Data Communication Issues
For Digital Power Management

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Data Communications Issues
For
Digital Power System Management

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Presentation Overview

• Requirements
  – Physical
  – Fiscal
  – Data Flow

• Data Communication Characteristics
  – Types Of Buses
  – Issues And Constraints

• Recommendations
  – By Data Bus
  – By Application
Fundamental Requirements

• Low Cost, Low Cost & Low Cost
  – Component - Low Cost
  – Development - Low Cost

• Robust
  – Carry Data Without Corruption Or Interruption In The Presence Of Noise
  – Does Not Pass the Burden To The Host

• Must Support Time Critical Communication
  – Address The Need For Alarms And Alerts
  – Address The Need For Fast Host Intervention
Additional Requirements: Who Talks To Whom?
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System Host To Local Controller
Additional Requirements: Who Talks To Whom?

Local Controller To Local Converters
Additional Requirements: Who Talks To Whom?
Additional Requirements: Who Talks To Whom?

Converter To Converter

System Host

Local Power Bus

DC-DC w/COMM

VOUT1

DC-DC w/COMM

VOUT2

Converter-Converter Comm

DC-DC w/o COMM

VOUT3

DC-DC w/o COMM

VOUT4

DC-DC w/o COMM

VOUT5

Local Comm Bus

Local Maintenance Processor

System Comm Bus

COMM Interface IC

Analog Control Lines (Sense, Enable, Trim, Power Good)
Additional Requirements: Real Time Data

• Time Critical Information Of Two Types
  – Events
  – Parametric

• Fault Events Can Be Catastrophic And Must Be Transmitted With Minimum Delay

• Parametric Data Requires Data Rates Of Tens Of Megabits Per Second

• Recommendation
  – Events: Dedicated Signal Lines
  – Parametric: Dedicated, Customized Buses
Additional Requirements: Hot Swap

• A Common Requirement
• Hot Insertion Or Removal Must Not:
  – Interrupt Bus Traffic
  – Require Complex System Response
• More On This Later
Data Communication Characteristics: Connectivity: Point-to-Point

Device A

Mux

Device B

Device C

Device A1

Device A2

Device B

Device C
Data Communication Characteristics:
Connectivity: Multi-Drop

- Device A
- Device B
- Device C
- Device D

Single Master
Or
Multi-Master
Data Communication Characteristics: Directing Communication On Multi-Drop Bus

• Chip/Device Select Lines
• Addressing
  – Hard Versus Soft Addresses
  – Allowable Addresses
  – Assuring Unique Addresses
  – Address Ties To Physical Location Or Function

• Address Pins – Not Just Binary
  – Tri-State
  – Resistor Programmable
Data Communication Characteristics: Bus Contention

• Bus Contention In Multi-Drop Buses Is Unavoidable For Multi-Master
• Lossless, Bitwise Arbitration Common For Simultaneous Attempts To Transmit
• Adding Priority To Messages (Like CAN Bus) Does Not Prevent Delayed Messages
  – If Bus Is Busy, Even High Priority Messages Have To Wait Until The Bus Is Clear
  – Continuous Stream Of Higher Priority Messages Can Indefinitely Delay A Lower Priority Message
Data Communication Characteristics: Speed And Timing

• Megabits Per Second Is Not The Whole Story
• How Fast Can Data Get From Sender To Receiver?
  – Over Communication Bus, Not Fast Enough For Most Time Critical Events
• Packet Overhead Reduces Effective Bit Rate
• Time Critical Data Should Be Routed Over Dedicated Buses Between Only The Devices Involved
  – Example: Real Time Digital Current Sharing
Data Communication Characteristics: Polling And Interrupts

• Polling
  – Simpler To Implement
  – Detection Of Failed Or Removed Devices
  – Consumes A Lot Of Resources
  – Possible Delay Time = Refresh Rate

• Alert Or Interrupt Driven
  – More Complicated Code
  – Reduces Burden On Host
  – Quick Notification Of Events

• Good Choice: Blend The Two
Data Communication Characteristics: Range And Number Of Devices

• Range
  – Often Capacitance Limited
  – Short Range, Open Drain Drivers = Low Cost

Watch Out For The Edges!
Data Communication Characteristics: Range And Number Of Devices

• Range
  – Often Capacitance Limited
  – Short Range, Open Drain Drivers = Low Cost

Obey The Spec – Or Else!
Data Communication Characteristics: Range And Number Of Devices

• Range
  – Often Capacitance Limited
  – Short Range, Open Drain Drivers = Low Cost
  – Longer Range Requires More Robust Drivers
Data Communication Characteristics: Range And Number Of Devices

• Range
  – Often Capacitance Limited
  – Short Range, Open Drain Drivers = Low Cost
  – Longer Range Requires More Robust Drivers

• Number Of Devices
  – Like Range, Often Load Limited
  – May Be Address Limited
  – Generally Not A Problem
Data Communication Characteristics: Range And Number Of Devices

Bus Master

Multiplexor

Slave Device
Slave Device

Repeater

Slave Device
Slave Device

Switch
Switch
Switch
Switch
Switch

Slave Device
Slave Device
Slave Device
Slave Device
Slave Device

SELECTOR
Data Communication Characteristics:
Range And Number Of Devices

A Number Of Options Are Available For Extending Buses And Number Of Devices
Data Communication Characteristics: Clock

• Synchronous
  – Clock Signal Sent With Data
Data Communication Characteristics: Clock

- Synchronous
  - Clock Signal Sent With Data
  - Receiving Devices Do Not Need An Oscillator
  - Range Limited
Data Communication Characteristics: Clock

• Synchronous
  – Clock Signal Sent With Data
  – Receiving Devices Do Not Need An Oscillator
  – Range Limited

• Asynchronous
  – No Clock Signal Sent With Data
  – Each Device Needs Its Own Oscillator
  – Can Loose Sync On Long Strings Of Ones Or Zeroes
    • Bit Stuffing
    • Fancy Coding
Manchester Coding (per IEEE 802.3)
Manchester Coding (per IEEE 802.3)

“CLOCK”

DATA

1 0 0 1 0 1 1

MANCHESTER CODED

RTZ Return To Zero Coding
Manchester Coding (per IEEE 802.3)

"CLOCK"

DATA

MANCHESTER CODED

Rising Edge Signals "1"
Manchester Coding (per IEEE 802.3)

“CLOCK”

DATA

MANCHESTER CODED

Falling Edge Signals “0”
Manchester Coding (per IEEE 802.3)

“CLOCK”

DATA

MANCHESTER CODED

Transmit Bandwidth = 2 × Data Bandwidth!
Manchester Coding (per IEEE 802.3)

Average Value Is Zero
Data Communication Characteristics: Single Ended Or Differential Signaling

- Single Ended Signaling
  - One Wire For Data
  - Lower Cost, Less Complicated
  - More Susceptible To Noise Then Differential

- Differential Signaling
  - Two Wires For Data
    - Opposite Polarity Signals On Each
  - More Immune To Noise
  - More Immune To Ground Voltage Differences
  - Higher Cost
Data Communication Characteristics: Transmission Control Issues

• Device Is Busy And Cannot Be Interrupted To Respond To Another Request
• Device Cannot Accept Data At Current Rate
• Device’s Buffer Is Full
• Bus Is Busy And Device Must Wait
Data Communication Characteristics: Transmission Protocols

• Read/Write
  – Complete Transaction In One Uninterrupted Flow
  – Example: Reading/Writing Serial Memory Device

• Message Based
  – Like Sending Email Messages Back And Forth
  – Example: IPMI
Data Communication Characteristics: Transmission Protocols

• Read/Write
  – Complete Transaction In One Uninterrupted Flow
  – Example: Reading/Writing Serial Memory Device

• Message Based
  – Like Sending Email Messages Back And Forth
  – Example: IPMI

Best For Most Power Conversion Devices
Data Communication Characteristics: Transmission Protocols

- **Read/Write**
  - Complete Transaction In One Uninterrupted Flow
  - Example: Reading/Writing Serial Memory Device

- **Message Based**
  - Like Sending Email Messages Back And Forth
  - Example: IPMI

Better For More Complex Devices Over Longer Distances
Data Communication Characteristics: Error Detection And Correction

• Possible Errors
  – Bit Value Changed
  – Beginning Or End Of A Byte Or Bit Sequence Not Recognized
  – Too Many/Too Few Bits In A Frame Or Packet
  – Start Or End Of A Packet Or Message Not Recognized

• Error Detection: Parity Bit, Checksum, CRC

• Error Correction
  – More Complex
  – Lots More Bits
Data Communication Characteristics: Fault Tolerance
Data Communication Characteristics: Fault Tolerance

True Fault Tolerance Only With Redundant Buses And Transmitters And Receivers!
Data Communication Characteristics: Hot Swap

• Hot Swap Issues
  – Removal And Insertion Without Disruption
  – How Does System Know If A Unit Has Been Added Or Removed?

• Most Buses Support Hot Swap Fairly Well

• Implementation Issues
  – Making Ground Connection “Last Break & First Make”
  – Preventing Unpowered Devices From Shorting Bus During Insertion Or Removal
  – MODULE_PRESENT Signal To Assist Detection
Data Communication Characteristics: Hardware Implementation

• Software Emulation Using GPIO
  – Possible To Do
  – A Source Of Many, Many Headaches
  – Timing Is Very Difficult Even For “Slow” Buses

• Integrated Solutions
  – Many Low Cost Microcontrollers Have Bus Interfaces Built In
  – Must Have For Complex Buses Like CAN Bus And Ethernet
Data Communication Characteristics: IP Issues

- Standard: De Facto vs. De Jure
- Who Controls?
  - An Organization
  - Single Company
  - No One
- Organization Ownership Preferred
  - Adopter’s Agreements
  - Compliance Assurance
- Royalty Free Or Not?
Recommendation By Bus Type
RS-232

• Advantages
  – Common Peripheral
  – Simple
  – Relatively Low Cost

• Disadvantages
  – Point-To-Point
  – Oscillator
  – Speed

• Recommended
  – Simple Point-To-Point With Logic Level Interface
Recommendation By Bus Type RS-485

• Advantages
  – Differential Signaling
  – Long Distance Communication

• Disadvantages
  – Additional Cost Of $1.00 to $1.50 In High Volume
  – All Protocol In Software

• Recommended
  – Longer Range Communication Such As Rack-To-Rack
Recommendation By Bus Type
I²C

• Advantages
  – Common Peripheral
  – Simple
  – Very Low Cost

• Disadvantages
  – Noise Sensitivity
  – Bus Capacitance Limitation

• Recommended
  – SMBus Is Better Choice In Almost Any Case
Recommendation By Bus Type
SMBus

• Advantages
  – Low Cost Like I²C
  – More Robust Than I²C
  – Additional Features

• Disadvantages
  – Bus Capacitance Limitation

• Recommended
  – On-Board And Shelf-Level Communication
Recommendation By Bus Type
SPI Bus

• Advantages
  – Simple
  – Chip Select Lines Eliminate Addressing Concerns
  – Good Speed (1 MHz)

• Disadvantages
  – No Standard
  – Chip Select Lines

• Recommended
  – Local Interconnect Of A Couple Of Peripherals
Recommendation By Bus Type
Dallas 1-Wire

• Advantages
  – 1-Wire
  – Unique ID In Every Device
  – Low Power

• Disadvantages
  – Noise Sensitivity
  – Proprietary
  – Cost

• Recommended
  – Only To Accommodate Legacy Situations
Recommendation By Bus Type
CAN Bus

• Advantages
  – Differential Signaling
  – Noise Immunity
  – Fault Tolerance

• Disadvantages
  – Cost
  – Requires Integrated Peripheral

• Recommended
  – Longer Range Communication Such As Rack-To-Rack And Beyond
Recommendation By Bus Type
LIN Bus

• Advantages
  – Single Wire
  – Reasonable Noise Immunity

• Disadvantages
  – Cost
  – Slow Speed
  – Complexity

• Recommended
  – Not Recommended (Use SMBus Or CAN Bus/RS-485 Instead)
Recommendation By Bus Type

USB

• Advantages
  – Well Supported
  – Hot Swap Friendly

• Disadvantages
  – Requires Hub To Initiate All Communication
  – Relatively Complex Software And Hardware

• Recommended
  – PC To Power System Interface For Service
Recommendation By Bus Type
Ethernet

• Advantages
  – Long Haul Capability
  – Electrical Isolation
  – Internet Friendly

• Disadvantages
  – Cost And Complexity
  – Very Large Packets
  – Software Support

• Recommended
  – Interface To An Embedded Web Server
    In A Power System Manager
SST: “New Kid On The Block”

• Advantages
  – One Wire
  – Relatively High Speed (~ 1 Mbit/s)
  – Low Gate Count
  – Low Error Rate/High Noise Immunity

Claim Needs Independent Verification
SST: “New Kid On The Block”

- Advantages
  - One Wire
  - Relatively High Speed (~ 1 Mbit/s)
  - Low Gate Count
  - Low Error Rate/High Noise Immunity

- Disadvantages
  - Not Widely Available
  - Not An Open Standard
  - Does Not Have Extensive Field Experience

Appears Promising – Worth Watching
Recommendation By Application

- On-Board/Single Board Power System
  - SMBus

- Shelf-Level/Chassis-Level Power System
  - SMBus If Capacitance Allows
  - RS-485 If Not

- Shelf-To-Shelf Or Rack-To-Rack
  - RS-485
  - CAN Bus
Recommendation By Application

- Facility Level
  - RS-485 Or CAN Bus
  - Ethernet
- Campus Level
  - Ethernet
- PC To Power System Manager
  - USB
Summary

• No One “Right” Bus For All Power Communications
  – The Scope and Benefits Extend Beyond The Local Area
  – Several Well Established Buses To Choose From
• Know Your Application And Its Requirements
• Be Knowledgeable About Your Choices
• Choose The “Right Tool For The Job”
• Be Smart In Your System Design
  – Imitate Successful Designs
  – Understand The Constraints Before You Start Your Design
Summary

• No One “Right” Bus For All Power Communications
  – The Scope and Benefits Extend

Follow The Specification!

– Understand The Constraints Before You Start Your Design
Thank You
For Your Time
And Attention