Industrial Applications of IEEE1394

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1394[SM]

TRADE ASSOCIATION

Overview

- Industrial applications of 1394
- Standards and Protocol overview
- Long-Haul media solutions for 1394b
- VersaPHY
- Implementation issues

Typical industrial applications of 1394

- Imaging / Machine Vision
- Industrial Fieldbus / Motion control
- Remote Sensor readout

- Requirements:
  - Guaranteed high bandwidth
  - Synchronisation
  - Power supply
  - Long-haul cabling
  - Cost efficient implementation
  - Industrial safe implementation

Latest developments of 1394 fulfil all these requirements !!

Standards Overview

- New version of IEEE 1394: IEEE1394-2008
  - Developed by 1394TA members
  - Approved by IEEE; to be published soon
  - Summarizes: 1394-1995, 1394a, 1394b, 1394c, Errata, S3200 Electrical Spec
- S1600 PHY announced by Symwave
- S3200 chip sets under development by several companies

Standards for Machine Vision (1)

- IIDC as widely established protocol for vision applications

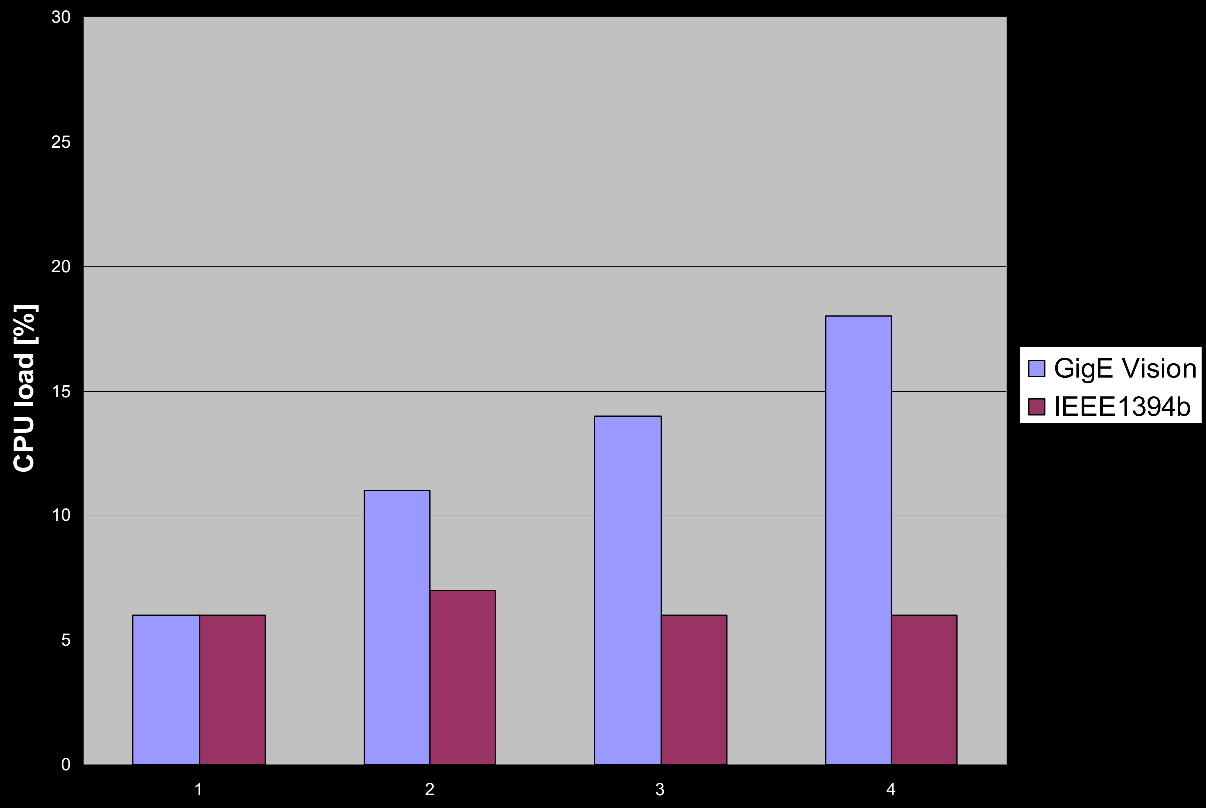
- IIDC Independent of camera implementations

- Broad software support for 1394 and IIDC:
  - Microsoft Windows: Full featured driver by Microsoft soon
  - Third-party drivers (Unibrain, Thesycon)
  - Mac OS X
  - Linux LibDC V2.0 (in combination with JuJu Stack)
  - Supported by Image Processing Libraries (Matrox MIL, …)

Standards for Machine Vision (2)

- Current Version: IIDC V1.31
- New release: IIDC V1.32
  - accepted by 1394 TA BoD; to be published soon
  - New features:
    - 12 bit mode
    - Little endian mode
    - Look-up tables
    - Control of Image buffer
    - Clarifications (Feature bits, Format 7)
- Development of IIDC V2.0 has started
  - Joint development of JIIA and 1394TA
  - Contact IIWG Chair for reflector instructions

1394 vs. GigEVision: Topology and performance tests



- Frame size of Jumbo packets: 9864 bytes
- No display allocation (only grabbing the images into a frame buffer)
- For GigE CPU load rises proportionally to camera count
- IEEE1394b does not increase CPU load due to DMA access of IEEE1394b card

1394 vs. GigEVision: Hardware Requirements

- GigE Vision
  - Common On-Board NIC: bad performance
  - Recommended PRO1000 NIC: scalable good performance
  - Frame grabber (i.e. Matrox Solios GigE): best performance + additional optiones (Trigger / digital I/O)
- IEEE1394b
  - Common On-Board interface or interface card -> always best performance
  - Frame grabber (NI PCIe-8255R): best performance + additional options

1394 vs. GigEVision: Usability

- GigE Vision
  - Vendor specific or third party filter driver needed
  - Vendor specific camera control software needed
  - Difficult system integration of different cameras
  - No real-time-support (Quality of Service)
  - Re-send mechanism (due to use of long-haul connectian via UTP cable)
- IEEE1394(b)
  - IIDC driver is part of operating system
  - Vendor or third party driver optionally delivered
  - Easy system integration of several different cameras
  - Real-time-support, Quality of Service
  - No Re-send mechanism (not needed due to missing packet losses via short distance STP cables or optical fibers)

Key features of 1394 for Automation

- Common network clock provides a means for accurate synchronization / coordination
- Data rates of 100Mbit+ provide enough bandwidth for simultaneous motion, I/O, and video
- Electrical isolation provided by transformer or POF
- Cable lengths >50m easily achievable over CAT5 with current transceivers
- Redundancy through the 1394b loop detection mechanism
- Because of the bus reset logic in the PHY, it is impossible to eliminate the possibility of a bus reset occurring during operation. Reconnect has to be fast (one of the reasons for IICP-Lite)
- Isochronous would be very attractive for closed-loop control, if it were possible to receive feedback and transmit control signal ~ <125uS

Time synchronization

- Uses the 1394 cycle time
  - A cycle master node needs to be present on the network, even if no isochronous traffic exists.
  - Common time reference across all nodes on the network, guaranteed by the cycle-time synchronization
  - Not the typical usage of cycle time, generally intended for synchronization of isochronous streams

1394 Protocols for Automation

- Industrial & Instrumentation Control Protocol (IICP)
  - Communication protocol similar to AV/C for industrial automation and instrumentation communications
  - Status: Accepted as TA1999016
- IEEE 488 over 1394 Industrial & Instrumentation Control Protocol
  - Status: Accepted as TA1999017
- IICP Lite (Currently proprietary protocol of Brooks Automation; plan to make it an official 1394TA spec)
- 1394AP
  - Protocol for synchronized control and data exchange for industrial devices like sensors, actors, motors, …
  - Features CAN-bus like top level interface (compliant to CAN CiA DS-301)
  - Status: Accepted as TA2005099

Long-Haul 1394b solutions

- Given by 1394b:

Cat 5 UTP	S100	100m
POF	S200	50m
Multi-mode fiber	S800	100m

- Recent 1394TA standards:

Cat 5e/6 UTP	S400	100m
Baseband Coax	S800	varies
Single-Mode fiber	S800	>2km

1394b long-haul repeaters

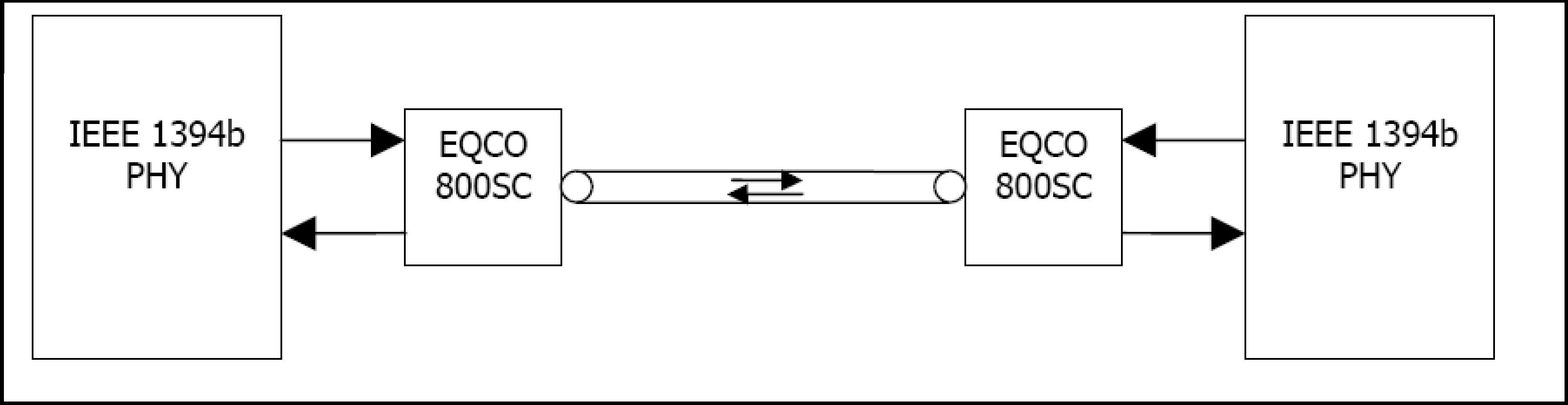
Newnex

Fraunhofer IPMS

Unibrain

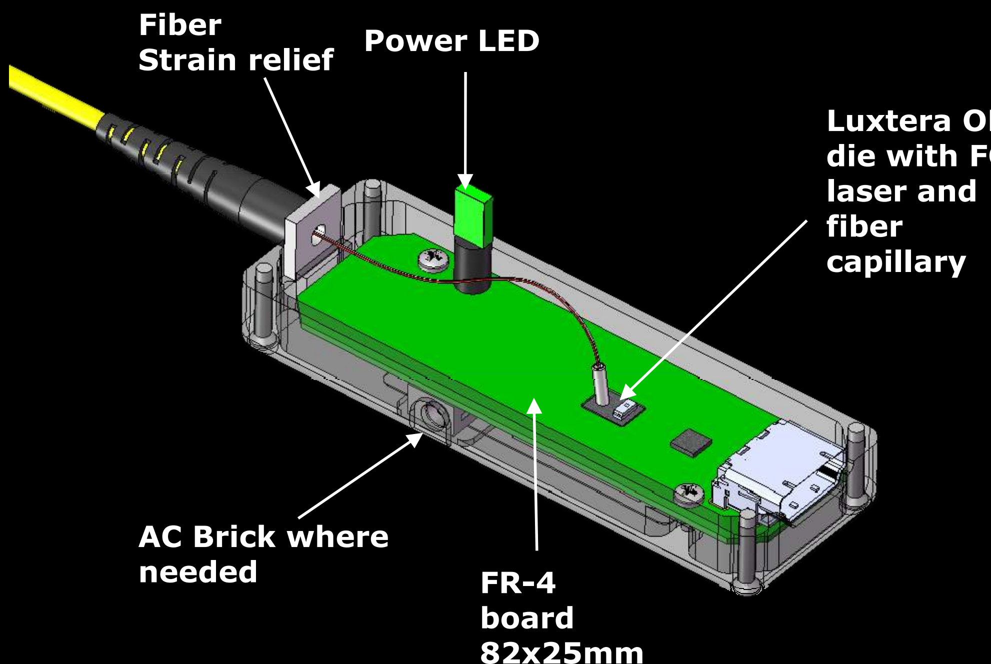
Eqcologic EQCO 800SC Solution

- Combined transmitter and receiver with an integrated equalizer to make a bidirectional connection over a single 50Ω coax cable
- Supports IEEE 1394b – S800, S400, S200 and S100 data rates
- Seamless connection with compliant PHY
- Auto-mute functionality for low-power standby mode operation, Limited power distribution may be possible over coax
- Range: 70-110m (dependent on coax cable)
- 16-pin QFN package



Single-Mode Fiber Solution

- Specification for SMF Solution (Length up several Km) currently under development (ready Q2 2009)
- Preliminary implementation by Luxtera



VersaPHY™ Background

- The VersaPHY™ concept comes out of a need for
  - lower cost and
  - simpler 1394 implementations
- The VersaPHY™ accomplishes this by
  - simplifying and in some cases eliminating device discovery after bus reset,
  - providing a simple means for control and data delivery and
  - a simple means for stream control
- Useful for exchange of small chunks of data (sensors, status & control, …)
- Basic interaction model consist of transaction capable node(s) (controllers) and VersaPHY™ devices (VPD)

VersaPHY™: New Facilities

- To make this happen a few new 1394 facilities are defined. The new facilities are:
  - Remotely and locally readable/writable PHY registers
    - Extended and scalable PHY register map
  - Read/write PHY packets
  - VersaPHY labels
  - VersaPHY label management

- The new facilities can be implemented using existing PHY silicon with external logic and/or software.
- External logic fits into small FPGA
- No controller / 1394 stack necessary

VersaPHY™ Labels

- 16K Labels – Why so many?
  - In the simplest case labels can be used as permanent or semi-permanent addressable names for nodes.
  - In more complex implementations labels can be used as permanent or semi-permanent addressable names for sub-functions within nodes.
    - Sub–functions are called profiles
      - Digital Camera profile
      - A/D profile
      - Switch profile
      - Sensor profile
      - CAN bus profile
      - Etc…
    - Nodes are still addressable using physical_IDs

VersaPHY™ Profiles

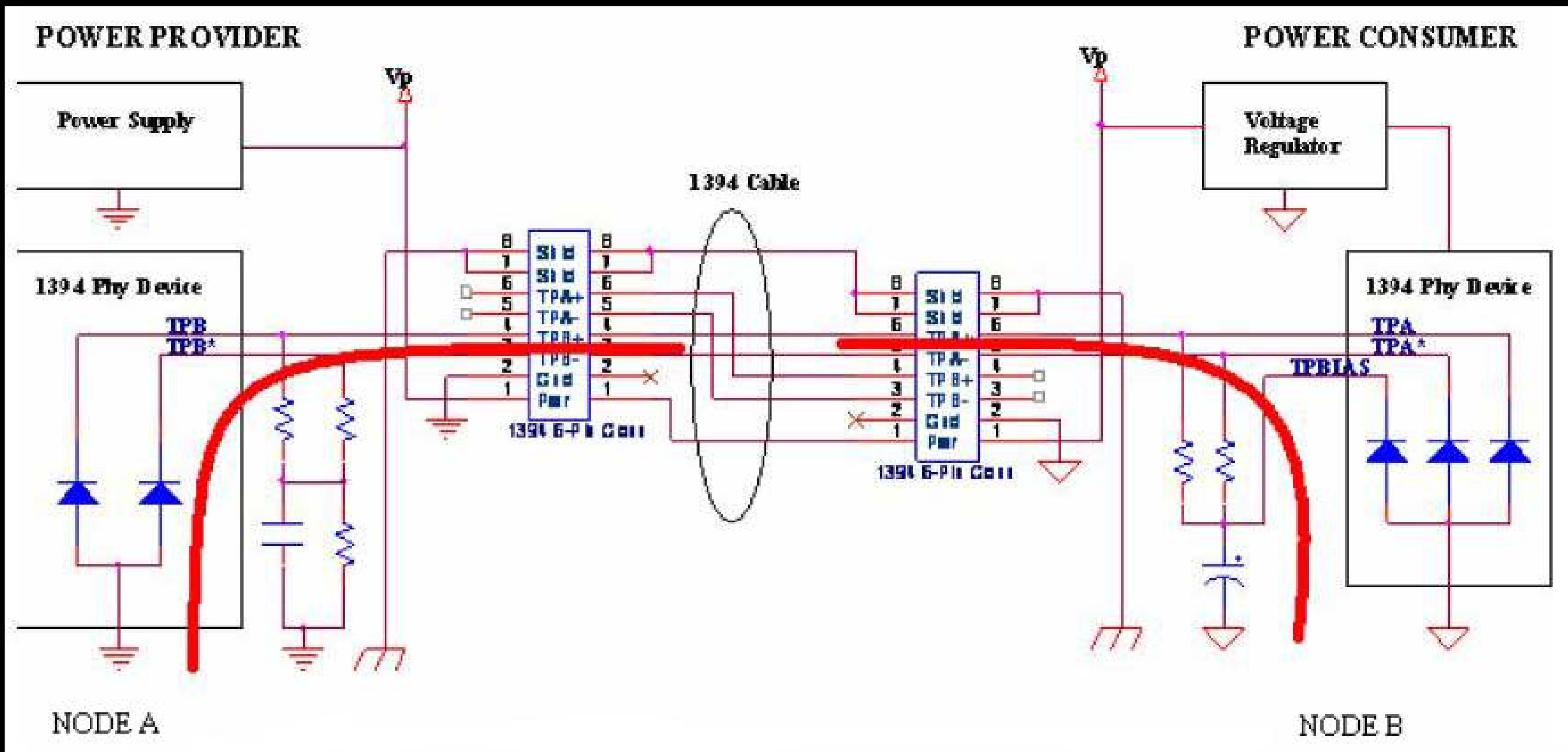
- Currently under development:
  - GPIO
  - I^2C
- Future Profiles
  - CAN
  - SPI
  - Serial Port
  - …

Implementation Issues

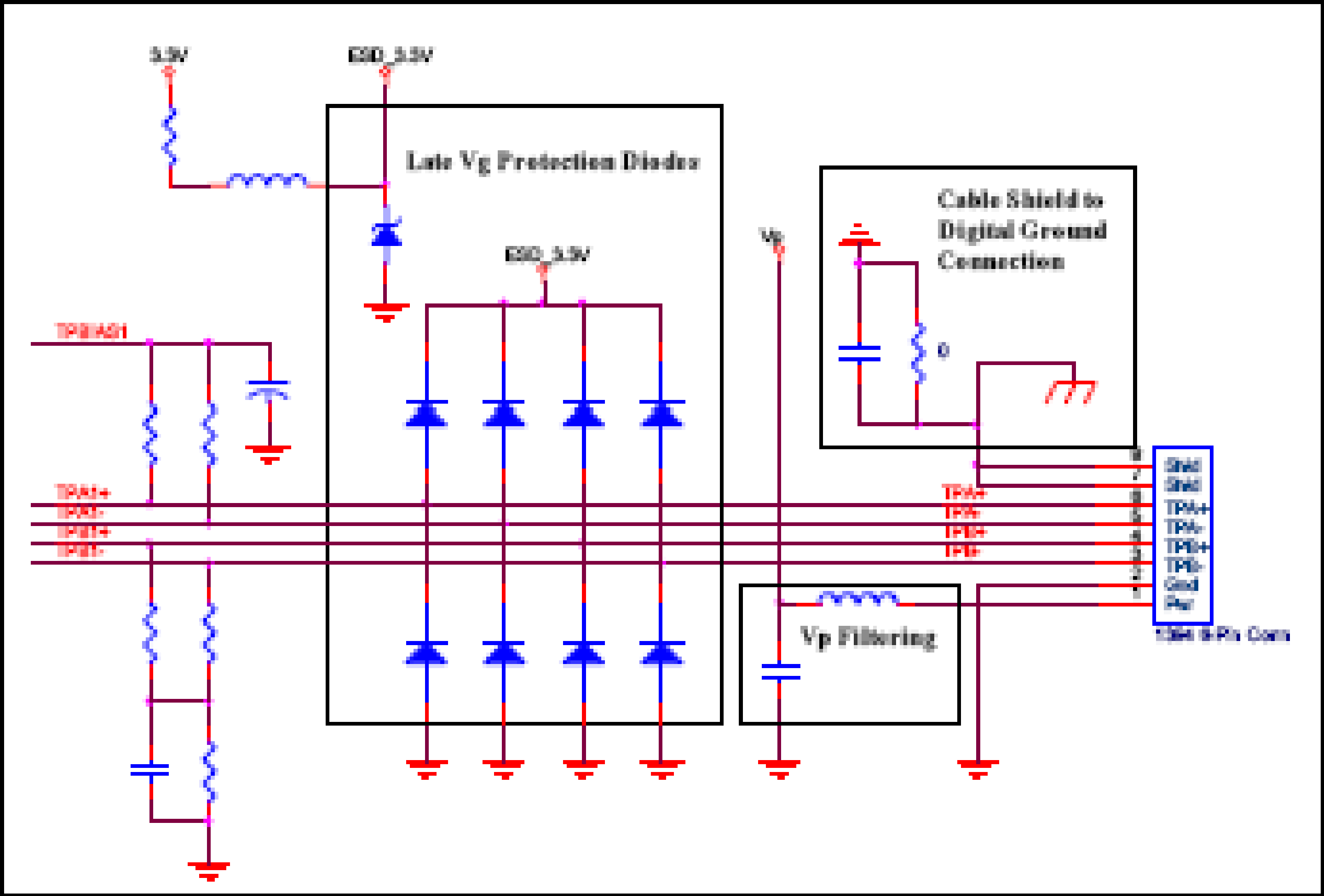
- Use of 1394b solves lots of problems for use of 1394 in industrial environments !!
- 1394TA has started process to gather information regarding industrial suited components for 1394

- "FireWire Design Guide" near to completion
  - "Hot" Connection Problems (also known as "Late-VG")
  - VP Line Fault Currents
  - Electrostatic Discharge (ESD)

„Late VG: Overview



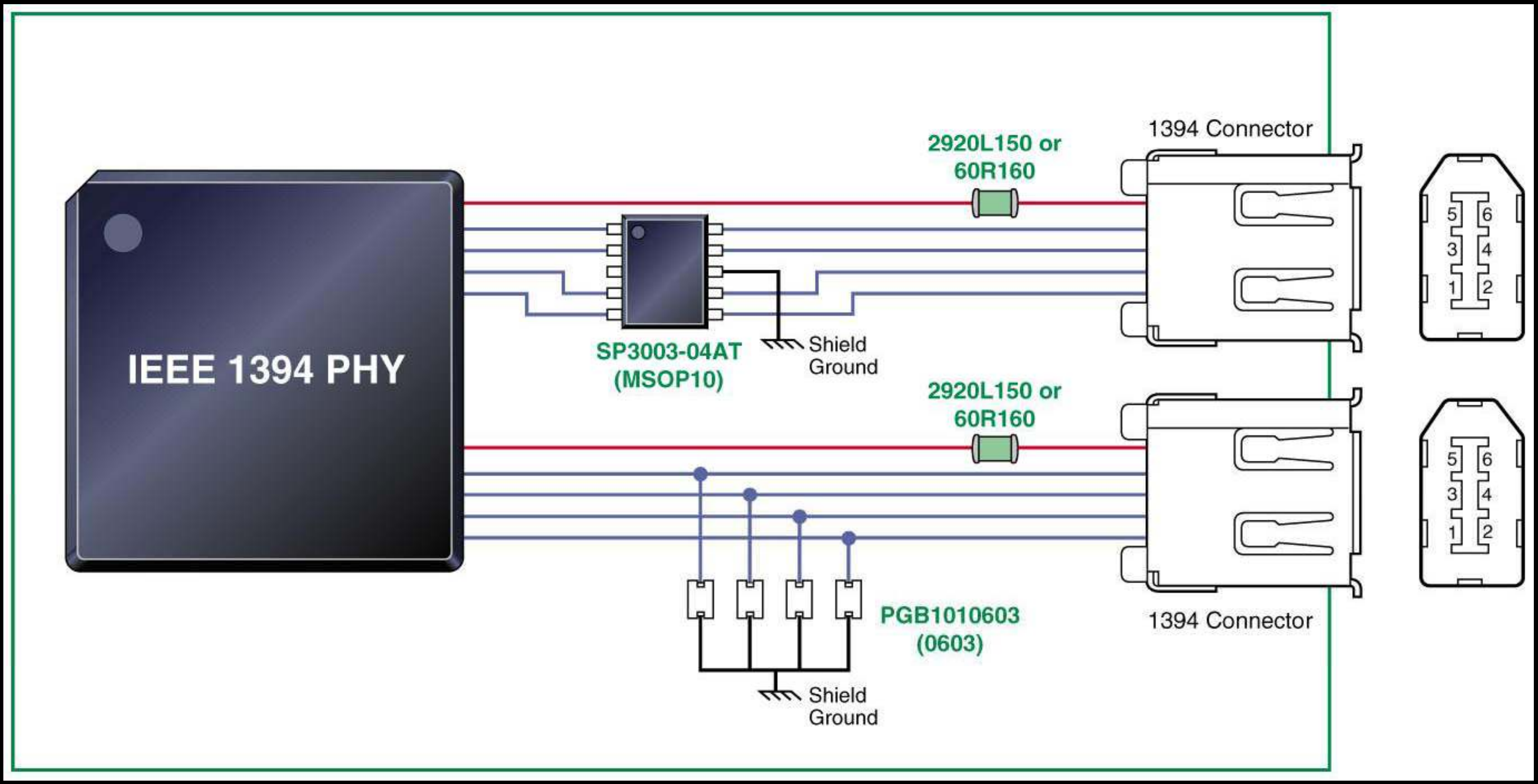
Late VG: Possible Solution



VP Line Fault Currents

- VP line from the 1394 port to the PHY should be protected from fault currents on the bus.
- Fault currents occur when a component connected to the power bus fails or is damaged such that its resistance value dramatically drops.
- To protect the PHY from high pass-through (fault) currents, the use of resettable fuses is recommended, because they have the ability to reset (restore power) after a fault current event is cleared/removed.
- Typically, these devices are positive temperature coefficient (PTC) thermistors, whose resistance increases due to self-heating (I2R), and thereby limit current in the line on which they are installed..
- Various PTC manufacturer ratings are available, from 6VDC to 72VDC, and 100mA to 9A. Surface mount and radial lead form factors can be supplied. In keeping with FireWire power specifications, resettable fuses should be rated for at least 33VDC operation.

Options for fault current and ESD protection



Summary

- Requirements:
  - Guaranteed high bandwidth:
    ✓ S3200 specification
  - Synchronisation:
    ✓ inherent feature of 1394 (no other bus standard has it !!)
  - Power supply:
    ✓ inherent feature of 1394
  - Long-haul cabling:
    ✓ various media with different ratio cost / cable range
  - Cost efficient implementation:
    ✓ VersaPHY
  - Industrial safe implementation:
    ✓ FireWire Design Guide

1394 is the optimum choice

for data transmission in industrial applications !!!

Thank You

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