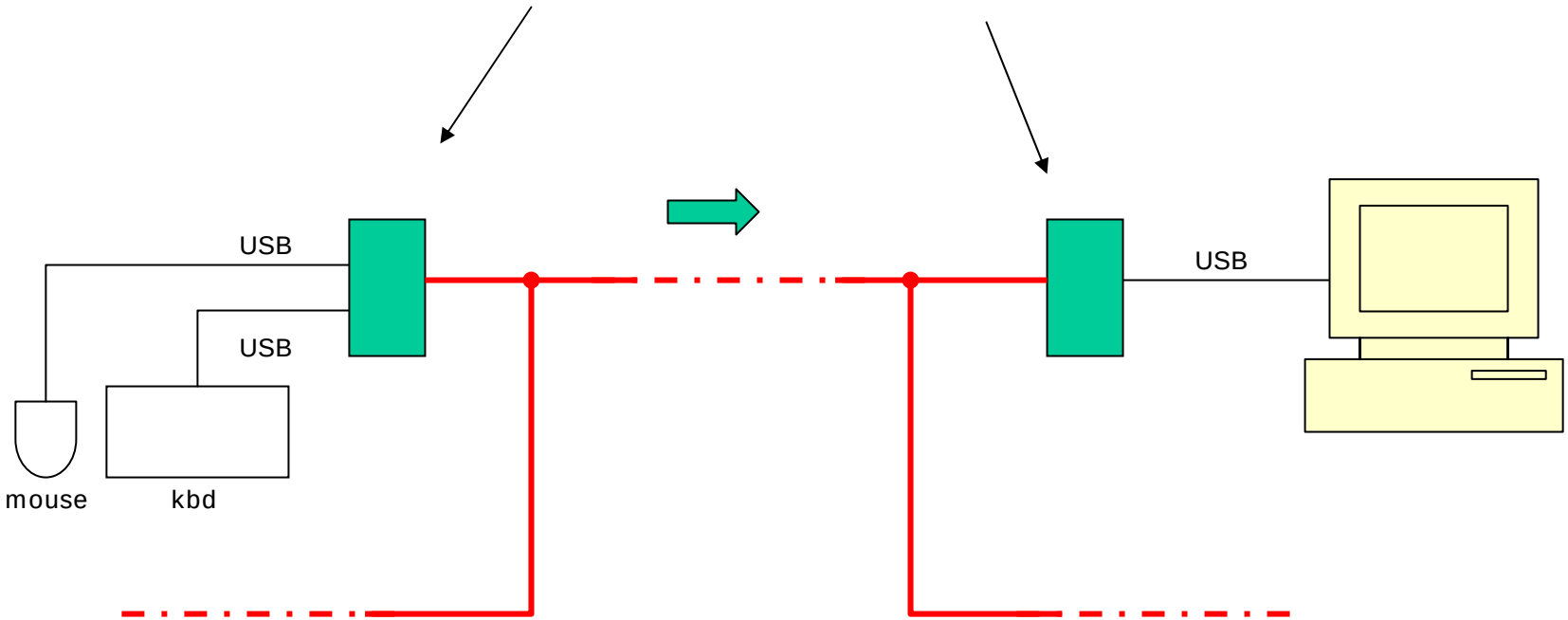
New method of video transfer and control functions
for training in computer classroom and for audiovisual applications

D1d: USB Connection

USB subsystem

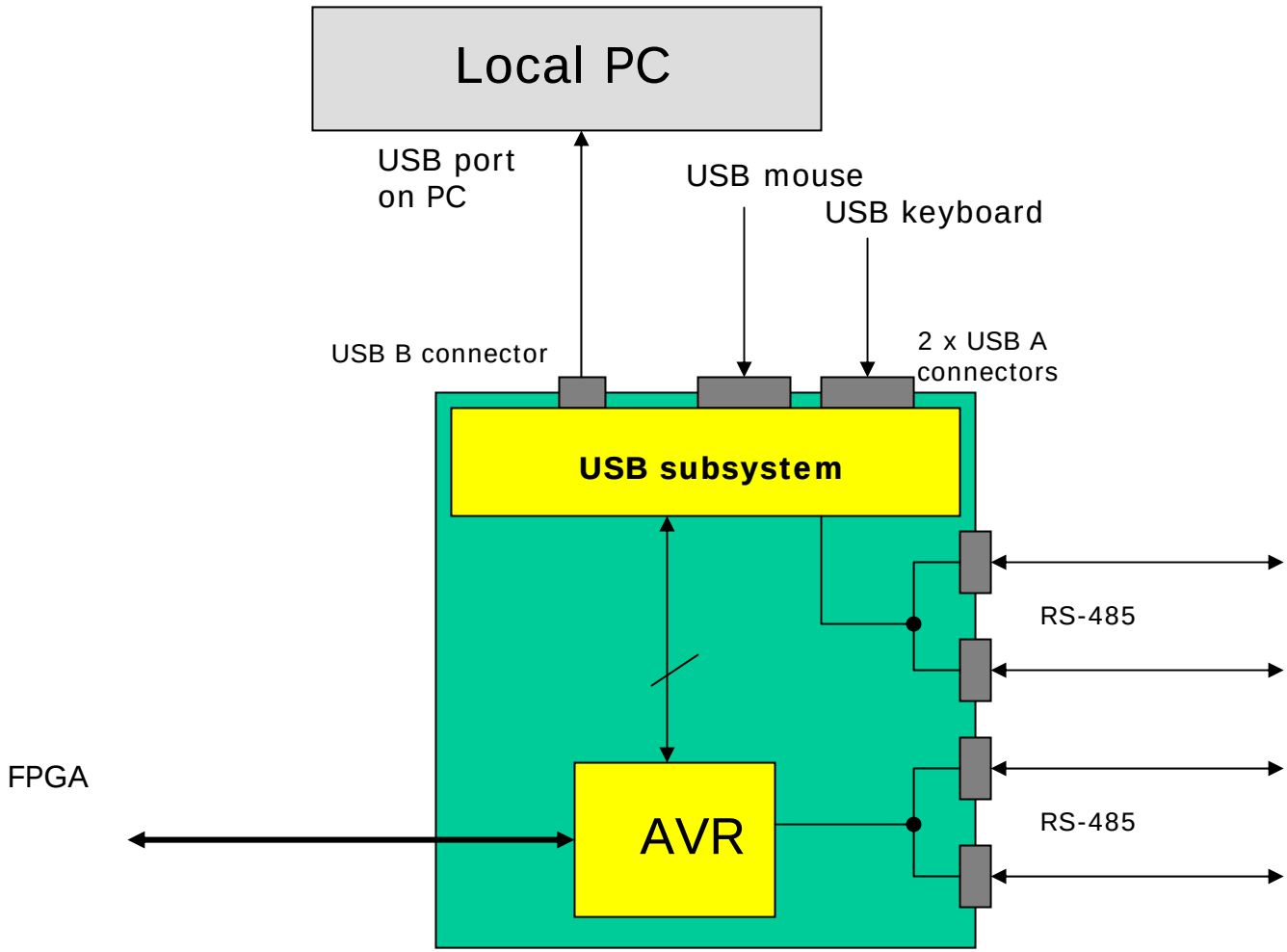
dedicated to information exchange between
remote USB devices and hosts



General requirements

- RS-485, half-duplex, multi-drop network for data transfer
- connection to USB mouse & USB keyboard
- connection to USB host port(s)
- interaction with AVR micro via GPIOs
- field upgrade is mandatory

Architecture

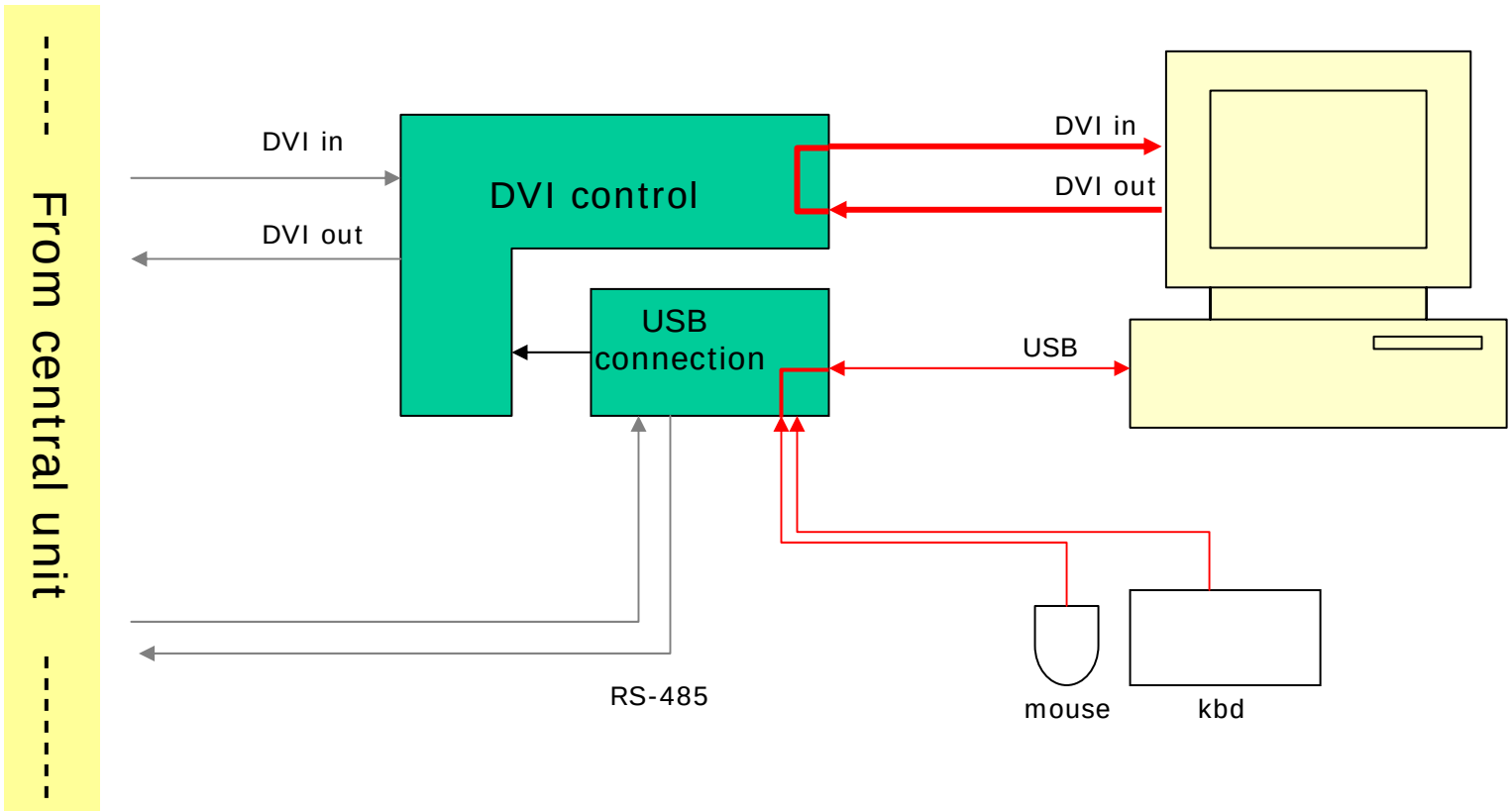


Operating modes

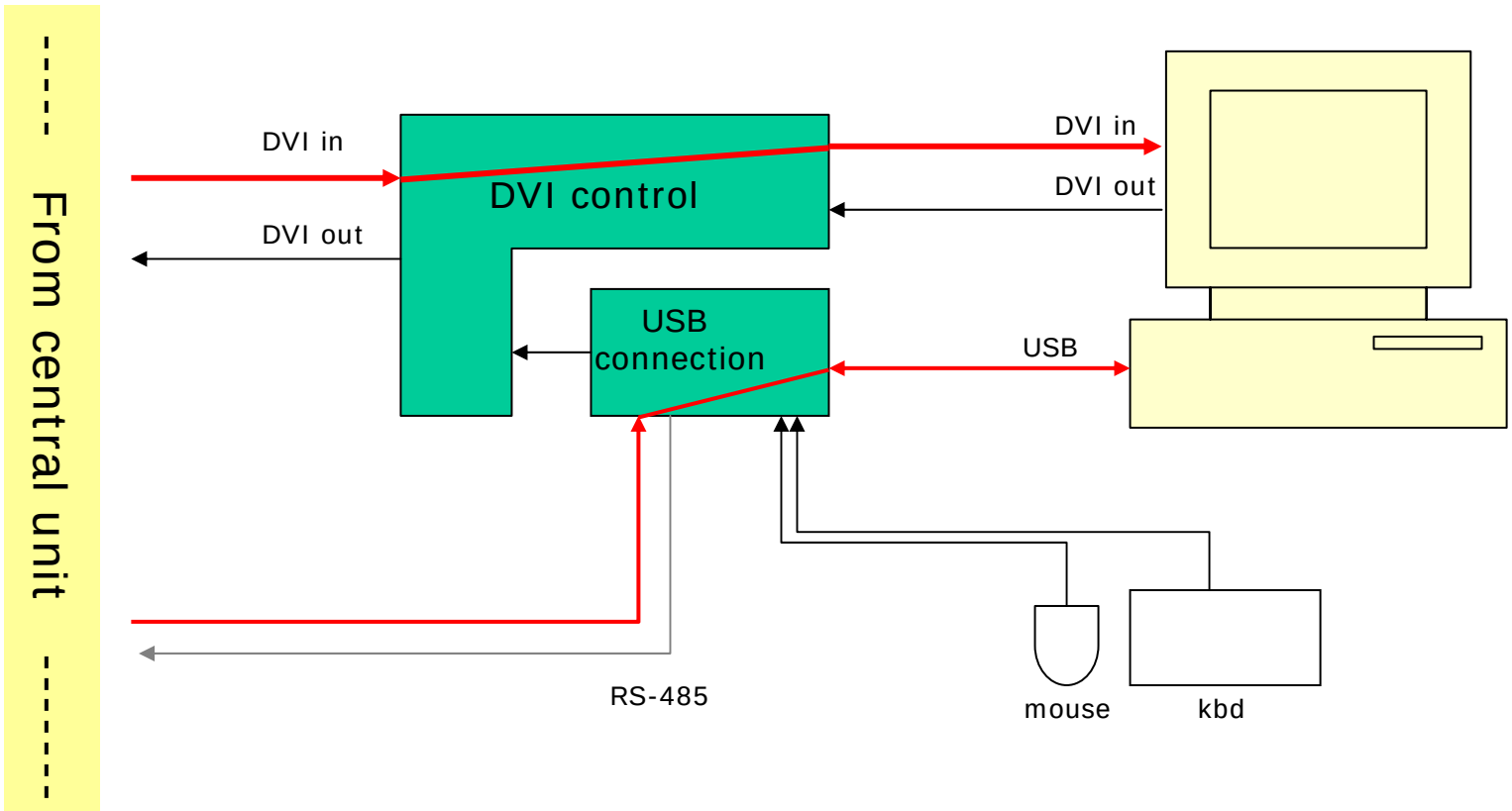
That determine data transfer from USB devices to host(s)

- local mode
- remote master
- remote slave

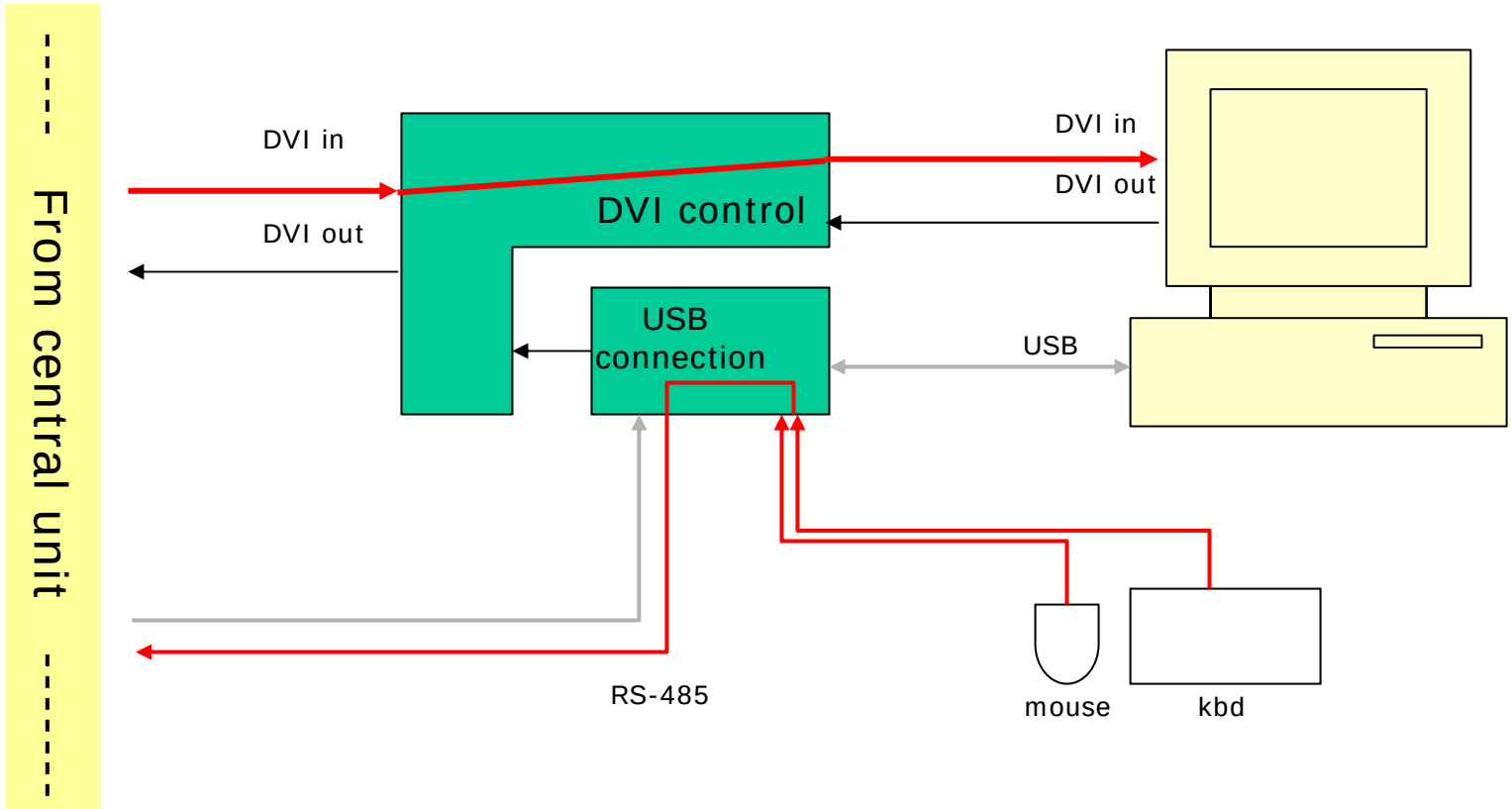
Operating modes: LOCAL



Operating modes: REMOTE MASTER



Operating modes: REMOTE SLAVE



Sequence of events

on USB subsystems

- local micro signals USB subsystem on node j to become a CM (Communication Master)
- all other USB subsystems must be in listening mode
- node j begins transmitting keypresses and mouse movements
- all other nodes receive the data and react accordingly to local state
- periodically (typ. 200 ms), the CM polls the receiving host in order to retrieve the reverse direction information, or RDI (which is typically a set of LED values on the keyboard)
- node j ends transmission of data when the local microcontroller signals end of transmission

Sequence of events, notes

• an INIT command must be sent by CM when establishing the new setup, in order to verify proper network status and to retrieve initial RDI values.

• network partitioning cannot be done at protocol level, but subnetworks must be physically separated.

• an explicit node ID is not required for the USB subsystem, as the local micro is the responsible for parsing incoming control messages that are directed only to specific nodes.

• In the case or remote monitoring, a choice must be done on priority for RDI. It is assumed that the local host always has priority.

RS-485 protocol (USB only), 1

- RS-485 minimum speed = 19200 baud
- actual speed will be fine tuned to the minimum latency allowed by end-to-end data transfer
- for low-speed USB devices, maximum data transfer is 800 bytes/s

overall data transfer estimate:

2 * 800 bytes/s = 12800 bps
(considering both the keyboard and the mouse)

RS-485 protocol (USB only), 2

Low-level protocol: binary, with 8-bit CRC and escape sequences (to avoid persistent out-of-sync situations)

General data packet:
<STX> <CMD> <LEN> <data>…<data> <CRC> <EOX>

where:
STX = Start of Packet
CMD = command (write, read)
LEN = number of data bytes, excluding CRC; it may be zero
CRC = CRC of all bytes from CMD to last data
EOX = End of Packet

STX, EOX: unique byte values
If the same must transmitted, it is substituted with a 2-byte sequence, as follows:
STX = 0x02, EOX = 0x04, ESC = 0x10
Inserted data byte = ESC XOR value

Then:
0x10 0x12 means a value of 0x02
0x10 0x14 means a value of 0x04
0x10 0x00 means a value of 0x10

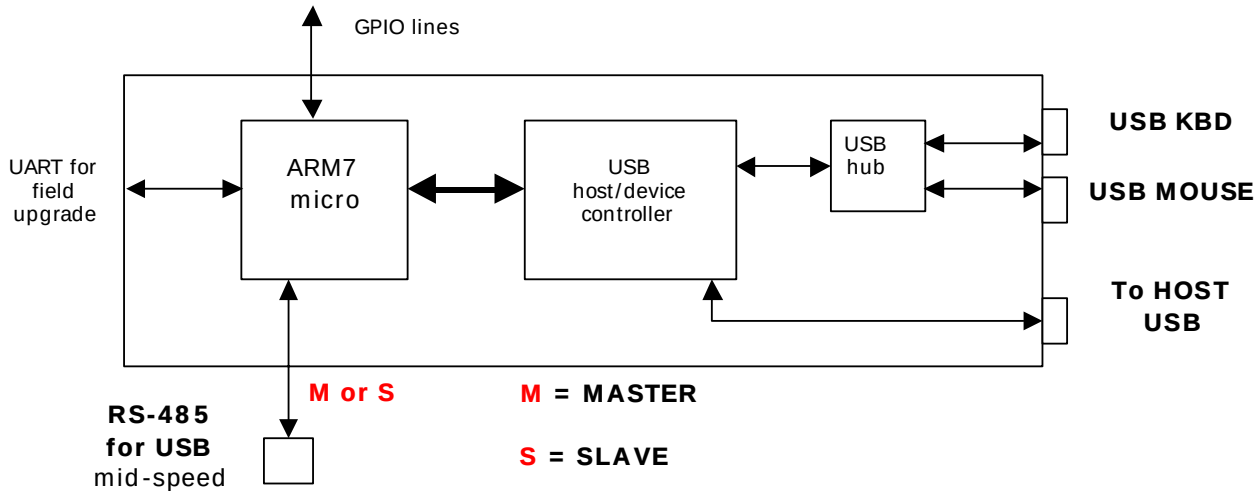
RS-485 protocol (USB only), 3

Command list

INIT	Request response from far end, retrieve RDI
TXDATA	transmit data
REQRDI	request RDI information
ERR	error code (for debug only)

USB subsystem organization

uncommitted serial port is available at CMOS levels on the card to allow In-System Reprogramming (ISP) for field upgrades



SIGNAL NAME	STATE = HI	STATE = LO	DIR
LOCK_USB	Lock mouse and keyboard	Release mouse and keyboard	IN
BUS2USB	Set mouse and keyboard for getting data from the bus	Clear (terminate) function	IN
USB2BUS	Set mouse and keyboard for sending data to the bus	Clear (terminate) mouse and keyboard transfer functions	IN
ERROR	Signal an error to the micro	No error	OUT

USB low-level details, 1

Transfer types

Control	used to request and send reliable short data packets. It is used to configure devices and every one is required to support a minimum set of control commands
Bulk	used to request or send reliable data packets up to the full bus bandwidth. Devices like scanners or SCSI adapters use this transfer type
Interrupt	similar to bulk transfers but are polled periodically. If an interrupt transfer was submitted the host controller driver will automatically repeat this request in a specified interval (1ms - 127ms)
Isochronous	receive data streams in real-time with guaranteed bus bandwidth but without any reliability. In general these transfer types are used for audio and video devices

USB low-level details, 2

Transfer speeds

Low-speed	1.5 Mbps	mice, keyboards, joysticks
Full-speed	12 Mbps	Most common
High-speed	480 Mbps	Introduced with USB 2.0

USB – HID devices

HID = Human Interface Devices

The HID class includes:
- keyboards, mice
- front panels, remote controls, telephone keypads, game controls
- bar-code readers, thermometers, voltmeters

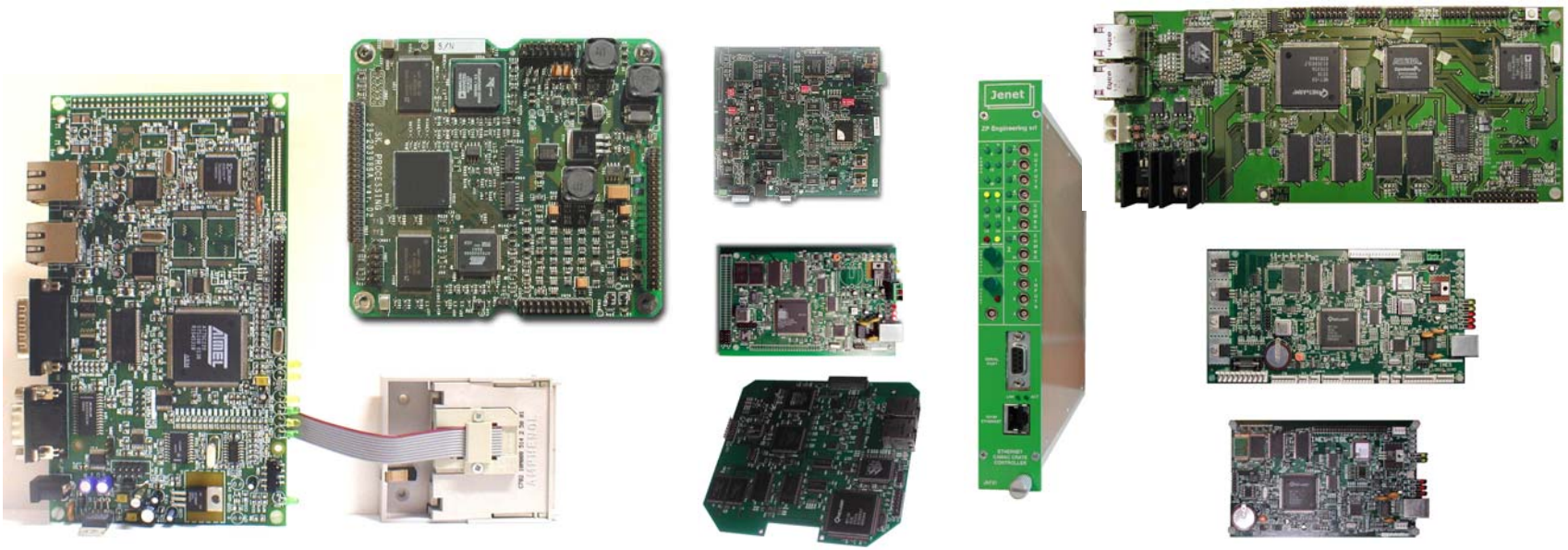
- full-speed HID can transfer up to 64,000 bytes per second (64 bytes in each 1ms frame)
- low-speed devices guarantee only 800 bytes per second (8 bytes every 10ms)
- A HID can request the host to poll the device periodically to find out if the device has data to send
- All data exchanged by a HID resides in defined data structures called reports

CRR & ARM7

•ARM7 is an industry standard

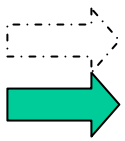
• several man-years of hands-on experience with ARM7 cores with various silicon providers (Atmel, Netsilicon, Philips, STM,...)

• used with uClinux, with real-time kernel or without OS



Microcontroller selection

- Philips LPC2000 family (with external bus)
- Low price point, good performance, internal memory
- widely used for simple embedded functions
- 16-bit memory bus



Part no.	FLASH	SRAM	CAN	tentative price @ 1kpcs
LPC2210	-	16K	-	3.8 USD
LPC2220	-	64K	-	6.7 USD
LPC2212	128K	16K	-	8.2 USD
LPC2214	256K	16K	-	9.1 USD
LPC2290	-	16K	2 ports	4.75 USD
LPC2292	256K	16K	2 ports	9.97 USD
LPC2294	256K	16K	4 ports	10.85 USD

USB SIE selection, 1

- Philips ISP1161A1
- single-chip USB HC (host controller) and DC (device controller)
- 16-bit memory bus
- double SIE
- specified for host & device implementations
- discrete support from community and forums

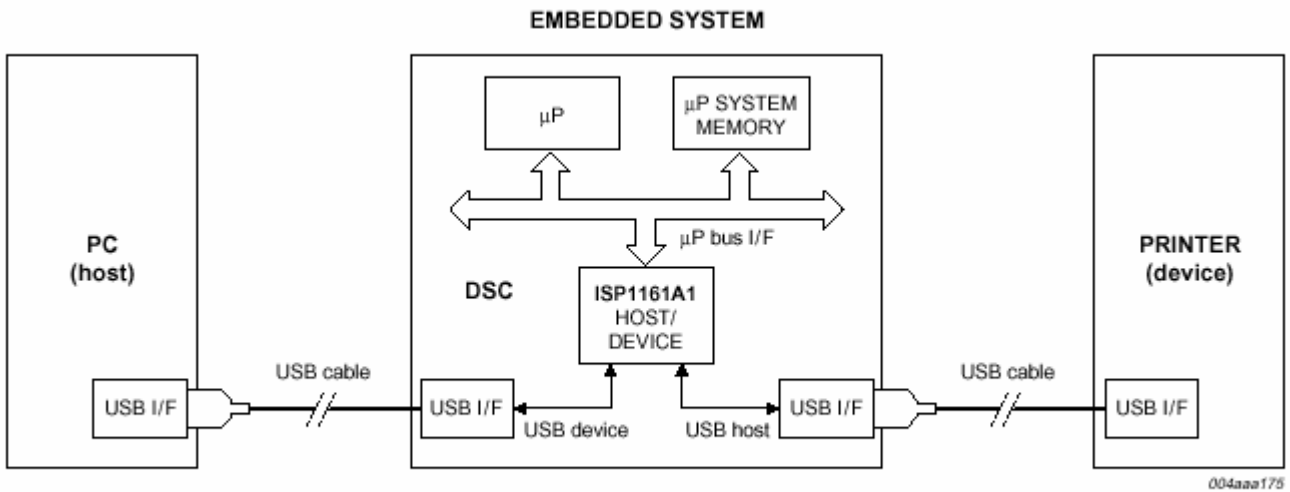
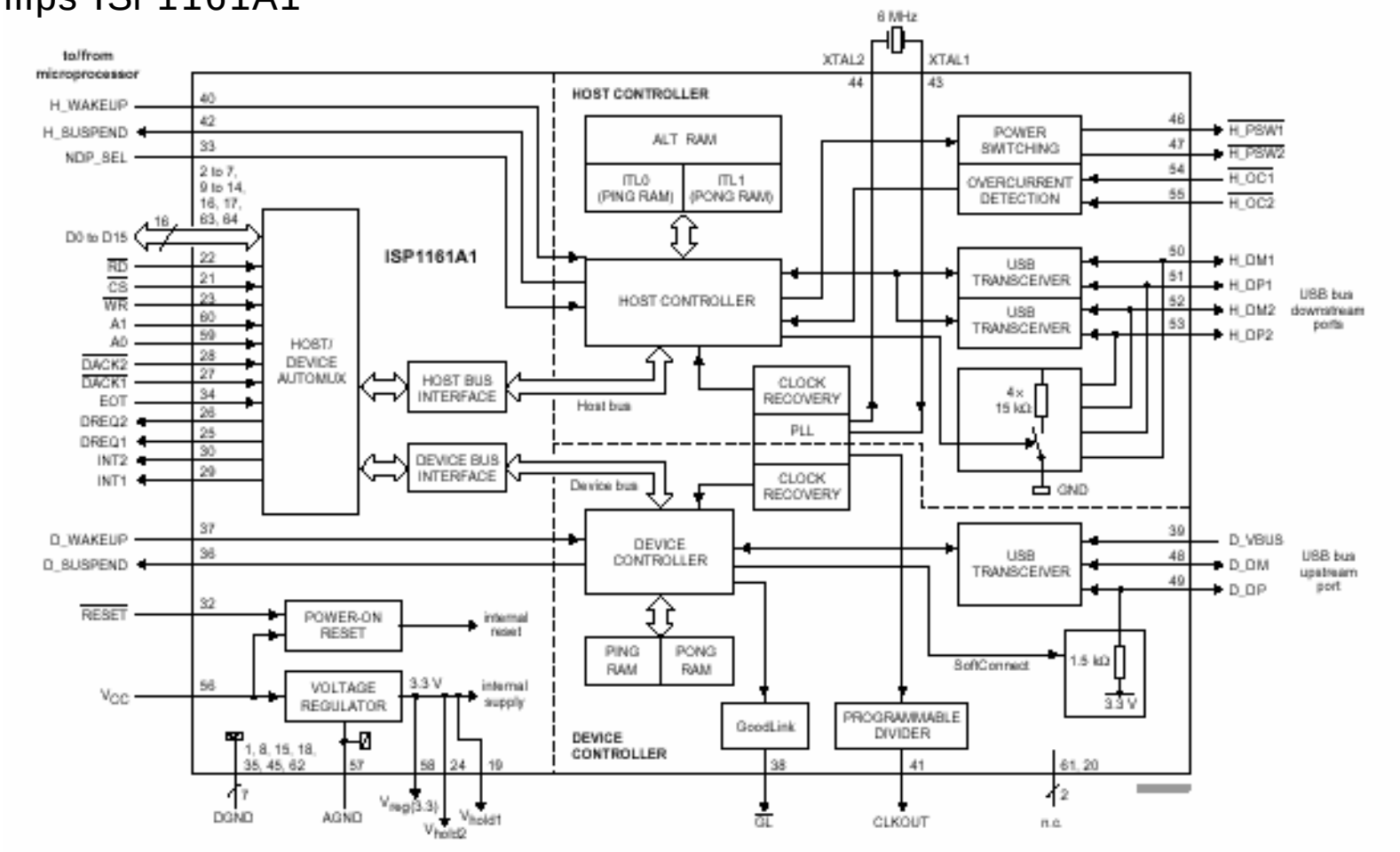


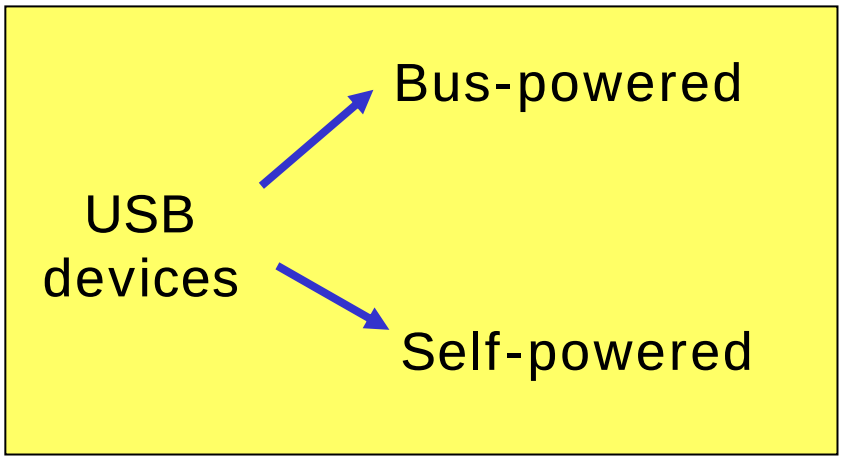
Fig 3. ISP1161A1 operating as both USB host and device simultaneously.

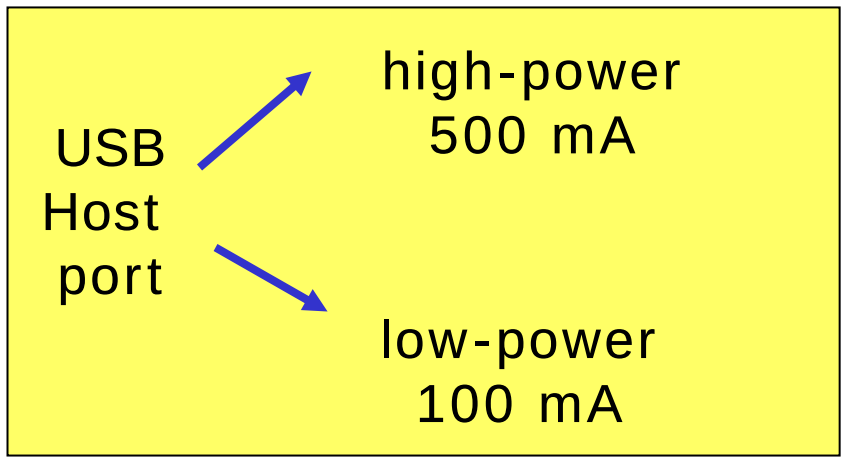
USB SIE selection, 2

Philips ISP1161A1



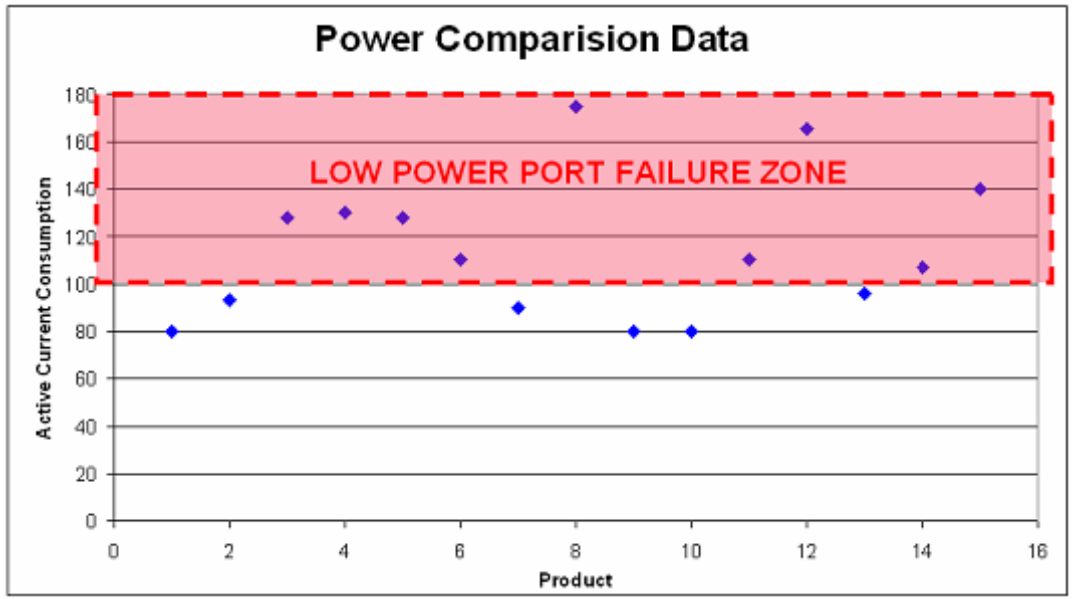
USB power considerations, 1





- **100 mA** are available during enumeration
- **500 mA** are available after proper recognition
- some root hus do not comply totally to the specs

USB power considerations, 2

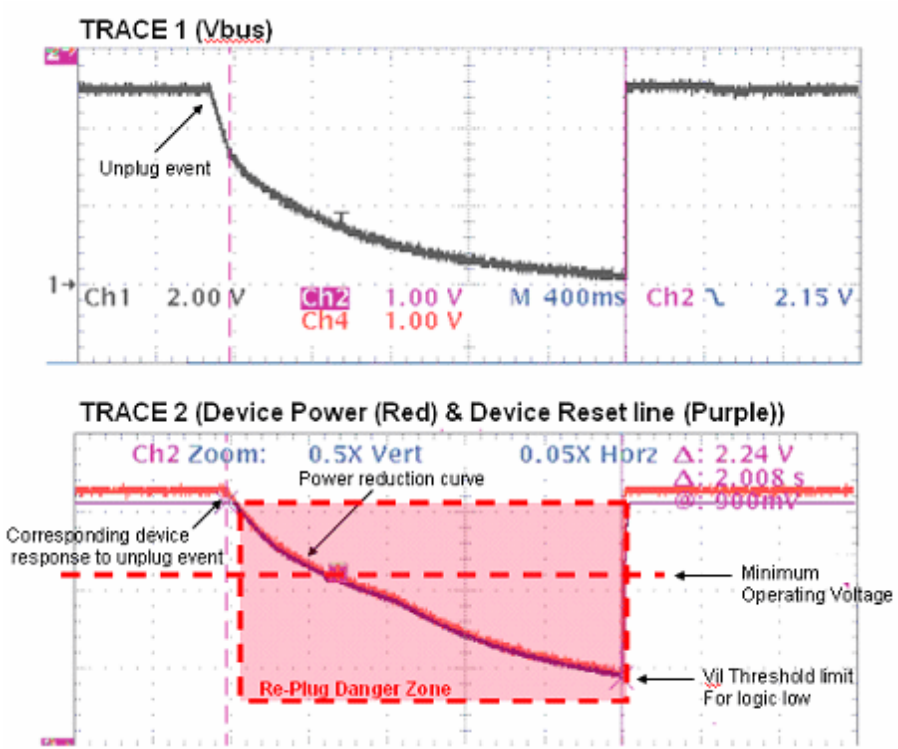


Failures at enumeration due to excessive power consumption

a common issue

USB power considerations, 3

Sensitivity to power cycling



Thank you