	µA
I_I	*Input leakage current*				1	µA
I_{OZ}	3-State output OFF-state current	OD (Open Drain) pins			5	µA

DC ELECTRICAL CHARACTERISTICS (AI/O PINS)

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS		UNIT
			Temp = 0°C to +70°C		
			MIN	MAX	
Leakage Current:					
I_{LO}	Hi–Z state data line leakage	0V < V_{IN} < 3.3V		10	µA
Input Levels:					
VDI	Differential input sensitivity	|(D+) – (D–)|[1]	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
Output Levels:					
V_{OL}	Static output LOW	RL of 1.5K to 3.6V		0.3	V
V_{OH}	Static output HIGH	RL of 1.5K to GND	2.8	3.6	V
Capacitance:					
C_{IN}	*Transceiver capacitance*	Pin to GND		20	pF
Output Resistance:					
ZDRV[2]	Driver output resistance	Steady state drive	28	43	

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 24 1% each on D+ and D–.

LOAD FOR D+/D–



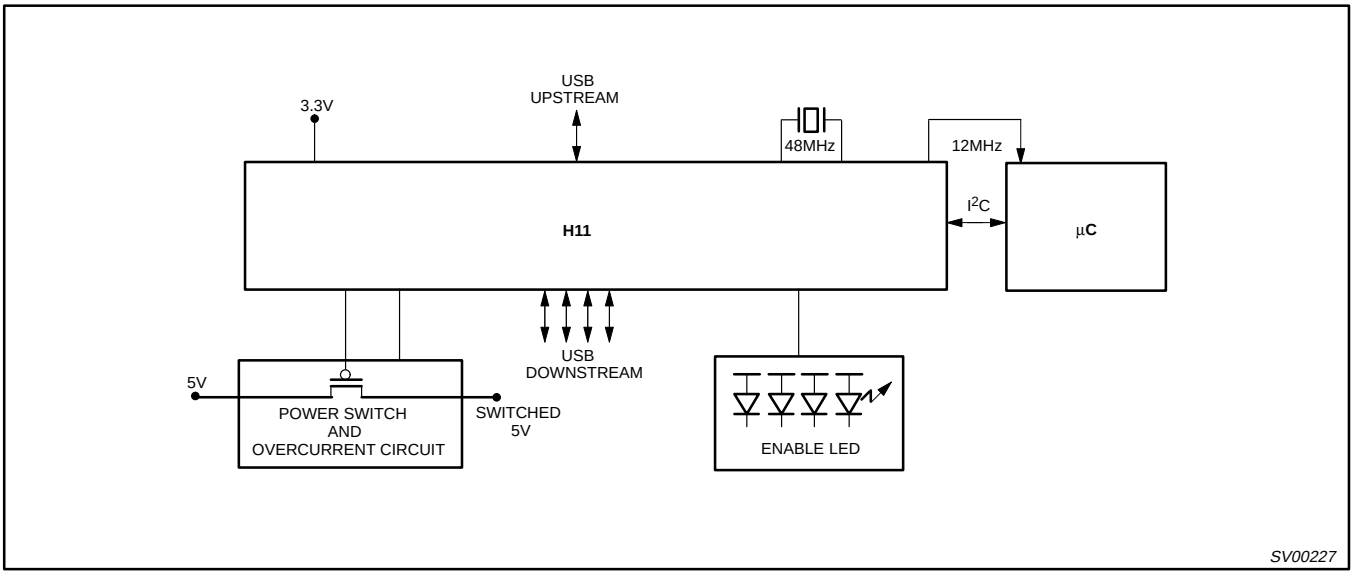
TEST	S1
D–/LS	CLOSE
D+/LS	OPEN
D–/FS	OPEN
D+/FS	CLOSE

C_L = 50pF, FULL SPEED
C_L = 50 pF, LOW SPEED (MIN TIMING)
C_L = 350pF, LOW SPEED (MAX TIMING)

* 1.5K OHM ON D– (LOW SPEED) OR D+ (FULL SPEED) ONLY

SV00237

APPLICATION DIAGRAM



I²C Interface.
The I²C bus is used to interface to an external micro–controller 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 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 (ex. 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.

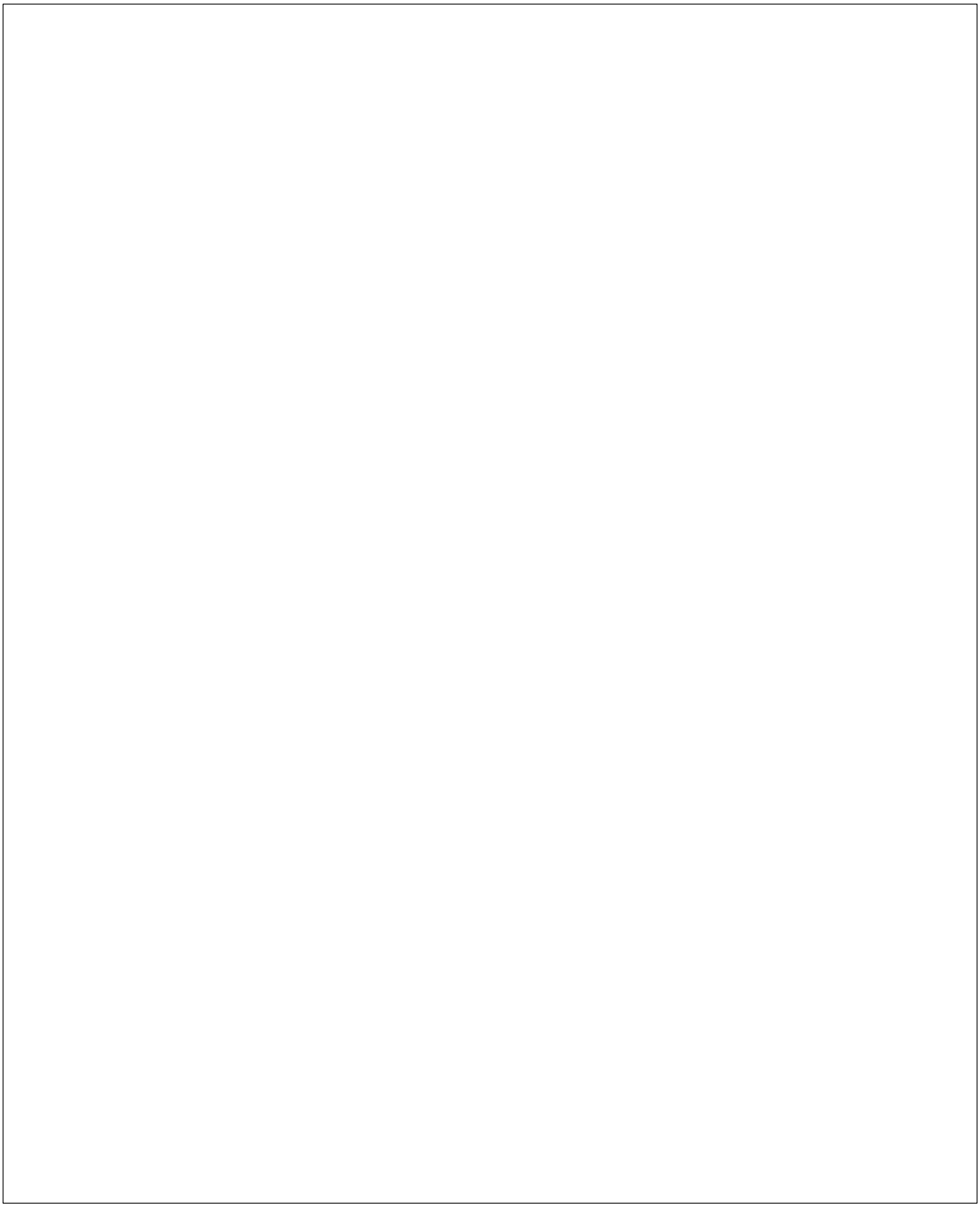
Timing
When the master writes data to the PDIUSBH11, the data is sampled 1 micro–second after the rising edge of SCL. When the PDIUSBH11 writes data to the master, the data is driven 1 micro–second after the falling edge of SCL.

COMMAND SUMMARY

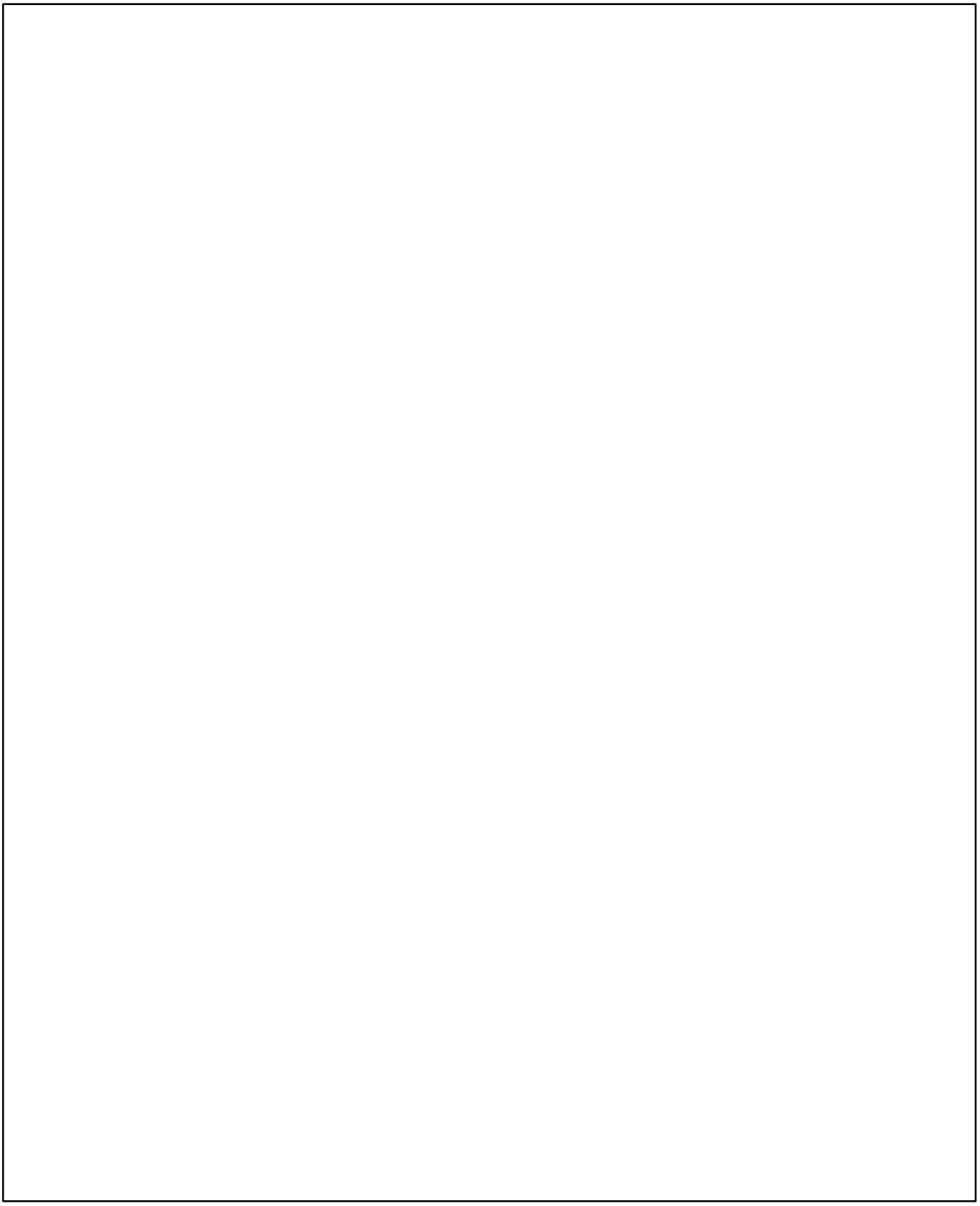
Some commands have the same command code (e.g., Read Buffer and Write Buffer). In these cases, the direction of the Data Phase (read or write) indicates which command is executed.

COMMAND NAME	RECIPIENT	CODING	DATA PHASE
Initialization Commands			
Set Address / Enable	Hub	D0h	Write 1 byte
	Embedded Function	D1h	Write 1 byte
Set Endpoint Enable	Hub + Embedded Function	D8h	Write 1 byte
Data Flow Commands			
Read Intereupt Register		F4h	Read 1 byte
Read Endpoint 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
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 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
Hub Commands			
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		E7h	Write 1 byte
General Commands			
Send Resume		F6h	None
Read Current Frame Number		F5h	Read 1 or 2 bytes

SO32: plastic small outline package; 32 leads; body width 7.5mm **SOT287-1**



SDIP32: plastic shrink dual in-line package; 32 leads (400 mil) **SOT232-1**



NOTES

DEFINITIONS

Data Sheet Identification	Product Status	Definition
Objective Specification	Formative or in Design	This data sheet contains the design target or goal specifications for product development. Specifications may change in any manner without notice.
Preliminary Specification	Preproduction Product	This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
Product Specification	Full Production	This data sheet contains Final Specifications. Philips Semiconductors reserves the right to make changes at any time without notice, in order to improve design and supply the best possible product.

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