



1. General description

The ISP1122 is a stand-alone Universal Serial Bus (USB) hub controller which complies with “*USB Specification Rev. 1.1*”. It integrates a Serial Interface Engine (SIE), hub repeater, hub controller, USB data transceivers and a 3.3 V voltage regulator. It has a configurable number of downstream ports, ranging from 2 to 5.

The ISP1122 can be bus-powered, self-powered or hybrid-powered. When it is hybrid-powered the hub functions are powered by the upstream power supply (V_{BUS}), but the downstream ports are powered by an external 5 Volt supply. The low power consumption in ‘suspend’ mode allows easy design of equipment that is compliant with the ACPI™, OnNow™ and USB power management requirements.

The ISP1122 has built-in overcurrent sense inputs, supporting both individual and ganged mode overcurrent protection for downstream ports. All ports (including the hub) have GoodLink™ indicator outputs for easy visual monitoring of USB traffic.

The ISP1122 has a serial I²C-bus interface for external EEPROM access, a reduced frequency (6 MHz) crystal oscillator and integrated bus termination resistors. These features allow significant cost savings in system design and make the implementation of advanced USB functionality into PC peripherals easy.

2. Features

- High performance USB interface with integrated hub repeater, hub controller, Serial Interface Engine (SIE), data transceivers and 3.3 V voltage regulator
- Complies with “*Universal Serial Bus Specification Rev. 1.1*” and ACPI, OnNow and USB power management requirements
- Configurable from 2 to 5 downstream ports with automatic speed detection
- Internal power-on reset and low voltage reset circuit
- Supports bus-powered, hybrid powered and self-powered application
- Individual or global power switching for downstream ports
- Individual or ganged port overcurrent protection with built-in sense circuits
- 6 MHz crystal oscillator with on-chip PLL for low EMI
- Visual USB traffic monitoring (GoodLink) for hub and downstream ports
- I²C-bus interface to read Vendor ID, Product ID and configuration bits from external EEPROM
- Operation over the extended USB bus voltage range (4.0 to 5.5 V)

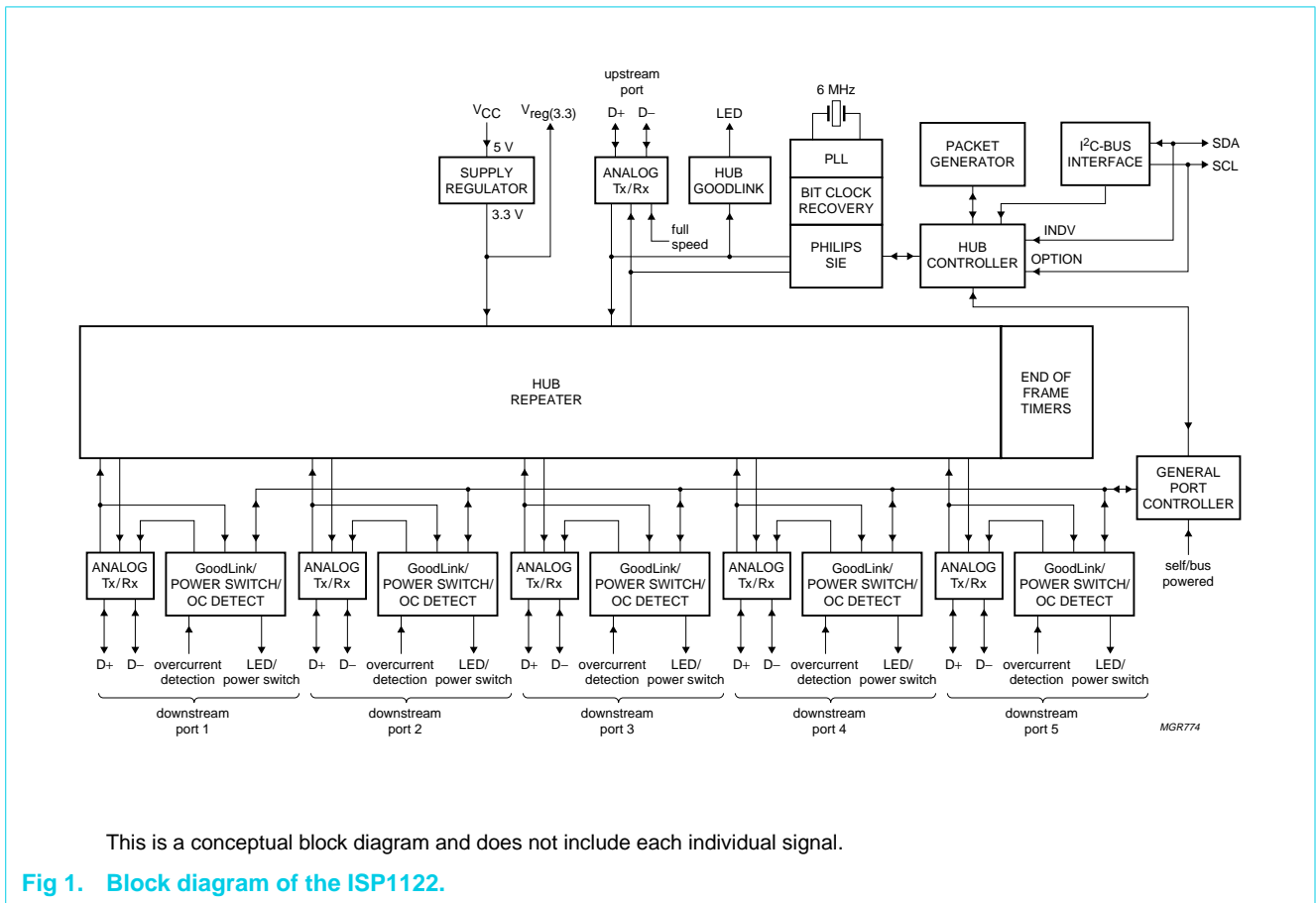
- Operating temperature range from -40 to +85 °C
- 8 kV in-circuit ESD protection for lower cost of external components
- Full-scan design with high test coverage
- Available in 32-pin SDIP and SO packages.

3. Ordering information

Table 1: Ordering information

Type number	Package		Version
	Name	Description	
ISP1122D	SO32	plastic small outline package; 32 leads; body width 7.5 mm	SOT287-1
ISP1122NB	SDIP32	plastic shrink dual in-line package; 32 leads (400 mil)	SOT232-1

4. Block diagram



5. Pinning information

5.1 Pinning

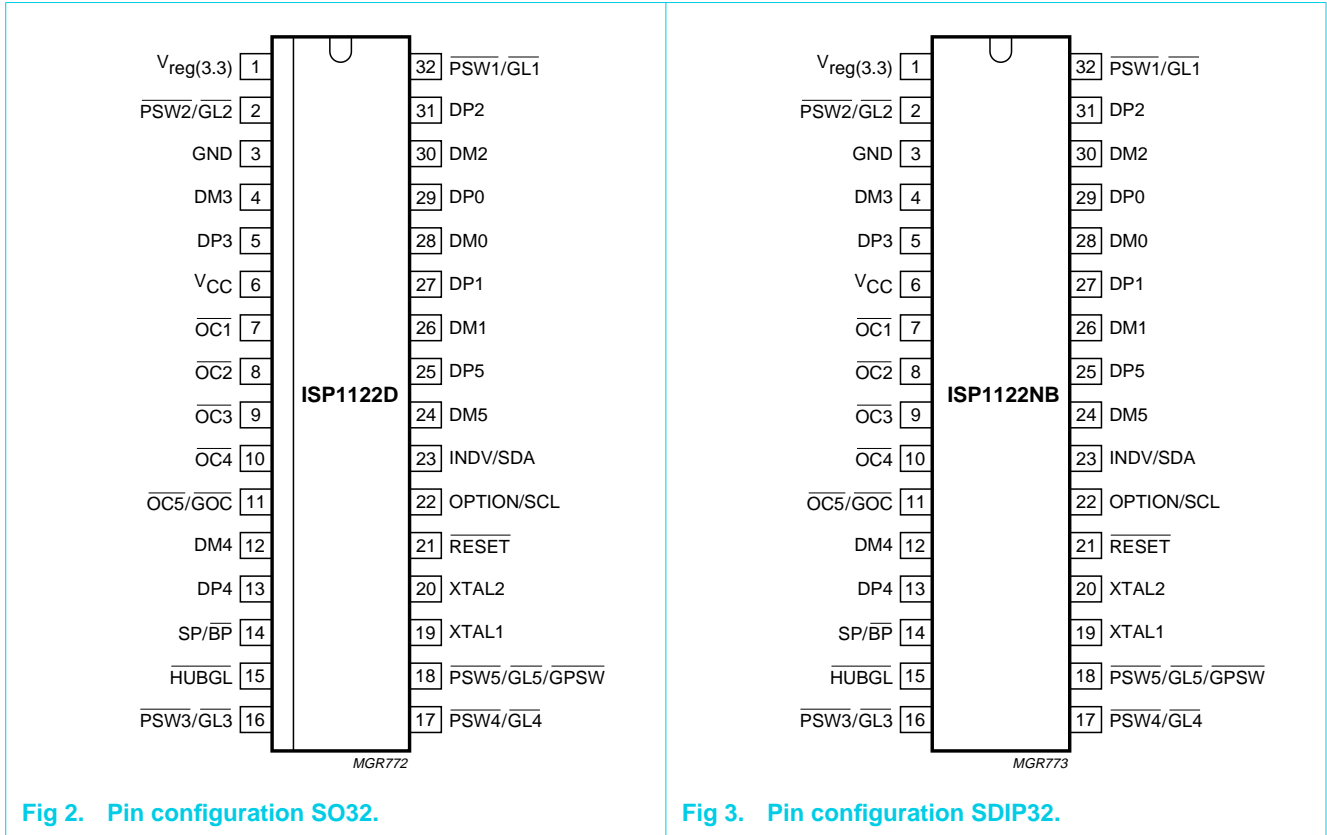


Fig 2. Pin configuration SO32.

Fig 3. Pin configuration SDIP32.

5.2 Pin description

Table 2: Pin description for SO32 and SDIP32

Symbol	Pin	Type	Description
V _{reg(3.3)}	1	-	regulated supply voltage (3.3 V ± 10%) from internal regulator; used to connect pull-up resistor on DP0 line
PSW2/GL2 ^[1]	2	O	modes 4 to 6: power switch control output for downstream port 2 modes 0 to 3, 7: GoodLink LED indicator output for downstream port 2 (open drain, 6 mA); to connect an LED use a 330 Ω series resistor
GND	3	-	ground supply
DM3	4	AI/O	downstream port 3 D- connection (analog) ^[2]
DP3	5	AI/O	downstream port 3 D+ connection (analog) ^[2]
V _{CC}	6	-	supply voltage; connect to USB supply V _{BUS} (bus-powered or hybrid-powered) or to local supply V _{DD} (self-powered)
OC1	7	AI/I	overcurrent sense input for downstream port 1 (analog) ^[3]
OC2	8	AI/I	overcurrent sense input for downstream port 2 (analog) ^[3]
OC3	9	AI/I	overcurrent sense input for downstream port 3 (analog) ^[3]

Table 2: Pin description for SO32 and SDIP32...continued

Symbol	Pin	Type	Description
$\overline{\text{OC4}}$	10	AI/I	overcurrent sense input for downstream port 4 (analog ^[3])
$\overline{\text{OC5/GOC}}$ ^[1]	11	AI/I	modes 5, 7: overcurrent sense input for downstream port 5 (analog ^[3]) modes 0, 1, 3: global overcurrent sense input (analog ^[3])
DM4	12	AI/O	downstream port 4 D- connection (analog) ^[2]
DP4	13	AI/O	downstream port 4 D+ connection (analog) ^[2]
SP/ $\overline{\text{BP}}$	14	I	selects power mode: self-powered: connect to V_{DD} (local power supply); also use this mode for hybrid-powered operation bus-powered: connect to GND via a 1 M Ω resistor; disable downstream port 5 to meet supply current requirements ^[2]
$\overline{\text{HUBGL}}$	15	O	hub GoodLink LED indicator output (open drain, 6 mA); to connect an LED use a 330 Ω series resistor; if unused connect to V_{CC} via a 10 k Ω resistor
$\overline{\text{PSW3/GL3}}$ ^[1]	16	O	modes 4 to 6: power switch control output for downstream port 3 modes 0 to 3, 7: GoodLink LED indicator output for downstream port 3 (open drain, 6 mA); to connect an LED use a 330 Ω series resistor
$\overline{\text{PSW4/GL4}}$ ^[1]	17	O	modes 4 to 6: power switch control output for downstream port 4 modes 0 to 3, 7: GoodLink LED indicator output for downstream port 4 (open drain, 6 mA); to connect an LED use a 330 Ω series resistor
$\overline{\text{PSW5/GL5/GPSW}}$ ^[1]	18	O	mode 5: power switch control output for downstream port 5 modes 3, 7: GoodLink LED indicator output for downstream port 5 (open drain, 6 mA); to connect an LED use a 330 Ω series resistor modes 0 to 2: gang mode power switch control output
XTAL1	19	I	crystal oscillator input (6 MHz)
XTAL2	20	O	crystal oscillator output (6 MHz)
$\overline{\text{RESET}}$	21	I	reset input (Schmitt trigger); a LOW level produces an asynchronous reset; connect to V_{CC} for power-on reset (internal POR circuit)
OPTION/SCL	22	I/O	mode selection input; also functions as I ² C-bus clock output (open drain, 6 mA)
INDV/SDA	23	I/O	selects individual (HIGH) or global (LOW) power switching and overcurrent detection; also functions as bidirectional I ² C-bus data line (open drain, 6 mA)
DM5	24	AI/O	downstream port 5 D- connection (analog) ^[2]
DP5	25	AI/O	downstream port 5 D+ connection (analog) ^[2]
DM1	26	AI/O	downstream port 1 D- connection (analog) ^[4]
DP1	27	AI/O	downstream port 1 D+ connection (analog) ^[4]
DM0	28	AI/O	upstream port D- connection (analog)
DP0	29	AI/O	upstream port D+ connection (analog)

Table 2: Pin description for SO32 and SDIP32...continued

Symbol	Pin	Type	Description
DM2	30	AI/O	downstream port 2 D- connection (analog) ^[4]
DP2	31	AI/O	downstream port 2 D+ connection (analog) ^[4]
$\overline{\text{PSW1/GL1}}$ ^[1]	32	O	modes 4 to 6: power switch control output for downstream port 1 modes 0 to 3, 7: GoodLink LED indicator output for downstream port 1 (open drain, 6 mA); to connect an LED use a 330 Ω series resistor

- [1] See [Table 3 "Mode selection"](#).
- [2] To disable a downstream port connect both D+ and D- to $V_{\text{reg}(3,3)}$; unused ports must be disabled in reverse order starting from port 5.
- [3] Analog detection circuit can be switched off via external EEPROM, see [Table 22](#). In that case the pin functions as a logic input (TTL level).
- [4] Downstream ports 1 and 2 cannot be disabled.

The ISP1122 has several modes of operation, each corresponding with a different pin configuration. Modes are selected by means of pins INDV, OPTION and SP/ $\overline{\text{BP}}$, as shown in [Table 3](#).

Table 3: Mode selection

Mode	INDV ^[1]	OPTION	SP/BP ^[2]	$\overline{\text{PSWn/GLn}}$ (n = 1 to 4)	$\overline{\text{PSW5/GL5/GPSW}}$	$\overline{\text{OCn}}$ (n = 1 to 4)	$\overline{\text{OC5/GOC}}$
0	0	0	0	GoodLink	ganged power	inactive	global overcurrent
1	0	0	1	GoodLink	ganged power	inactive	global overcurrent
2	0	1	0	GoodLink	ganged power	inactive ^[3]	inactive ^[3]
3	0	1	1	GoodLink ^[4]	GoodLink ^[4]	inactive	global overcurrent
4	1	0	0	individual power	inactive	individual overcurrent	inactive
5	1	0	1	individual power	individual power	individual overcurrent	individual overcurrent
6	1	1	0	individual power	inactive	inactive ^[3]	inactive ^[3]
7	1	1	1	GoodLink ^[4]	GoodLink ^[4]	individual overcurrent	individual overcurrent

- [1] Port power switching: logic 0 = ganged, logic 1 = individual.
- [2] Power mode: logic 0 = bus-powered, logic 1 = self-powered (or hybrid-powered).
- [3] No overcurrent detection.
- [4] No power switching.

6. Functional description

The ISP1122 is a stand-alone USB hub with up to 5 downstream ports. The number of ports can be configured between 2 and 5. The downstream ports can be used to connect low-speed or full-speed USB peripherals. All standard USB requests from the host are handled by the hardware without the need for firmware intervention. The block diagram is shown in [Figure 1](#).

The ISP1122 requires only a single supply voltage. An internal 3.3 V regulator provides the supply voltage for the analog USB data transceivers.

The ISP1122 supports both bus-powered and self-powered hub operation. When using bus-powered operation a downstream port cannot supply more than 100 mA to a peripheral. In case of self-powered operation an external supply is used to power the downstream ports, allowing a current consumption of max. 500 mA per port.

A basic I²C-bus interface is provided for reading Vendor ID, Product ID and configuration bits from an external EEPROM upon a reset.

6.1 Analog transceivers

The integrated transceiver interfaces directly to the USB cables through external 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. The slew rates are adjusted according to the speed of the device connected and lie within the range mentioned in the *"USB Specification Rev. 1.1"*.

6.2 Philips Serial Interface Engine (SIE)

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 (de-)stuffing, CRC checking/generation, PID verification/generation, address recognition, handshake evaluation/generation.

6.3 Hub repeater

The hub repeater is responsible for managing connectivity on a 'per packet' basis. It implements 'packet signalling' and 'resume' connectivity. Low-speed devices can be connected to downstream ports. If a low-speed device is detected the repeater will not propagate upstream packets to the corresponding port, unless they are preceded by a PREAMBLE PID (Packet Identifier).

6.4 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.

6.5 General and individual port controller

The general and individual port controllers together provide status and control of individual downstream ports. Any port status change will be reported to the host via the hub status change (interrupt) endpoint.

6.6 GoodLink

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

During enumeration the LED blinks ON momentarily. After successful configuration of the ISP1122, the LED is permanently ON. The LED blinks OFF for 100 ms upon each successful packet transfer (with ACK). The hub GoodLink indicator blinks when the hub receives a packet addressed to it. Downstream GoodLink indicators blink upon an acknowledgment from the associated port. In 'suspend' mode the LED is OFF.

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.

6.7 Bit clock recovery

The bit clock recovery circuit recovers the clock from the incoming USB data stream using a 4× oversampling principle. It is able to track jitter and frequency drift as specified by the "USB Specification Rev. 1.1".

6.8 Voltage regulator

A 5 V to 3.3 V DC-DC regulator is integrated on-chip to supply the analog transceiver and internal logic. This can also be used to supply the terminal 1.5 kΩ pull-up resistor on the D+ line of the upstream connection.

6.9 PLL clock multiplier

A 6 to 48 MHz clock multiplier Phase Locked Loop (PLL) is integrated on-chip. This allows for the use of low-cost 6 MHz crystals. The low crystal frequency also minimizes Electro-Magnetic Interference (EMI). The PLL requires no external components.

6.10 Overcurrent detection

An overcurrent detection circuit for downstream ports has been integrated on-chip. It is self-reporting, resets automatically, has a low trip time and requires no external components. Both individual and gang mode overcurrent detection are supported.

6.11 I²C-bus interface

A basic serial I²C-bus interface (single master, 100 kHz) is provided to read VID, PID and configuration bits from an external I²C EEPROM (e.g. Philips PCF8582 or equivalent). At reset the ISP1122 reads 6 bytes of data from the external memory.

The I²C-bus interface timing complies with the standard mode of operation as described in "The I²C-bus and how to use it", order number 9398 393 40011.

7. Endpoint descriptions

Each USB device is logically composed of several independent endpoints. An endpoint acts as a terminus of a communication flow between the host and the device. At design time each endpoint is assigned a unique number (endpoint identifier, see [Table 4](#)). 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 ISP1122 has two endpoints, endpoint 0 (control) and endpoint 1 (interrupt).

Table 4: Hub endpoints

Function	Ports	Endpoint identifier	Transfer type	Direction [1]	Max. packet size (bytes)
Hub	0: upstream	0	control	OUT	64
	1 to 5: downstream			IN	64
		1	interrupt	IN	1

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

7.1 Hub endpoint 0 (control)

All USB devices and functions must implement a default control endpoint (ID = 0). This endpoint is used by the host to configure the device and to perform generic USB status and control access.

The ISP1122 hub supports the following USB descriptor information through its control endpoint 0, which can handle transfers of max. 64 bytes:

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

7.2 Hub endpoint 1 (interrupt)

Endpoint 1 is used by the ISP1122 hub to provide status change information to the host. This endpoint can be accessed only after the hub has been configured by the host (by sending the Set Configuration command).

Endpoint 1 is an interrupt endpoint: the host polls it once every 255 ms by sending an IN token. If the hub has detected no change in the port status it returns a NAK (Not Acknowledge) response to this request, otherwise it sends the Status Change byte (see [Table 5](#)).

Table 5: Status Change byte: bit allocation

Bit	Symbol	Description
0	Hub SC	a logic 1 indicates a status change on the hub's upstream port
1	Port 1 SC	a logic 1 indicates a status change on downstream port 1
2	Port 2 SC	a logic 1 indicates a status change on downstream port 2

Table 5: Status Change byte: bit allocation...continued

Bit	Symbol	Description
3	Port 3 SC	a logic 1 indicates a status change on downstream port 3
4	Port 4 SC	a logic 1 indicates a status change on downstream port 4
5	Port 5 SC	a logic 1 indicates a status change on downstream port 5
6	reserved	not used
7	reserved	not used

8. Host requests

The ISP1122 handles all standard USB requests from the host via control endpoint 0. The control endpoint can handle a maximum of 64 bytes per transfer.

Remark: Please note that the USB data transmission order is Least Significant Bit (LSB) first. In the following tables multi-byte variables are displayed least significant byte first.

8.1 Standard requests

Table 6 shows the supported standard USB requests. Some requests are explicitly unsupported. All other requests will be responded with a STALL packet.

Table 6: Standard USB requests

Request name	bmRequestType byte 0 [7 to 0] (Bin)	bRequest byte 1 (Hex)	wValue byte 2, 3 (Hex)	wIndex byte 4, 5 (Hex)	wLength byte 6, 7 (Hex)	Data
Address						
Set Address	X000 0000	05	address ^[1]	00, 00	00, 00	none
Configuration						
Get Configuration	1000 0000	08	00, 00	00, 00	01, 00	configuration value = 01H
Set Configuration (0)	X000 0000	09	00, 00	00, 00	00, 00	none
Set Configuration (1)	X000 0000	09	01, 00	00, 00	00, 00	none
Descriptor						
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
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

Table 6: Standard USB requests...continued

Request name	bmRequestType byte 0 [7 to 0] (Bin)	bRequest byte 1 (Hex)	wValue byte 2, 3 (Hex)	wIndex byte 4, 5 (Hex)	wLength byte 6, 7 (Hex)	Data
Feature						
Clear Device Feature (REMOTE_WAKEUP)	X000 0000	01	01, 00	00, 00	00, 00	none
Clear Endpoint (1) Feature (HALT/STALL)	X000 0010	01	00, 00	81, 00	00, 00	none
Set Device Feature (REMOTE_WAKEUP)	X000 0000	03	01, 00	00, 00	00, 00	none
Set Endpoint (1) Feature (HALT/STALL)	X000 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 ^[3] , 00	02, 00	endpoint 0 status
Get Endpoint (1) Status	1000 0010	00	00, 00	81, 00	02, 00	endpoint 1 status
Unsupported						
Set Descriptor	0000 0000	07	XX, XX	XX, XX	XX, XX	descriptor; STALL
Get Interface	1000 0001	0A	00, 00	XX, XX	01, 00	STALL
Set Interface	X000 0001	0B	XX, XX	XX, XX	00, 00	STALL
Synch Frame	1000 0010	0C	00, 00	XX, XX	02, 00	STALL

[1] Device address: 0 to 127 Dec.

[2] Returned value in bytes.

[3] MSB specifies transfer direction: 0 = OUT, 1 = IN.

8.2 Hub specific requests

In Table 7 the supported hub specific requests are listed, as well as some unsupported requests. Table 8 provides the feature selectors for setting or clearing port features.

Table 7: Hub specific requests

Request name	bmRequestType byte 0 [7:0] (Bin)	bRequest byte 1 (Hex)	wValue byte 2, 3 (Hex)	wIndex byte 4, 5 (Hex)	wLength byte 6, 7 (Hex)	Data
Descriptor						
Get Hub Descriptor	1010 0000	06	00, 00/29 ^[1]	00, 00	length ^[2] , 00	hub descriptor
Feature						
Clear Hub Feature (C_LOCAL_POWER)	X010 0000	01	00, 00	00, 00	00, 00	none
Clear Port Feature (feature selectors)	X010 0011	01	feature ^[3] , 00	port ^[4] , 00	00, 00	none
Set Port Feature (feature selectors)	X010 0011	03	feature ^[3] , 00	port ^[4] , 00	00, 00	none

Table 7: Hub specific requests...continued

Request name	bmRequestType byte 0 [7:0] (Bin)	bRequest byte 1 (Hex)	wValue byte 2, 3 (Hex)	wIndex byte 4, 5 (Hex)	wLength byte 6, 7 (Hex)	Data
Status						
Get Hub Status	1010 0000	00	00, 00	00, 00	04, 00	hub status and status change field
Get Port Status	1010 0011	00	00, 00	port ^[4] , 00	04, 00	port status
Unsupported						
Get Bus Status	1010 0011	02	00, 00	port ^[4] , 00	01, 00	STALL
Clear Hub Feature (C_OVER_CURRENT)	X010 0000	01	01, 00	00, 00	00, 00	STALL
Set Hub Descriptor	0010 0000	07	XX, XX	00, 00	3E, 00	STALL
Set Hub Feature (C_LOCAL_POWER)	X010 0000	03	00, 00	00, 00	00, 00	STALL
Set Hub Feature (C_OVER_CURRENT)	X010 0000	03	01, 00	00, 00	00, 00	STALL

[1] "USB Specification Rev. 1.0" uses 00 Hex, "USB Specification Rev. 1.1" specifies 29 Hex.

[2] Returned value in bytes.

[3] Feature selector value, see Table 8.

[4] Downstream port identifier: 1 to N with N = number of enabled ports (2 to 5).

Table 8: Port feature selectors

Feature selector	Value (Hex)	Set feature	Clear feature
PORT_CONNECTION	00	not used	not used
PORT_ENABLE	01	not used	disables a port
PORT_SUSPEND	02	suspends a port	resumes a port
PORT_OVERCURRENT	03	not used	not used
PORT_RESET	04	resets and enables a port	not used
PORT_POWER	08	powers on a port	powers off a port
PORT_LOW_SPEED	09	not used	not used
C_PORT_CONNECTION	10	not used	clears port connection change bit
C_PORT_ENABLE	11	not used	clears port enable change bit
C_PORT_SUSPEND	12	not used	clears port suspend change bit
C_PORT_OVERCURRENT	13	not used	clears port overcurrent change bit
C_PORT_RESET	14	not used	clears port reset change bit

8.3 Descriptors

The ISP1122 hub controller supports the following standard USB descriptors:

- Device
- Configuration
- Endpoint
- Hub
- Interface
- String.

Table 9: Device descriptor

Offset (bytes)	Field name	Size (bytes)	Value (Hex)	Comments
0	bLength	1	12	descriptor length (18 bytes)
1	bDescriptorType	1	01	type = DEVICE
2	bcdUSB	2	10, 01	"USB Specification Rev. 1.1"
4	bDeviceClass	1	09	HUB_CLASSCODE
5	bDeviceSubClass	1	00	-
6	bDeviceProtocol	1	00	-
7	bMaxPacketSize0	1	40	packet size = 64 bytes
8	idVendor	2	CC, 04	Philips Semiconductors vendor ID (04CC); can be customized via external EEPROM (see Table 22)
10	idProduct	2	22, 11	ISP1122 product ID; can be customized via external EEPROM (see Table 22)
12	bcdDevice	2	00, 01	device release 1.0; silicon revision increments this value
14	iManufacturer	1	00	no manufacturer string; can be enabled (01 Hex) via external EEPROM
15	iProduct	1	00	no product string; can be enabled (02 Hex) via external EEPROM
16	iSerialNumber	1	00	no serial number string
17	bNumConfigurations	1	01	one configuration

Table 10: Configuration descriptor

Offset (bytes)	Field name	Size (bytes)	Value (Hex)	Comments
0	bLength	1	09	descriptor length = 9 bytes
1	bDescriptorType	1	02	type = CONFIGURATION
2	wTotalLength	2	19, 00	total length of configuration, interface and endpoint descriptors (25 bytes)
4	bNumInterfaces	1	01	one interface
5	bConfigurationValue	1	01	configuration value = 1
6	iConfiguration	1	00	no configuration string

Table 10: Configuration descriptor...continued

Offset (bytes)	Field name	Size (bytes)	Value (Hex)	Comments
7	bmAttributes	1	E0	self-powered with remote wake-up ^[1]
			A0	bus-powered with remote wake-up ^[1]
8	MaxPower	1	32 ^[2]	100 mA (default)
			00 ^[2]	0 mA (via external EEPROM)
			FA ^[2]	500 mA (via external EEPROM)

[1] Selected by input SP/ $\overline{\text{BP}}$.

[2] Value in units of 2 mA.

Table 11: Endpoint descriptor

Offset (bytes)	Field name	Size (bytes)	Value (Hex)	Comments
0	bLength	1	07	descriptor length = 7 bytes
1	bDescriptorType	1	05	type = ENDPOINT
2	bEndpointAddress	1	81	endpoint 1, direction: IN
3	bmAttributes	1	03	interrupt endpoint
4	wMaxPacketSize	2	01, 00	packet size = 1 byte
6	bInterval	1	FF	polling interval (255 ms)

Table 12: Hub descriptor

Offset (bytes)	Field name	Size (bytes)	Value (Hex)	Comments
0	bDescLength	1	09	descriptor length = 9 bytes
1	bDescriptorType	1	29	type = HUB
2	bNbrPorts	1	05 to 02	number of enabled downstream ports; selectable by DP/DM strapping
3	wHubCharacteristics	2	09, 00	individual power switching ^[1] , overcurrent protection active (modes 1, 3, 4, 5, 7)
			11, 00	individual power switching ^[1] , no overcurrent protection (modes 2, 6) ^[2]
5	bPwrOn2PwrGood	1	32 ^[3]	100 ms (default; modes 1, 2, 4, 5, 6)
			FA	500 ms (via external EEPROM); see Table 22
6	bHubContrCurrent	1	64	max. hub controller current (100 mA)
7	DeviceRemovable	1	00	all devices removable
8	PortPwrCtrlMask	1	FF	must be all ones for compatibility with "USB Specification Rev. 1.0"

[1] ISP1122 always reports power management status on an individual basis, even for ganged/global modes. This is compliant with "USB Specification Rev. 1.1".

[2] Condition with no overcurrent detection is reported to the host.

[3] Value in units of 2 ms.

Table 13: Interface descriptor

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

Table 14: String descriptors

Offset (bytes)	Field name	Size (bytes)	Value (Hex)	Comments
String descriptor (0)				
0	bLength	1	04	descriptor length = 4 bytes
1	bDescriptorType	1	03	type = STRING
2	bString	2	09, 04	LANGID code zero
String descriptor (1)				
0	bLength	1	2E	descriptor length = 46 bytes
1	bDescriptorType	1	03	type = STRING
2	bString	44	UC ^[1]	"Philips Semiconductors"
String descriptor (2)				
0	bLength	1	10	descriptor length = 16 bytes
1	bDescriptorType	1	03	type = STRING
2	bString	14	UC ^[1]	"ISP1122"

[1] Unicode encoded string.

8.4 Hub responses

This section describes the hub responses to requests from the USB host.

8.4.1 Get device status

The hub returns 2 bytes, see [Table 15](#).

Table 15: Get device status response

Bit #	Function	Value	Description
0	self powered	0	bus powered
		1	self powered
1	remote wake-up	0	no remote wake-up
		1	remote wake-up enabled
2 to 15	reserved	0	-

8.4.2 Get configuration

The hub returns 1 byte, see [Table 16](#).

Table 16: Get configuration response

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

8.4.3 Get interface status

The hub returns 2 bytes, see [Table 17](#).

Table 17: Get interface status response

Bit #	Function	Value	Description
0 to 15	reserved	0	-

8.4.4 Get hub status

The hub returns 4 bytes, see [Table 18](#).

Table 18: Get hub status response

Bit #	Function	Value	Description
0	local power source	0	local power supply good
		1	local power supply lost
1	overcurrent indicator	0	no overcurrent condition
		1	hub overcurrent condition detected
2 to 15	reserved	0	-
16	local power status change	0	no change in local power status
		1	local power status changed
17	overcurrent indicator change	0	no change in overcurrent condition
		1	overcurrent condition changed
18 to 31	reserved	0	-

8.4.5 Get port status

The hub returns 4 bytes. The first 2 bytes contain the port status bits (wPortStatus, see Table 19). The last 2 bytes hold the port status change bits (wPortChange, see Table 20).

Table 19: Get port status response (wPortStatus)

Bit #	Function	Value	Description
0	current connect status	0	no device present
		1	device present on this port
1	port enabled/disabled	0	port disabled
		1	port enabled
2	suspend	0	port not suspended
		1	port suspended
3	overcurrent indicator	0	no overcurrent condition
		1	overcurrent condition detected
4	reset	0	reset not asserted
		1	reset asserted
5 to 7	reserved	0	-
8	port power	0	port powered off
		1	port power on
9	low speed device attached	0	full-speed device attached
		1	low-speed device attached
10 to 15	reserved	0	-

Table 20: Get port status response (wPortChange)

Bit #	Function	Value	Description
0	connect status change	0	no change in current connect status
		1	current connect status changed
1	port enabled/disabled change	0	no port error
		1	port disabled by a port error
2	suspend change	0	no change in suspend status
		1	resume complete
3	overcurrent indicator change	0	no change in overcurrent status
		1	overcurrent indicator changed
4	reset change	0	no change in reset status
		1	reset complete
5 to 15	reserved	0	-

8.4.6 Get configuration descriptor

The hub returns 25 bytes containing the configuration descriptor (9 bytes, see [Table 10](#)), the interface descriptor (9 bytes, see [Table 13](#)) and the endpoint descriptor (7 bytes, see [Table 11](#)).

8.4.7 Get device descriptor

The hub returns 18 bytes containing the device descriptor, see [Table 9](#).

8.4.8 Get hub descriptor

The hub returns 9 bytes containing the hub descriptor, see [Table 12](#).

8.4.9 Get string descriptor (0)

The hub returns 4 bytes containing the language ID, see [Table 14](#).

8.4.10 Get string descriptor (1)

The hub returns 46 bytes containing the manufacturer name, see [Table 14](#).

8.4.11 Get string descriptor (2)

The hub returns 16 bytes containing the product name, see [Table 14](#).

9. I²C-bus interface

A simple I²C-bus interface is provided in the ISP1122 to read customized Vendor ID, Product ID and some other configuration bits from an external EEPROM. The interface supports single master operation at a bus speed of almost 100 kHz.

The I²C-bus interface is intended for bidirectional communication between ICs via two serial bus wires, SDA (data) and SCL (clock). Both lines are driven by open drain circuits and must be connected to the positive supply voltage via pull-up resistors.

9.1 Protocol

The I²C-bus protocol defines the following conditions:

- **Bus free:** both SDA and SCL are 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 are stable during the HIGH period of SCL; data on SDA may only change while SCL is LOW.

Each device on the I²C-bus has a unique slave address, which the master uses to select a device for access.

The master starts a data transfer using a Start condition and ends it by generating a Stop condition. Transfers can only be initiated when the bus is free. The receiver must acknowledge each byte by means of a LOW level on SDA during the ninth clock pulse on SCL.

For detailed information please consult “*The I²C-bus and how to use it*”, order number 9398 393 40011.

9.2 Hardware connections

Via the I²C-bus interface the ISP1122 can be connected to an external EEPROM (PCF8582 or equivalent). The hardware connections are shown in [Figure 4](#).

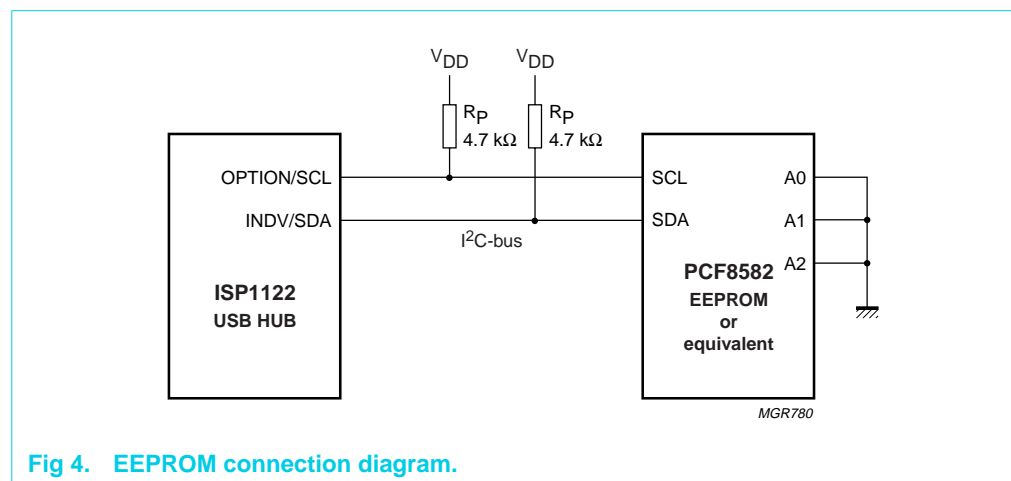


Fig 4. EEPROM connection diagram.

The slave address which ISP1122 uses to access the EEPROM is 1010000 Bin. Page mode addressing is not supported, so pins A0, A1 and A2 of the EEPROM must be connected to GND (logic 0).

9.3 Data transfer

When the ISP1122 is reset, the I²C-bus interface tries to read 6 bytes of configuration data from an external EEPROM. If no response is detected the levels on inputs SDA and SCL are interpreted as INDV and OPTION to select the operating mode (see [Table 3](#)).

The data in the EEPROM memory are organized as shown in [Table 21](#).

Table 21: EEPROM organization

Address (Hex)	Default value (Hex)	Contents
00	CC	idVendor ^[1] (lower byte)
01	04	idVendor ^[1] (upper byte)
02	22	idProduct ^[2] (lower byte)
03	11	idProduct ^[2] (upper byte)
04		see Table 22
05	AA	signature

[1] Vendor ID code in the Device descriptor, see [Table 9](#).

[2] Product ID code in the Device descriptor, see [Table 9](#).

Table 22: Configuration bits

Bit	Function	Value	Description
C0	OPTION	see Table 3 "Mode selection"	
C1	INDV	see Table 3 "Mode selection"	
C2	reserved	0 ^[1]	must always be programmed to logic 0
C3	PwrOn2PwrGood ^[2]	0 ^[1]	100 ms (bPwrOn2PwrGood = 32 Hex)
		1	500 ms (bPwrOn2PwrGood = FA Hex)
C4	string descriptor enable	0 ^[1]	string descriptors disabled
		1	string descriptors enabled (strings: "Philips Semiconductors", "ISP1122")
C5	internal analog overcurrent detection enable	0	internal analog overcurrent detection circuit disabled; overcurrent pins \overline{OCn} function as digital inputs (TTL level)
		1 ^[1]	internal analog overcurrent detection circuit enabled
C7, C6	MaxPower ^[3]	00 ^[1]	100 mA (MaxPower = 32 Hex)
		01	500 mA (MaxPower = FA Hex)
		1X	0 mA (MaxPower = 00 Hex)

[1] Default value at reset if no external EEPROM is present.

[2] Modifies the Hub Descriptor field 'bPwrOn2PwrGood', see [Table 12](#).

[3] Modifies the Hub Descriptor field 'MaxPower', see [Table 12](#).

10. Hub power modes

USB hubs can either be self-powered or bus-powered.

Self-powered — Self-powered hubs have a 5 V local power supply on board which provide power to the hub and the downstream ports. The “*USB Specification Rev. 1.1*” requires that these hubs limit the current to 500 mA per downstream port and report overcurrent conditions to the host. The hub may optionally draw 100 mA from the USB supply (V_{BUS}) to power the interface functions (**hybrid-powered**).

Bus-powered — Bus-powered hubs obtain all power from the host or an upstream self-powered hub. The maximum current is 100 mA per downstream port. Current limiting and reporting of overcurrent conditions are both optional.

Power switching of downstream ports can be done **individually** or **ganged**, where all ports are switched simultaneously with one power switch. The ISP1122 supports both modes, which can be selected using input INDV (see [Table 3](#)).

10.1 Voltage drop requirements

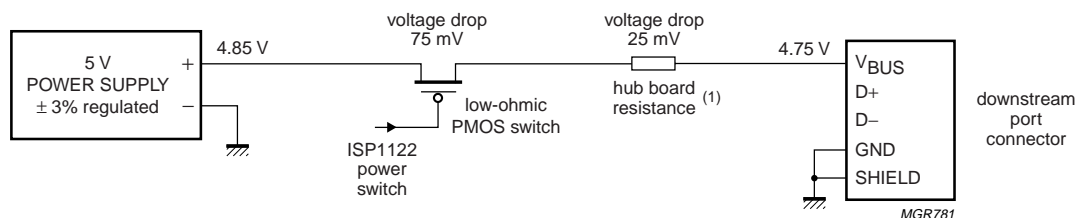
10.1.1 Self-powered hubs

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 UL (Underwriters Laboratory Inc.) 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 $5\text{ V} \pm 3\%$ 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:

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

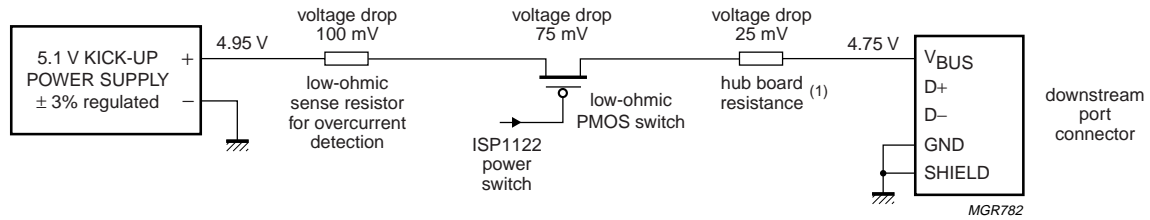
PCB resistance and power supply connector resistance may cause a drop of 25 mV, leaving only 75 mV as the voltage drop allowed across the power switch and overcurrent sense device. The individual voltage drop components are shown in [Figure 5](#).



(1) Includes PCB traces, ferrite beads, etc.

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

In case of 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 \pm 3%, as shown in Figure 6.



(1) Includes PCB traces, ferrite beads, etc.

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

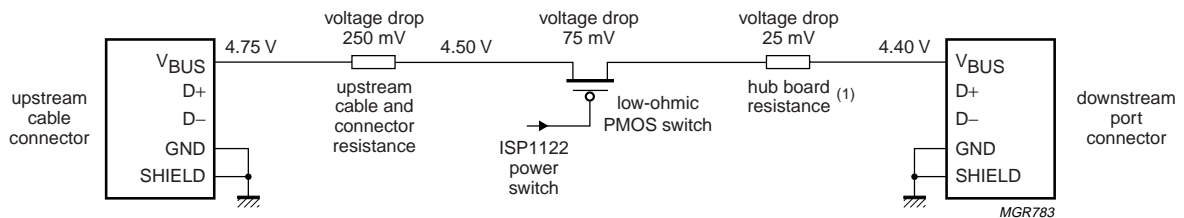
10.1.2 Bus-powered hubs

Bus-powered hubs are guaranteed to receive a supply voltage of 4.75 V at the upstream connector of the cable and must provide a minimum of 4.4 V to the downstream port connectors. To achieve this the “USB Specification Rev. 1.1” defines a maximum voltage drop for bus-powered hubs of 350 mV. This includes a voltage drop across:

- USB cable with connectors
- Hub PCB (power and ground traces, ferrite beads)
- Power switch (FET on-resistance)
- Overcurrent sense device.

The voltage drop in the USB cable may not exceed 250 mV (according to the “USB Specification Rev. 1.1”). This allows 100 mV for the voltage drop across the hub PCB to the downstream port connector. The PCB resistance may cause a drop of 25 mV, which leaves 75 mV for the power switch and overcurrent sense device. The voltage drop components are shown in Figure 7.

For bus-powered hubs overcurrent protection is optional. It may be implemented for all downstream ports on a global or individual basis.



(1) Includes PCB traces, ferrite beads, etc.

Fig 7. Typical voltage drop components in bus-powered mode (no overcurrent detection).

11. Overcurrent detection

The ISP1122 has an analog overcurrent detection circuit for monitoring downstream port lines. This circuit automatically reports an overcurrent condition to the host and turns off the power to the faulty port. The host must reset the condition flag.

Pins $\overline{OC1}$ to $\overline{OC5}/\overline{GOC}$ are used for individual port overcurrent detection. Pin $\overline{OC5}/\overline{GOC}$ can also be used for global overcurrent detection. This is controlled by input INDV (see Table 3).

The overcurrent detection circuit can be switched off via external EEPROM (see Table 22). In that case the overcurrent pins \overline{OCn} function as logic inputs (TTL level).

11.1 Overcurrent circuit description

The integrated overcurrent detection circuit of ISP1122 senses the voltage drop across the power switch or an extra low-ohmic sense resistor. The reference voltage is $V_{SP/\overline{BP}}$ (self-powered mode) or V_{CC} (bus-powered mode).

Apart from the power switch and the sense resistor (self-powered, global overcurrent detection only) no other external components are required. For proper circuit operation the power switch specification limits given in Table 23 must be strictly followed.

Since the number of downstream ports can be configured from 2 to 5, the number of ports which can be ganged together is always equal to the number of enabled ports.

Table 23: Power switch specification

Number of ganged ports	Port current (A)		Sense device resistance (m Ω) [1]		Recommended PMOS switch
	Min [2]	Max [3]	Min	Max	
Self-powered, individual overcurrent detection					
1	0.75	5	32	150	Philips PHP109
Self-powered, global overcurrent detection					
2	1.10	5	32	100	
3	1.65	5	32	67	
4	2.20	5	32	50	
5	2.75	5	32	40	
Bus-powered mode [4]					
1	0.15	5	32	750	
2	0.30	5	32	375	Philips PHP125
3	0.45	5	32	250	Philips PHP212
4	0.60	5	32	187.5	Philips BSP100

[1] Self-powered, ganged mode: sense resistor value; other modes: on-resistance of PMOS switch.

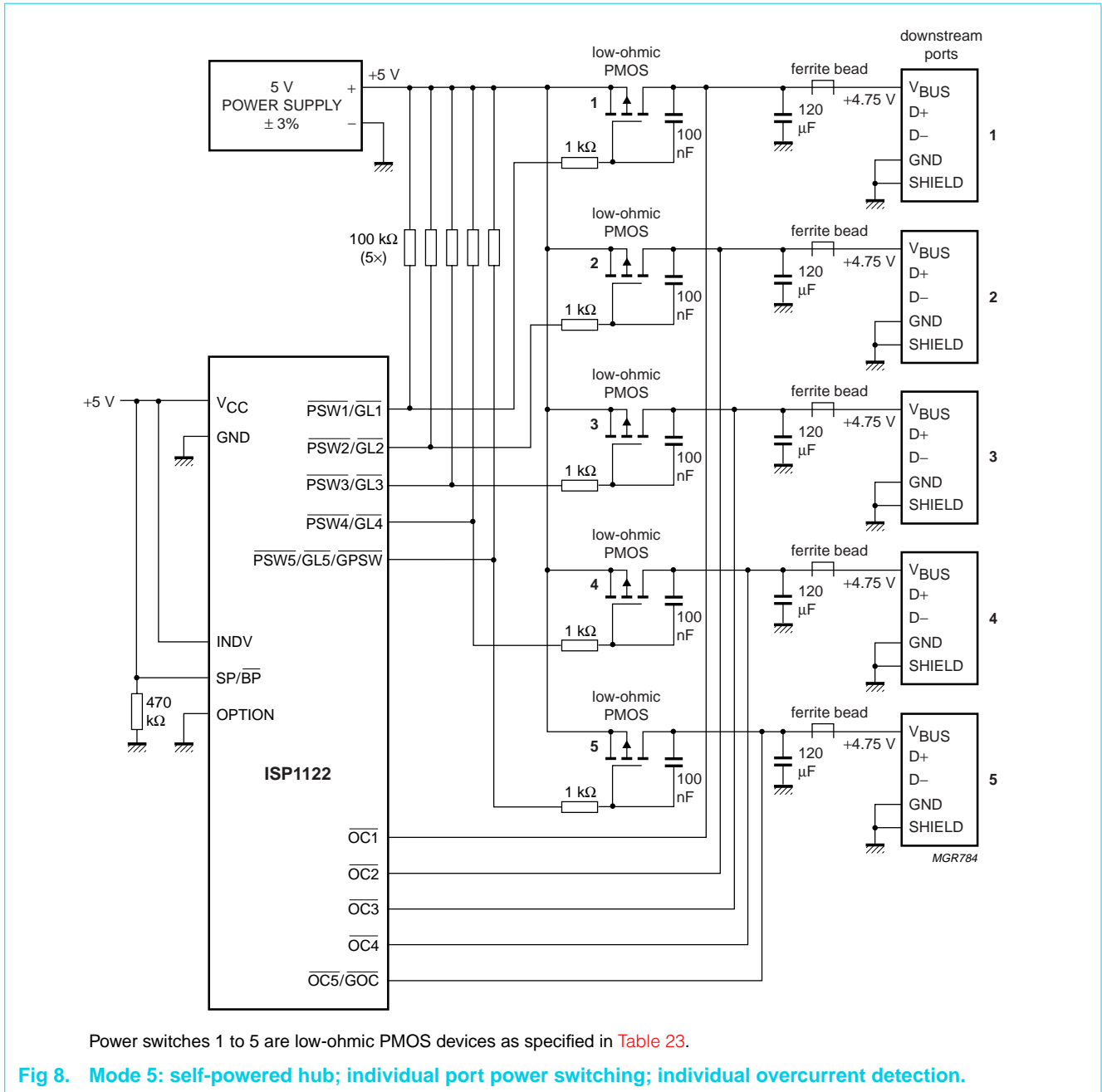
[2] Below the minimum value no overcurrent reporting is done. The minimum value is 50% above the allowable limit for bus-powered mode and 10% above the allowable limit for self-powered mode.

[3] Above the maximum value overcurrent reporting is guaranteed.

[4] Due to current restrictions no more than 4 ports may be used in bus-powered mode.

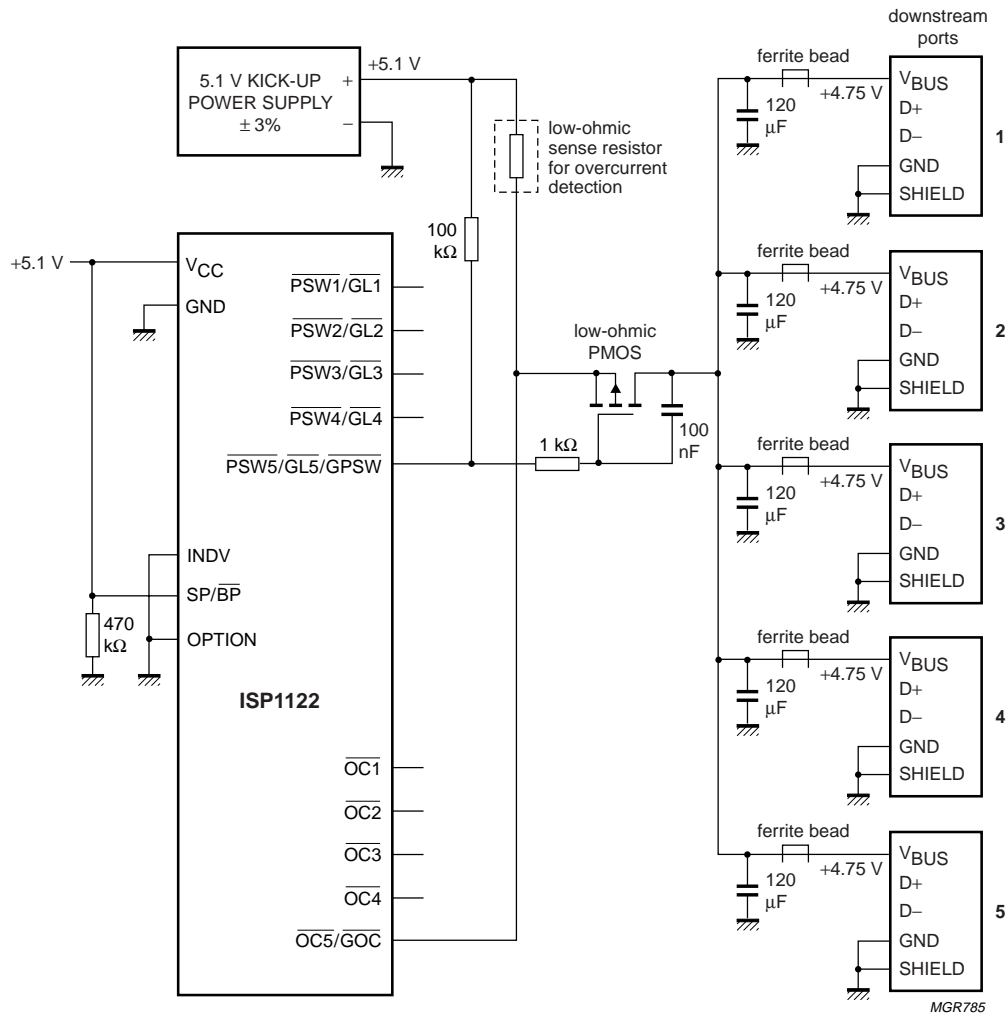
11.2 Reference circuits

Some typical examples of port power switching and overcurrent detection modes are given in Figure 8 to Figure 11.



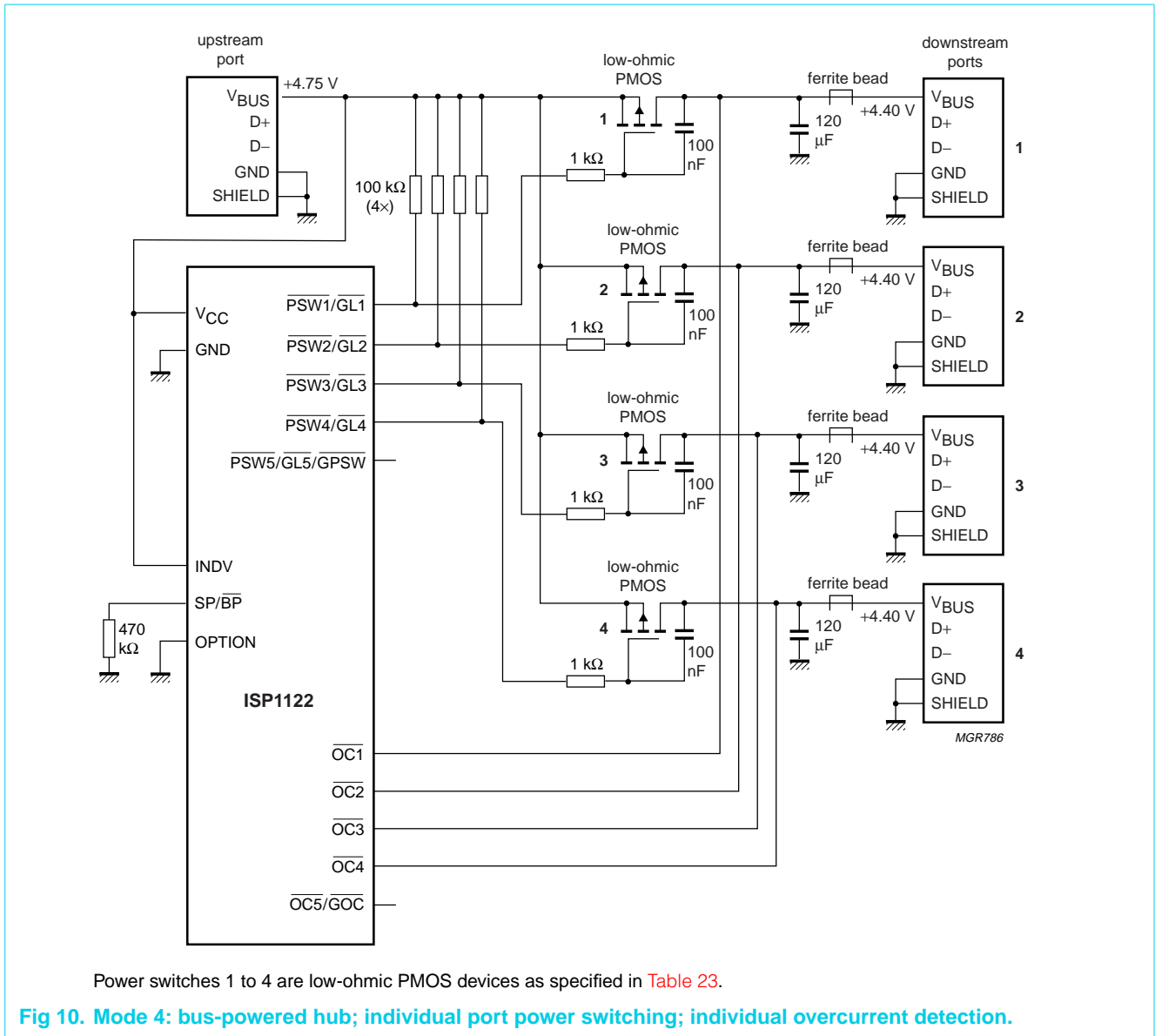
Power switches 1 to 5 are low-ohmic PMOS devices as specified in Table 23.

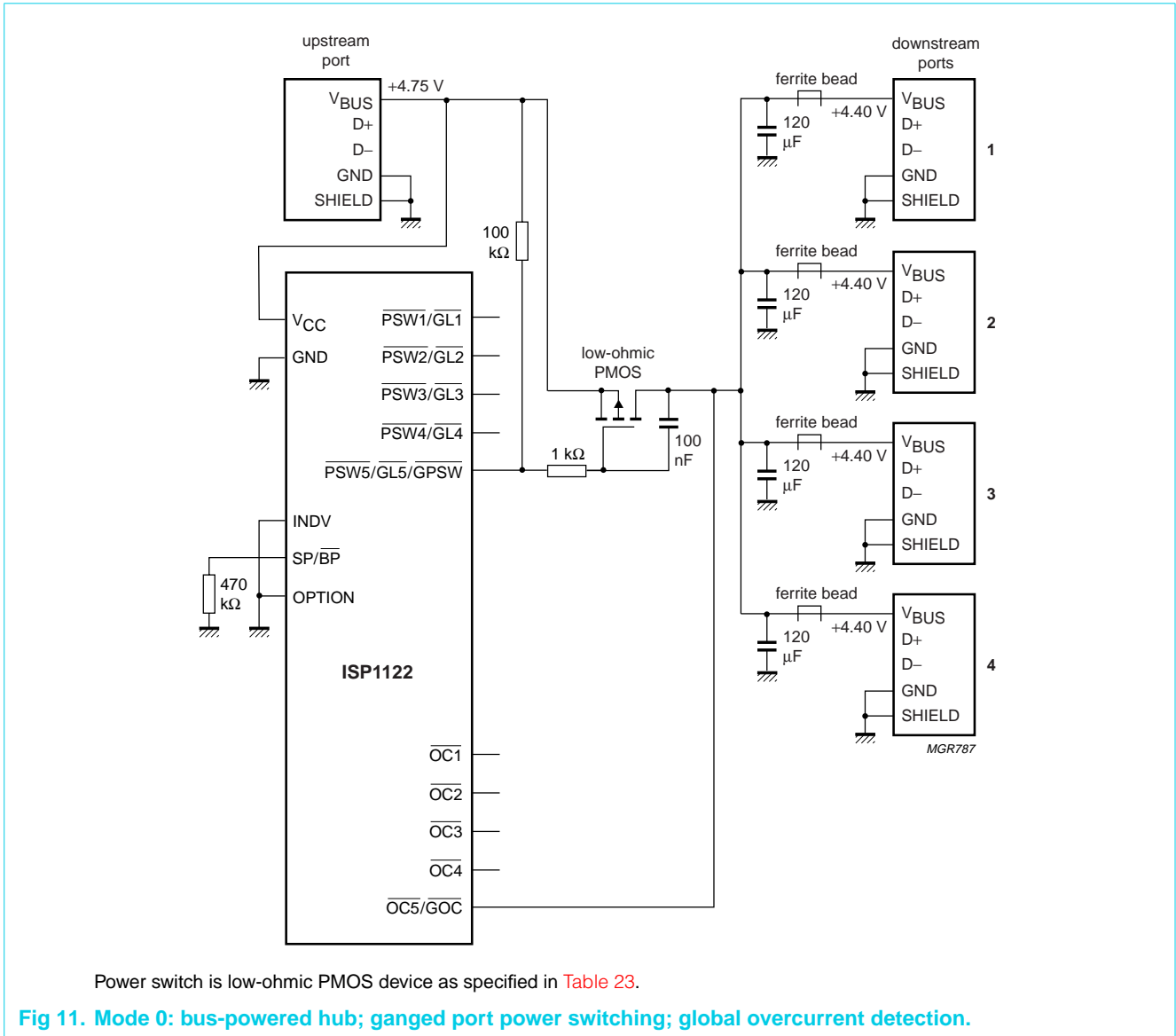
Fig 8. Mode 5: self-powered hub; individual port power switching; individual overcurrent detection.



Power switch is low-ohmic PMOS device as specified in Table 23.

Fig 9. Mode 1: self-powered hub; ganged port power switching; global overcurrent detection.





Power switch is low-ohmic PMOS device as specified in Table 23.

Fig 11. Mode 0: bus-powered hub; ganged port power switching; global overcurrent detection.

12. Limiting values

Table 24: Absolute maximum ratings

In accordance with the Absolute Maximum Rating System (IEC 134).

Symbol	Parameter	Conditions	Min	Max	Unit
V_{CC}	supply voltage		-0.5	+5.5	V
V_I	input voltage		[1] -0.5	+5.5	V
$V_{I(I/O)}$	input voltage on digital I/O pins		-0.5	$V_{CC} + 0.5$	V
$V_{I(AI/O)}$	input voltage on analog I/O pins (D+/D-)		<tbf>	<tbf>	V
V_O	open drain output voltage		[1] -0.5	$V_{CC} + 0.5$	V
I_O	output sink or source current for:	$0 \leq V_O \leq V_{CC}$			
	analog I/O pins (D+/D-)		-	± 50	mA
	other pins		-	± 15	mA
I_{CC}	supply current		-	± 100	mA
I_{GND}	ground supply current		-	± 100	mA
V_{esd}	electrostatic discharge voltage	device only	[2] [3] -4000	+4000	V
T_{stg}	storage temperature		-60	+150	°C
P_{tot}	total power dissipation		-	<tbf>	W

[1] The input and output voltage ratings may be exceeded if the input and output current ratings are observed.

[2] Equivalent to discharging a 100 pF capacitor via a 1.5 k Ω resistor.

[3] In-circuit V_{esd} ranges from -8000 to +8000 V.

Table 25: Recommended operating conditions

Symbol	Parameter	Conditions	Min	Max	Unit
V_{CC}	supply voltage		4.0	5.5	V
V_I	input voltage		0	5.5	V
$V_{I(AI/O)}$	input voltage on analog AI/O pins		0	V_{CC}	V
T_{amb}	operating ambient temperature		[1] -40	+85	°C

[1] See Section 13 "Static characteristics" and Section 14 "Dynamic characteristics".

13. Static characteristics

Table 26: Static characteristics; supply pins

$V_{CC} = 4.0$ to 5.5 V; $V_{GND} = 0$ V; $T_{amb} = -40$ to $+85$ °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{reg(3.3)}$	regulated supply voltage		3.0	3.3	3.6	V
I_{CC}	operating supply current		-	-	<tbf>	mA
$I_{CC(susp)}$	suspend supply current		-	<tbf>	-	mA

Table 27: Static characteristics: digital pins

$V_{CC} = 4.0$ to 5.5 V; $V_{GND} = 0$ V; $T_{amb} = -40$ to $+85$ °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Input levels						
V_{IL}	LOW-level input voltage		-	-	0.8	V
V_{IH}	HIGH-level input voltage		2.0	-	-	V
Schmitt trigger inputs						
$V_{th(LH)}$	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
Output levels						
V_{OL}	LOW-level output voltage	$I_{OL} = \text{rated drive}$	[1] -	-	0.4	V
		$I_{OL} = 20 \mu\text{A}$	-	-	0.1	V
V_{OH}	HIGH-level output voltage	$I_{OL} = \text{rated drive}$	[1] 2.4	-	-	V
		$I_{OL} = 20 \mu\text{A}$	$V_{CC} - 0.1$	-	-	V
Leakage current						
I_{LI}	input leakage current				± 1	μA
Open drain outputs						
I_{OZ}	OFF-state output current				± 1	μA

[1] Nominal driver output current; see Table 2.

Table 28: Static characteristics: overcurrent sense pins

$V_{CC} = 4.0$ to 5.5 V; $V_{GND} = 0$ V; $T_{amb} = -40$ to $+85$ °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
ΔV_{trip}	overcurrent detection trip voltage on \overline{OCn} pins	$V_{CC} - V_{\overline{OCn}}$	[1] 110	135	160	mV
		$V_{SP/\overline{BP}} - V_{\overline{OCn}}$	[2]			

[1] Bus-powered mode.

[2] Self-powered or hybrid-powered mode.

Table 29: Static characteristics: analog I/O pins (D+, D-) [1] $V_{CC} = 4.0$ to 5.5 V; $V_{GND} = 0$ V; $T_{amb} = -40$ to $+85$ °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Input levels						
V_{DI}	differential input sensitivity	$ V_{I(D+)} - V_{I(D-)} $	0.2	-	-	V
V_{CM}	differential common mode voltage	includes V_{DI} range	0.8	-	2.5	V
V_{IL}	LOW-level input voltage		-	-	0.8	V
V_{IH}	HIGH-level input voltage		2.0	-	-	V
Output levels						
V_{OL}	LOW-level output voltage	$R_L = 1.5$ k Ω to +3.6V	-	-	0.3	V
V_{OH}	HIGH-level output voltage	$R_L = 1.5$ k Ω to GND	2.8	-	3.6	V
Leakage current						
I_{LZ}	OFF-state leakage current		-	-	± 10	μ A
Capacitance						
C_{IN}	transceiver capacitance	pin to GND	-	-	20	pF
Resistance						
Z_{DRV} [2]	driver output impedance	steady-state drive	28	-	44	Ω
Z_{INP}	input impedance		10	-	-	M Ω
Termination						
V_{TERM} [3]	termination voltage for upstream port pull-up (R_{PU})		3.0	-	3.6	V

[1] D+ is the USB positive data pin (DPn); D- is the USB negative data pin (DMn).

[2] Includes external resistors of $22 \Omega \pm 1\%$ on both D+ and D-.[3] This voltage is available at pin $V_{reg(3.3)}$.

14. Dynamic characteristics

Table 30: Dynamic characteristics $V_{CC} = 4.0$ to 5.5 V; $V_{GND} = 0$ V; $T_{amb} = -40$ to $+85$ °C; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Reset						
$t_{W(RESET)}$	pulse width on input RESET		<tbf>	-	-	μ s
Crystal oscillator						
f_{XTAL}	crystal frequency		-	6	-	MHz

Table 31: Dynamic characteristics: analog I/O pins (D+, D-); full-speed mode [1] $V_{CC} = 4.0$ to 5.5 V; $V_{GND} = 0$ V; $T_{amb} = -40$ to $+85$ °C; $C_L = 50$ pF; $R_{PU} = 1.5$ k Ω on D+ to V_{TERM} .; 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; 10 to 90% of $ V_{OH} - V_{OL} $	4	-	20	ns

Table 31: Dynamic characteristics: analog I/O pins (D+, D-); full-speed mode [1]...continued

$V_{CC} = 4.0$ to 5.5 V; $V_{GND} = 0$ V; $T_{amb} = -40$ to $+85$ °C; $C_L = 50$ pF; $R_{PU} = 1.5$ kΩ on D+ to V_{TERM} ; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
FRFM	differential rise/fall time matching (t_{FR}/t_{FF})		[2] 90	-	111.11	%
V_{CRS}	output signal cross-over voltage		[2] 1.3	-	2.0	V
Data source timing						
t_{DJ1}	source differential jitter for consecutive transitions	see Figure 12	[2] [3] -3.5	-	+3.5	ns
t_{DJ2}	source differential jitter for paired transitions	see Figure 12	[2] [3] -4	-	+4	ns
t_{FEOPT}	source EOP [4] width	see Figure 13	160	-	175	ns
t_{FDEOP}	source differential data-to-EOP transition skew	see Figure 13	-2	-	+5	ns
Receiver timing						
t_{JR1}	receiver data jitter tolerance for consecutive transitions	see Figure 14	-18.5	-	+18.5	ns
t_{JR2}	receiver data jitter tolerance for paired transitions	see Figure 14	-9	-	+9	ns
t_{FEOPR}	receiver SE0 width	accepted as EOP	82	-	-	ns
t_{FST}	width of SE0 during differential transition	rejected as EOP; see Figure 15	-	-	14	ns
Hub timing (downstream ports configured as full speed)						
t_{FHDD}	hub differential data delay	see Figure 16	[5] -	-	40	ns
t_{FSOP}	data bit width distortion after SOP [6]	see Figure 16	[5] -5	-	+3	ns
t_{FEOPD}	hub EOP delay relative to t_{HDD}	see Figure 17	[5] 0	-	15	ns
t_{FHESK}	hub EOP output width skew	see Figure 17	[5] -15	-	+15	ns

[1] Test circuit: see Figure 19.

[2] Excluding the first transition from Idle state.

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

[4] End Of Package, indicated by a SE0 (single-ended zero) condition of two bit periods on both D+ and D-.

[5] Both upstream and downstream.

[6] Start Of Package, indicated by a logic level reversal on both D+ and D- (from Idle to K-state).

Table 32: Dynamic characteristics: analog I/O pins (D+, D-); low-speed mode [1]

$V_{CC} = 4.0$ to 5.5 V; $V_{GND} = 0$ V; $T_{amb} = -40$ to $+85$ °C; $C_L = 50$ pF; $R_{PU} = 1.5$ kΩ on D- to V_{TERM} ; unless otherwise specified.

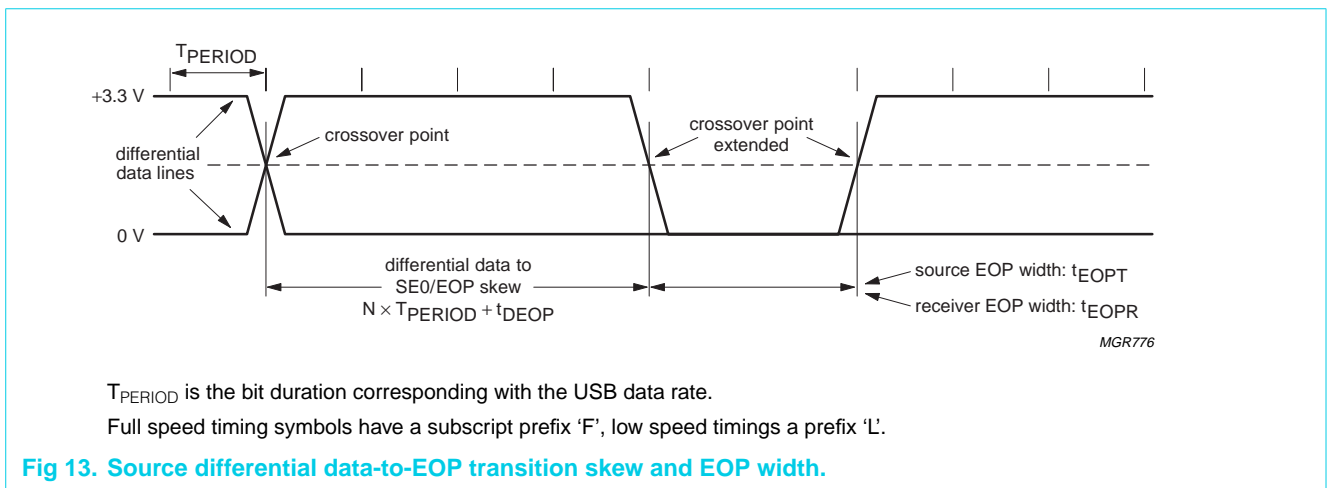
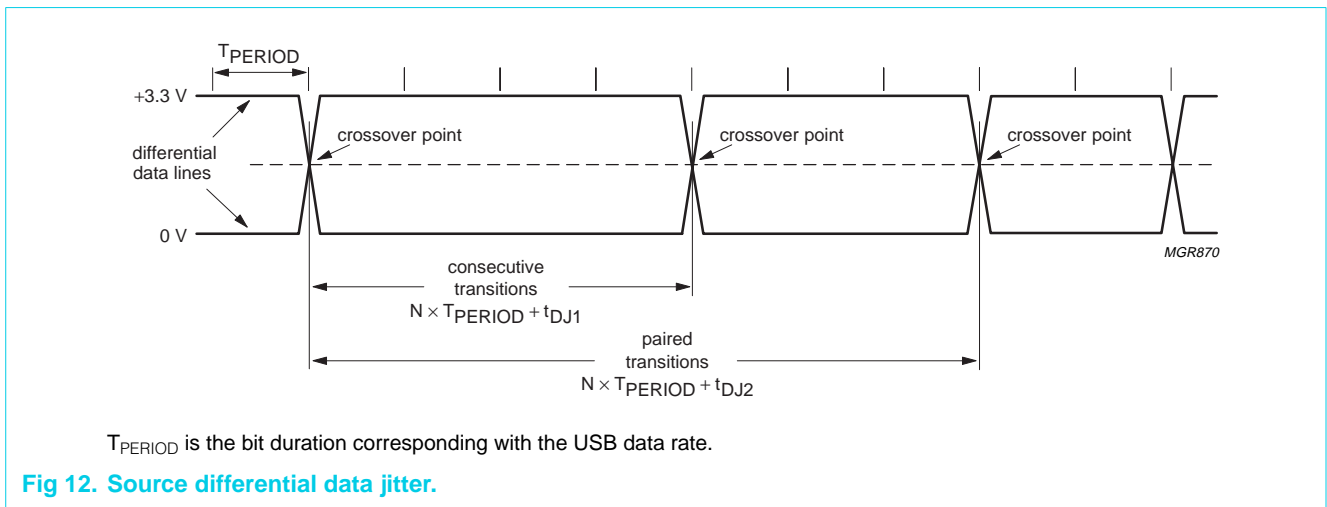
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Driver characteristics						
t_{LR}	rise time	$C_L = 200$ to 600 pF; 10 to 90% of $ V_{OH} - V_{OL} $	75	-	300	ns
t_{LF}	fall time	$C_L = 200$ to 600 pF; 10 to 90% of $ V_{OH} - V_{OL} $	75	-	300	ns
LRFM	differential rise/fall time matching (t_{LR}/t_{LF})		[2] 80	-	125	%
V_{CRS}	output signal cross-over voltage		[2] 1.3	-	2.0	V

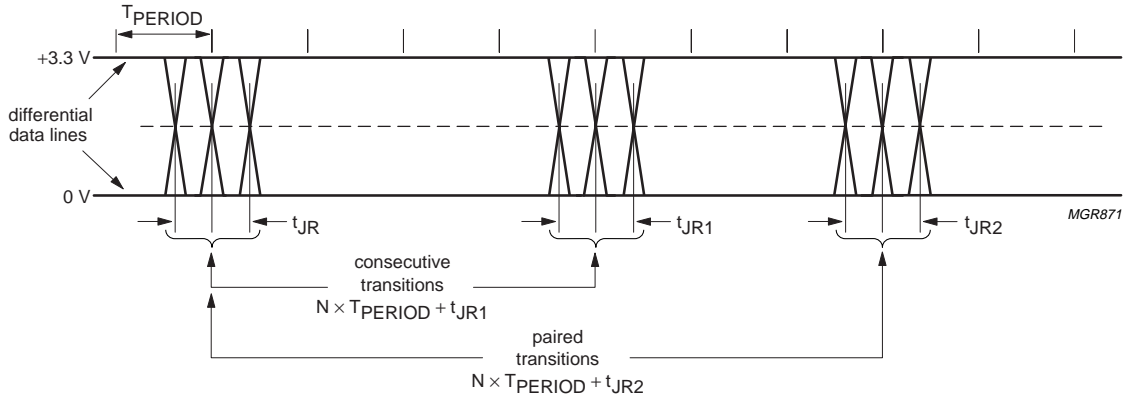
Table 32: Dynamic characteristics: analog I/O pins (D+, D-); low-speed mode [1]...continued

$V_{CC} = 4.0$ to 5.5 V; $V_{GND} = 0$ V; $T_{amb} = -40$ to $+85$ °C; $C_L = 50$ pF; $R_{PU} = 1.5$ k Ω on D- to V_{TERM} ; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Hub timing (downstream ports configured as low speed)						
t_{LHDD}	hub differential data delay	see Figure 16	[3] -	-	300	ns
t_{LSOP}	data bit width distortion after SOP [4]	see Figure 16	[3] -60	-	+60	ns
t_{LEOPD}	hub EOP delay relative to t_{HDD}	see Figure 17	[3] 0	-	200	ns
t_{LHESK}	hub EOP output width skew	see Figure 17	[3] -300	-	+300	ns

- [1] Test circuit: see Figure 19.
- [2] Excluding the first transition from Idle state.
- [3] Both upstream and downstream.
- [4] Start Of Package, indicated by a logic level reversal on both D+ and D- (from Idle to K-state).





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

Fig 14. Receiver differential data jitter.

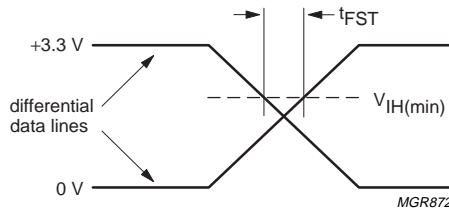
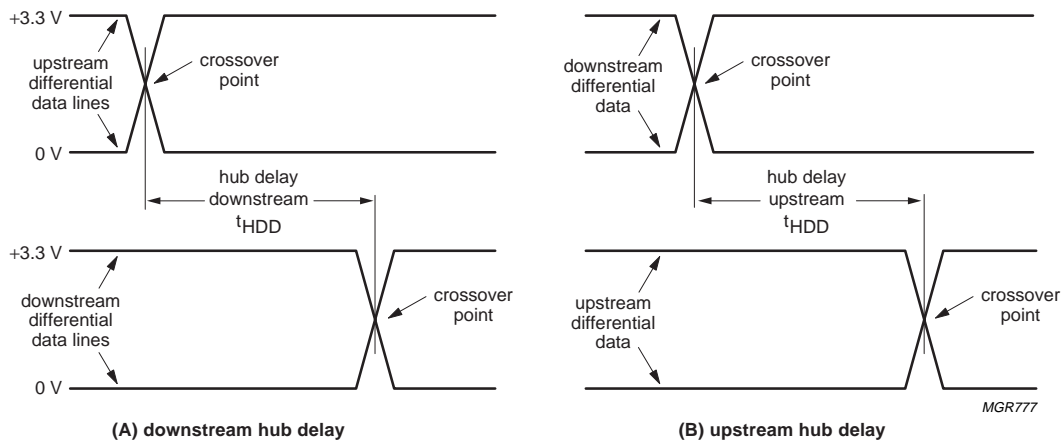


Fig 15. Receiver SE0 width tolerance.



SOP distortion:
 $t_{SOP} = t_{HDD}(SOP) - t_{HDD}(\text{next } J)$

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

Fig 16. Hub differential data delay and SOP distortion.

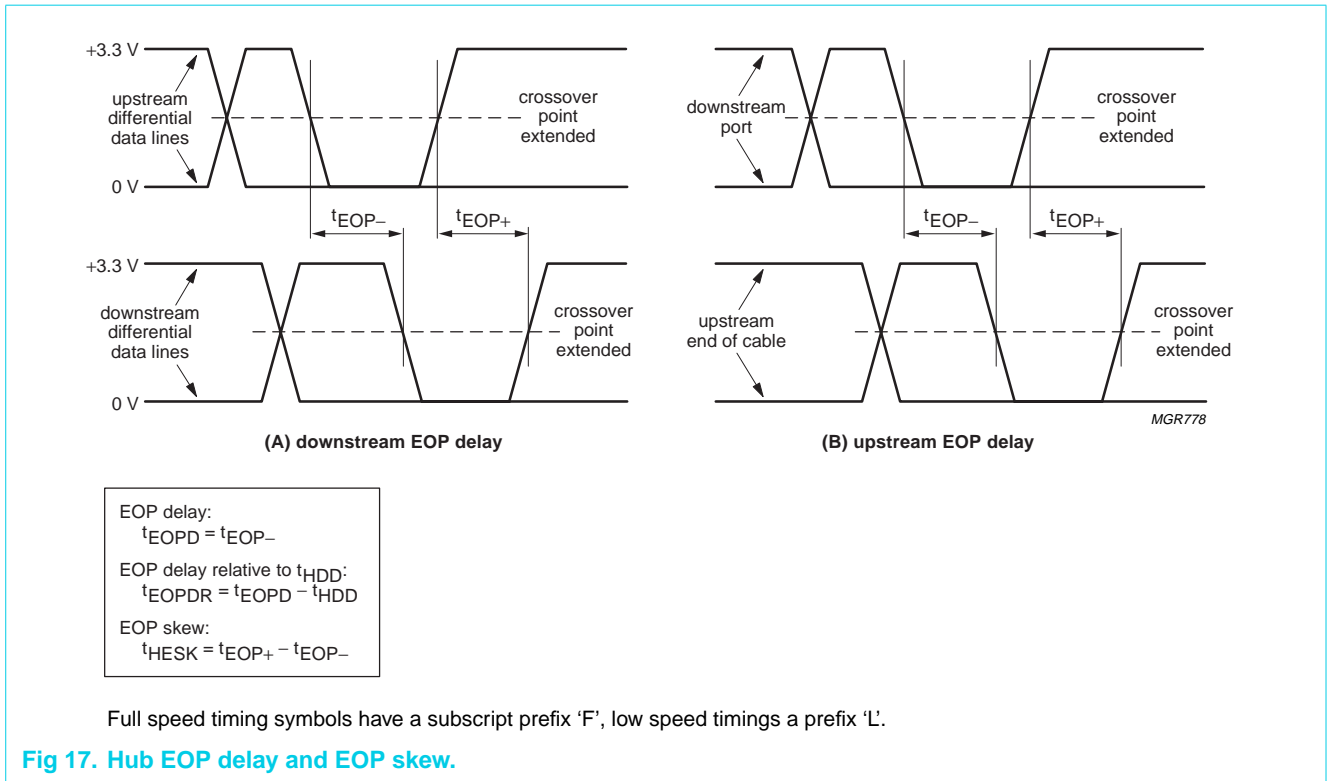


Table 33: Dynamic characteristics: I²C-bus pins (SDA, SCL)

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{SCL}	SCL clock frequency	$f_{XTAL} = 6\text{ MHz}$	0	93.75 [1]	100	kHz
t_{BUF}	bus free time		4.7	-	-	μs
$t_{SU;STA}$	START condition set-up time		250	-	-	ns
$t_{HD;STA}$	hold time START condition		4.0	-	-	μs
t_{LOW}	SCL LOW time		4.7	-	-	μs
t_{HIGH}	SCL HIGH time		4.0	-	-	μs
t_r	SCL and SDA rise time	[2]	-	-	1000	ns
t_f	SCL and SDA fall time		-	-	300	ns
$t_{SU;DAT}$	data set-up time		250	-	-	ns
$t_{HD;DAT}$	data hold time		0	-	-	μs
$t_{VD;DAT}$	SCL LOW to data out valid time		-	-	0.4	μs
$t_{SU;STO}$	STOP condition set-up time		4.0	-	-	μs
C_b	capacitive load for each bus line		-	-	400	pF

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

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

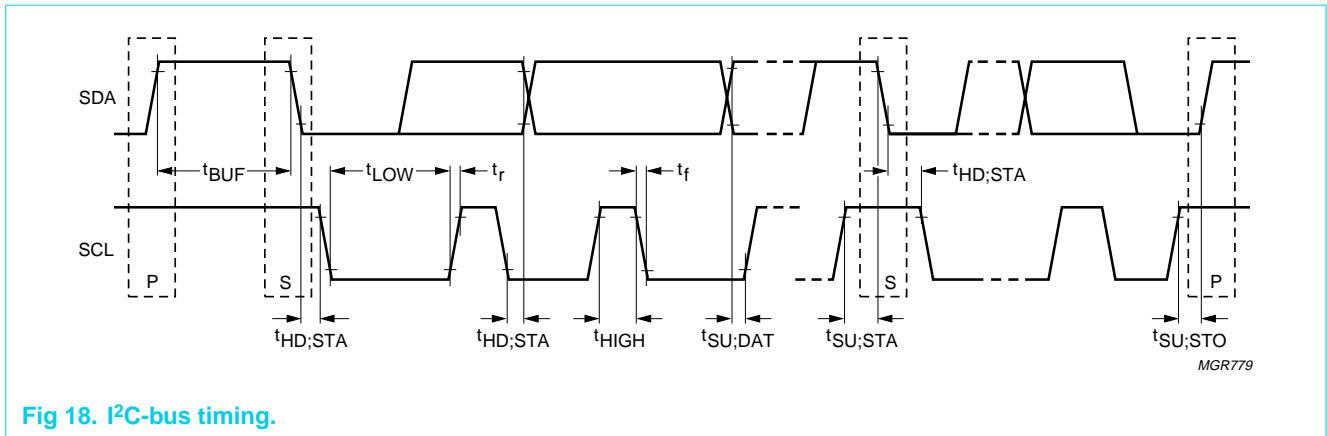


Fig 18. I²C-bus timing.

15. Test information

The dynamic characteristics of the analog I/O ports (D+ and D-) as listed in [Table 31](#) and [Table 32](#), were determined using the circuit shown in [Figure 19](#).

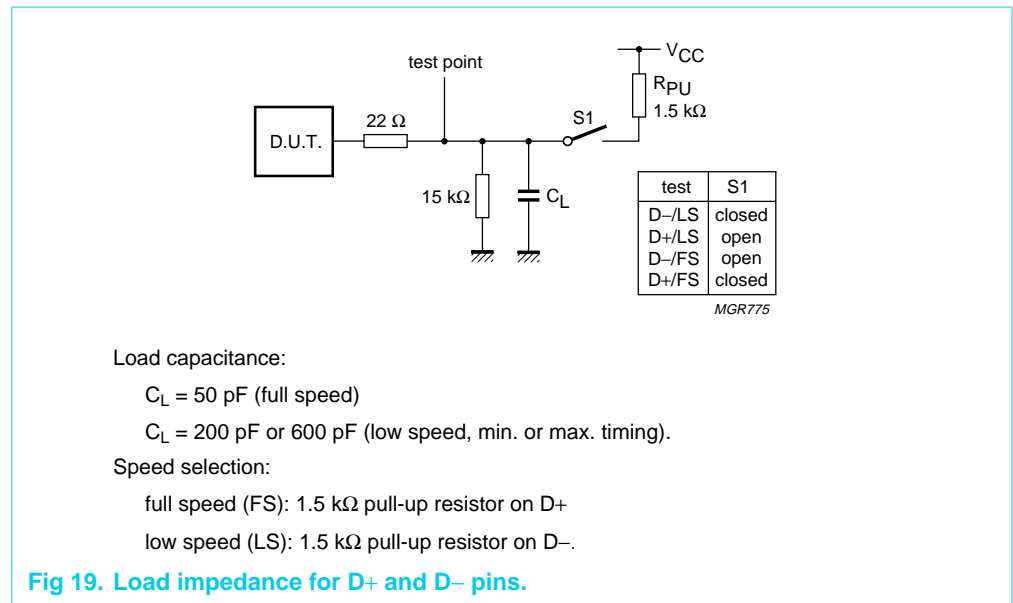


Fig 19. Load impedance for D+ and D- pins.

16. Package outline

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

SOT287-1

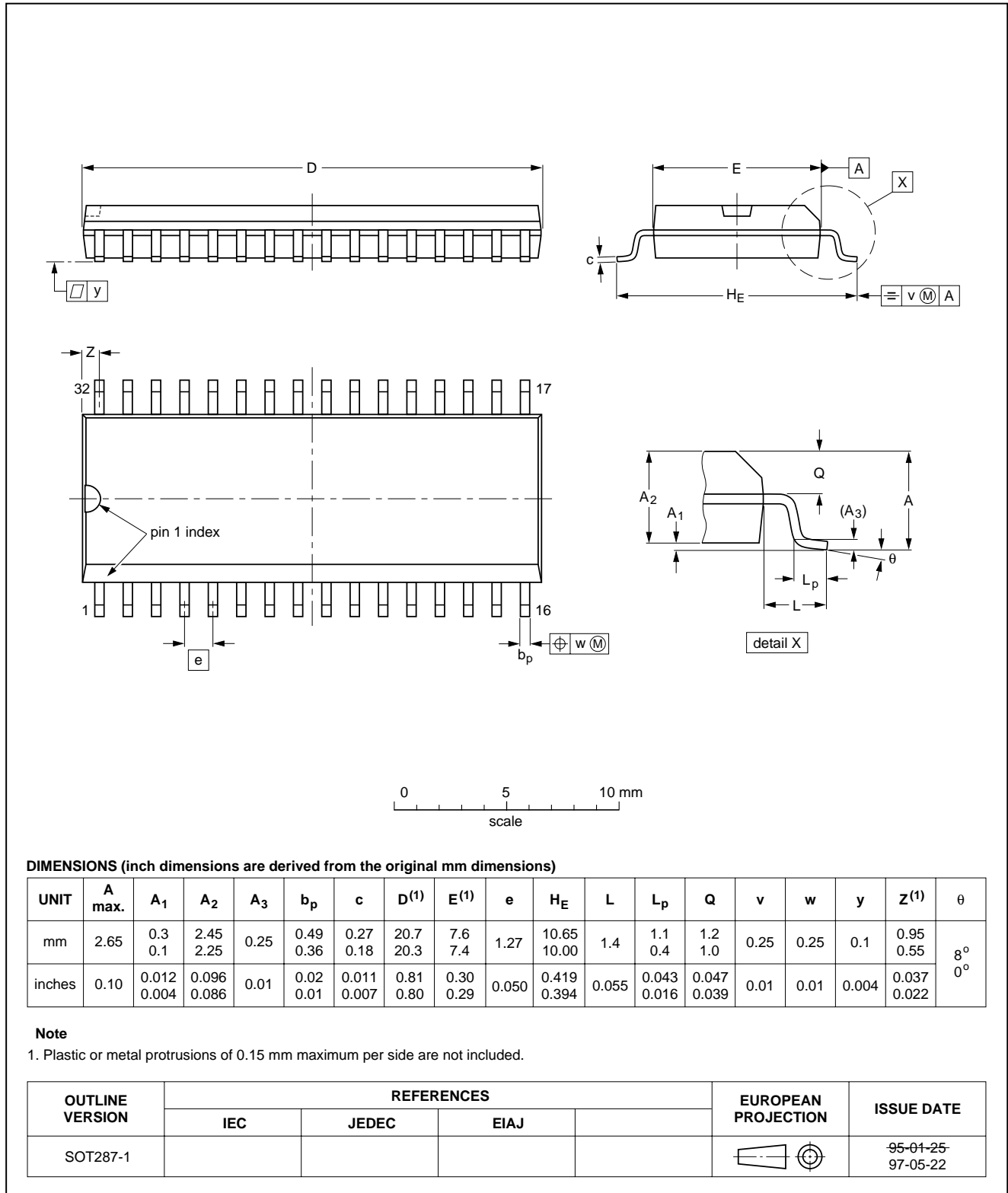


Fig 20. SO32 package outline.

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

SOT232-1

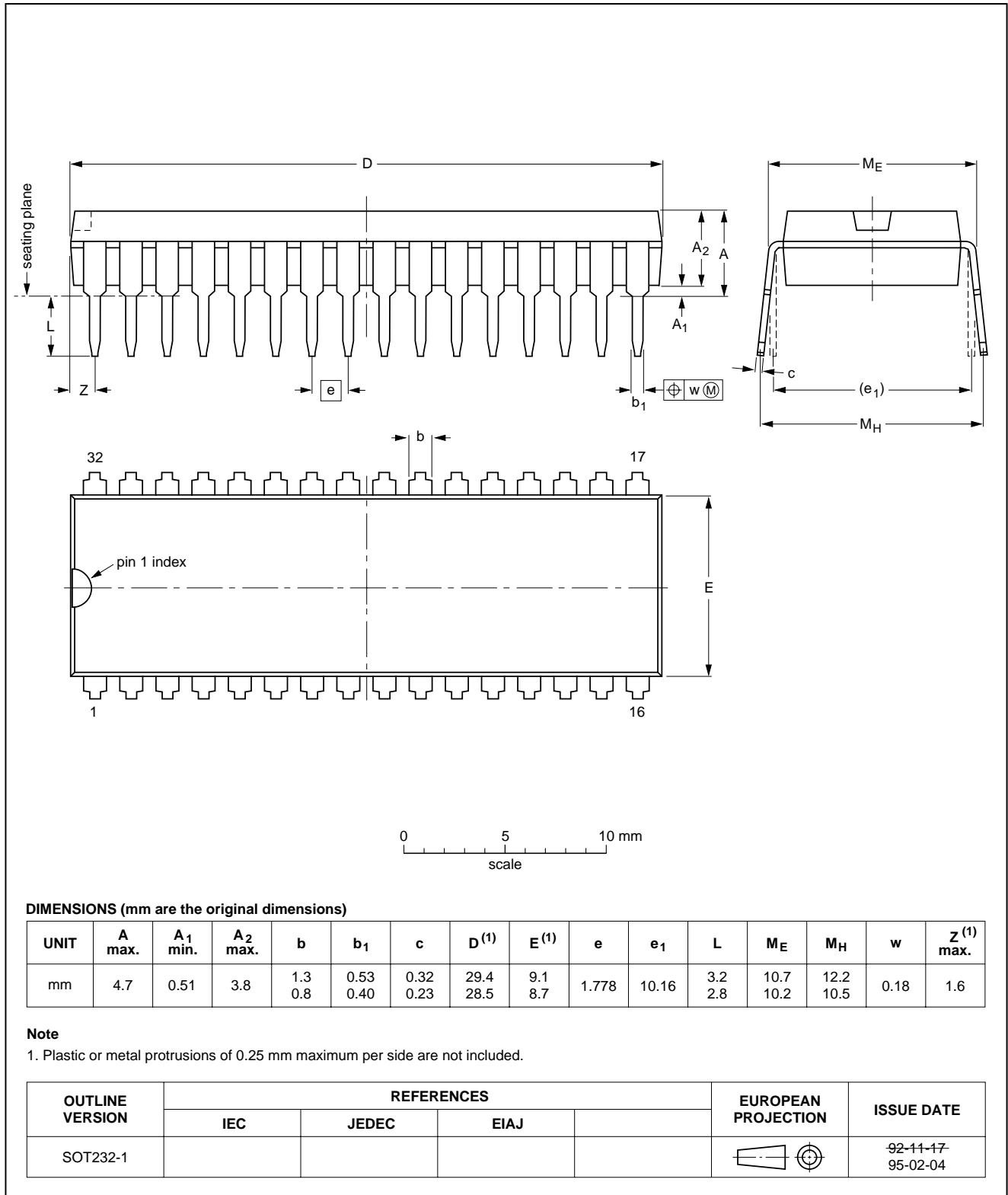


Fig 21. SDIP32 package outline.

17. Soldering

17.1 Introduction

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

There is no soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and surface mount components are mixed on one printed-circuit board. However, wave soldering is not always suitable for surface mount ICs, or for printed-circuit boards with high population densities. In these situations reflow soldering is often used.

17.2 Surface mount packages

17.2.1 Reflow soldering

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

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

Typical reflow peak temperatures range from 215 to 250 °C. The top-surface temperature of the packages should preferably be kept below 230 °C.

17.2.2 Wave soldering

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

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

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

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.
- For packages with leads on two sides and a pitch (e):
 - larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;
 - smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

The footprint must incorporate solder thieves at the downstream end.

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

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

Typical dwell time is 4 seconds at 250 °C. A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

17.2.3 Manual soldering

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

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

17.3 Through-hole mount packages

17.3.1 Soldering by dipping or by solder wave

The maximum permissible temperature of the solder is 260 °C; solder at this temperature must not be in contact with the joints for more than 5 seconds. The total contact time of successive solder waves must not exceed 5 seconds.

The device may be mounted up to the seating plane, but the temperature of the plastic body must not exceed the specified maximum storage temperature ($T_{stg(max)}$). If the printed-circuit board has been pre-heated, forced cooling may be necessary immediately after soldering to keep the temperature within the permissible limit.

17.3.2 Manual soldering

Apply the soldering iron (24 V or less) to the lead(s) of the package, either below the seating plane or not more than 2 mm above it. If the temperature of the soldering iron bit is less than 300 °C it may remain in contact for up to 10 seconds. If the bit temperature is between 300 and 400 °C, contact may be up to 5 seconds.

17.4 Package related soldering information

Table 34: Suitability of IC packages for wave, reflow and dipping soldering methods

Mounting	Package	Soldering method		
		Wave	Reflow [1]	Dipping
Through-hole mount	DBS, DIP, HDIP, SDIP, SIL	suitable [2]	–	suitable
Surface mount	BGA, SQFP	not suitable	suitable	–
	HLQFP, HSQFP, HSOP, HTSSOP, SMS	not suitable [3]	suitable	–
	PLCC, SO, SOJ	suitable	suitable	–
	LQFP, QFP, TQFP	not recommended [4][5]	suitable	–
	SSOP, TSSOP, VSO	not recommended [6]	suitable	–

- [1] All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect). For details, refer to the Drypack information in the “Data Handbook IC26; Integrated Circuit Packages; Section: Packing Methods”.
- [2] For SDIP packages, the longitudinal axis must be parallel to the transport direction of the printed-circuit board.
- [3] These packages are not suitable for wave soldering as a solder joint between the printed-circuit board and heatsink (at bottom version) can not be achieved, and as solder may stick to the heatsink (on top version).
- [4] If wave soldering is considered, then the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.
- [5] Wave soldering is only suitable for LQFP, QFP and TQFP packages with a pitch (e) equal to or larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.
- [6] Wave soldering is only suitable for SSOP and TSSOP packages with a pitch (e) equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.5 mm.

18. Revision history

Table 35: Revision history

Rev	Date	CPCN	Description
01	981223		Preliminary specification, second draft. Corrections after review (BK, MD, JT). Three new timing diagrams added (figs. 12, 14, 15).
01	981120		Preliminary specification, first draft.

Data sheet status

Datasheet status	Product status	Definition [1]
Objective specification	Development	This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice.
Preliminary specification	Qualification	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	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.

[1] Please consult the most recently issued datasheet before initiating or completing a design.

Definitions

Short-form specification — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

Limiting values definition — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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