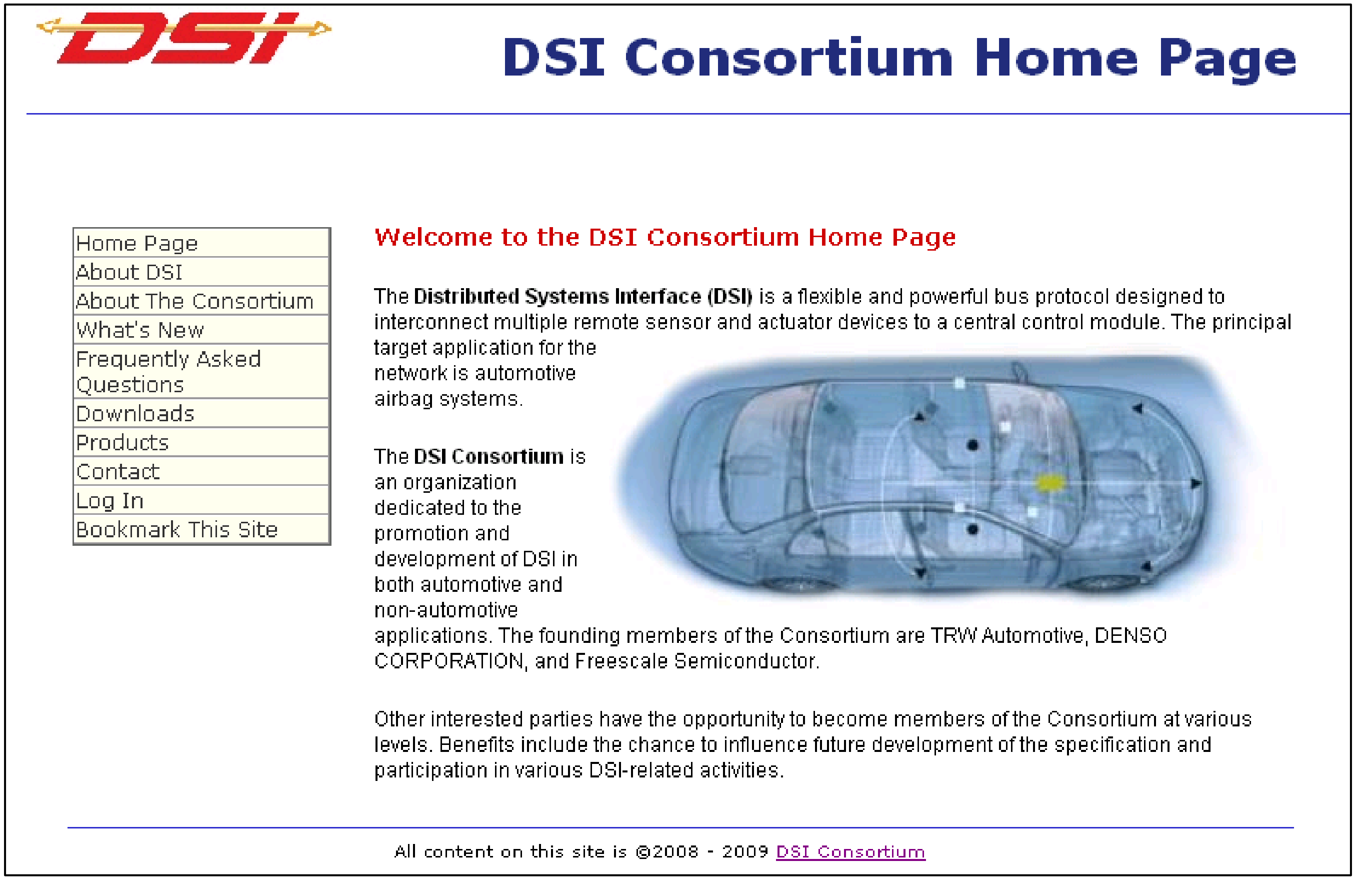
Distributed Systems Interface


DSI Consortium Home Page

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Welcome to the DSI Consortium Home Page

The **Distributed Systems Interface (DSI)** is a flexible and powerful bus protocol designed to interconnect multiple remote sensor and actuator devices to a central control module. The principal target application for the network is automotive airbag systems.

The **DSI Consortium** is an organization dedicated to the promotion and development of DSI in both automotive and non-automotive applications. The founding members of the Consortium are TRW Automotive, DENSO CORPORATION, and Freescale Semiconductor.

Other interested parties have the opportunity to become members of the Consortium at various levels. Benefits include the chance to influence future development of the specification and participation in various DSI-related activities.

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http://www.dsiconsortium.org/

Agenda

1. What is the DSI Consortium?
2. What are the consortium goals for the 3rd generation DSI standard (DSI3)?
3. What are the key features of DSI3?
4. How has DSI3 been improved?
5. How does DSI3 compare to other automotive sensor interfaces?
6. What is the status of the DSI3 standard?
7. Summary
8. Questions and Answers

What is the DSI Consortium?

- The DSI Consortium is an organization dedicated to the promotion and development of DSI in both automotive and non-automotive applications.

- Founding Members:
  - TRW Automotive
  - DENSO CORPORATION
  - Freescale Semiconductor.

- Other interested parties have the opportunity to become members of the consortium at various levels. Benefits include:
  - An opportunity to influence future development of the specification
  - Participation in other DSI-related activities (like FTF).

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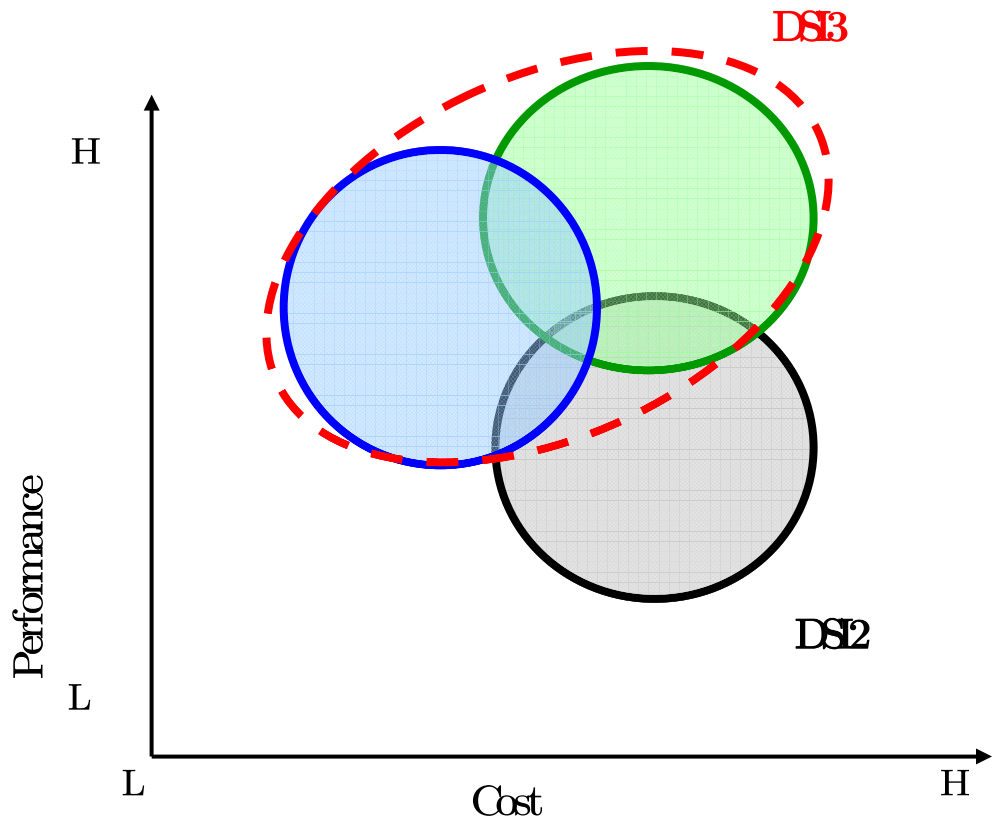
What are the DSI3 Goals?

Improve Performance

Reduce Cost

Promote Open Standard



What are the DSI3 Goals?

- Reduce Cost
  - Scalable definition allows for optimized system solutions
  - External component reduction via simplified daisy chain satellite architecture
- Increase Performance
  - Increase response data rates to support high-end safety applications
  - Enable expansion into other applications such as powertrain, body, etc.
  - Enhance command structure to support emerging functional safety requirements
  - Improve EM Compatibility to meet increasingly stringent customer requirements while maintaining a system cost advantage
- Promote DSI prominence as an Open Standard
  - DSI is proven as an open standard with multiple suppliers of components and systems

DENSO freescale semiconductor TRW DSI

DSI3 Development Strategy

Goals

- Reduce Cost
  Optimize for Airbag
- Improve EMC Performance
  Simplify noise suppression
- Increase Data Rate / Number of Nodes
  Support future high end safety applications
- Increase Functional safety
  Satisfy new requirements

Strategies	Solutions
Use a single ended 2 level interface (simple circuit) for Airbag applications	• Implemented wave shape control • Decreased voltage fluctuations • Decreased frequency of voltage fluctuations

Reduce the frequency of master induced voltage fluctuations required for master to slave communication	• Optimized data rates for each communication phase
	  • Startup / Initialization: 125kbps
	  • Normal : 8kbps

Maintain a constant bus line power supply for reducing slave complexity	• Eliminated need for separate response and power phases
Reduce the slave power consumption and the master power supply voltage	• Lowered master output voltage to 5V by eliminating bus switches and utilizing an innovative addressing technique
Increase the communication speed from the slave to the master	• Compressed the slave to master communication data by bit encoding
Scale implementations based on requirements: data sources vs. controls and actuators	• Implemented an optional power phase to support actuators and discontinuous loads of power applications
Increase the diagnostic coverage of data source messages	• Implemented a run-time, Background Diagnostics Mode

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DSI3 Solution

- Two System Classes
  - Signal Class
    - Intended for slaves with sensor only functions
  - Power Class
    - Intended for slaves with both sensor and actuator functions

- Two Primary Modes of Operation
  - Command and Response Mode
    - Optimized for Power Class actuators and fast initialization of Signal Class sensors
    - Dedicated two-way communication
      - Command Phase
      - Response Phase
      - Optional Power Phase (Power Class)
  - Periodic Data Collection Mode
    - Optimized for slave source data transmissions
    - Time-division multiplexed slave response

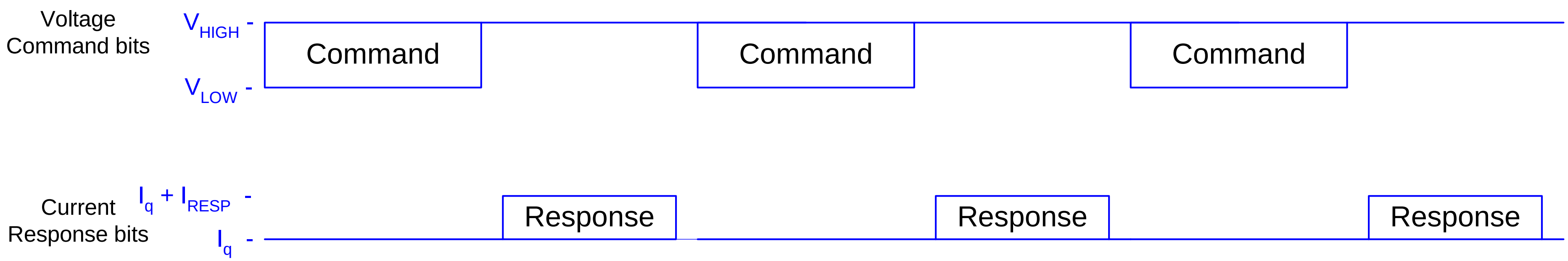
DSI3 Signal Class

- Intended for sensor-only applications
- Supports command and response mode, periodic data collection mode and background diagnostics mode
- Uses command phase and response phase
  - Power phase not required
- Optimizes periodic data collection from multiple data sources
- Requires constant quiescent current during the response phase
  - Minimal energy storage required at slaves - only required for micro-break

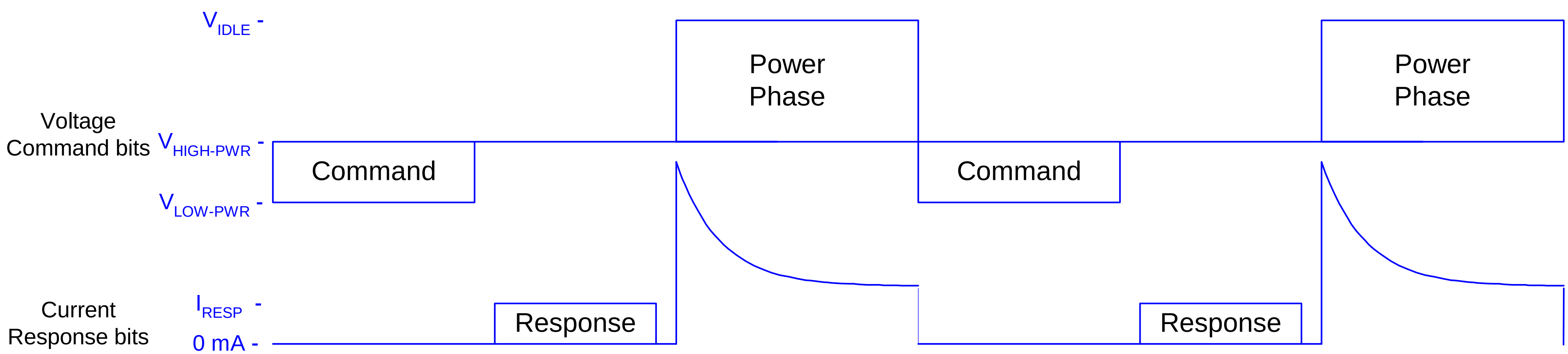
DSI3 Power Class

- Intended for sensor / actuator applications
- Supports only command and response mode
  - collects periodic data samples similar to DSI2
- Uses command, response, and power phases
  - Similar to DSI2 except half duplex
- Optimizes command and response transactions for actuators and controls
- No quiescent current during command phase and response phase
  - Energy storage required at slaves

DSI3 Command and Response Mode



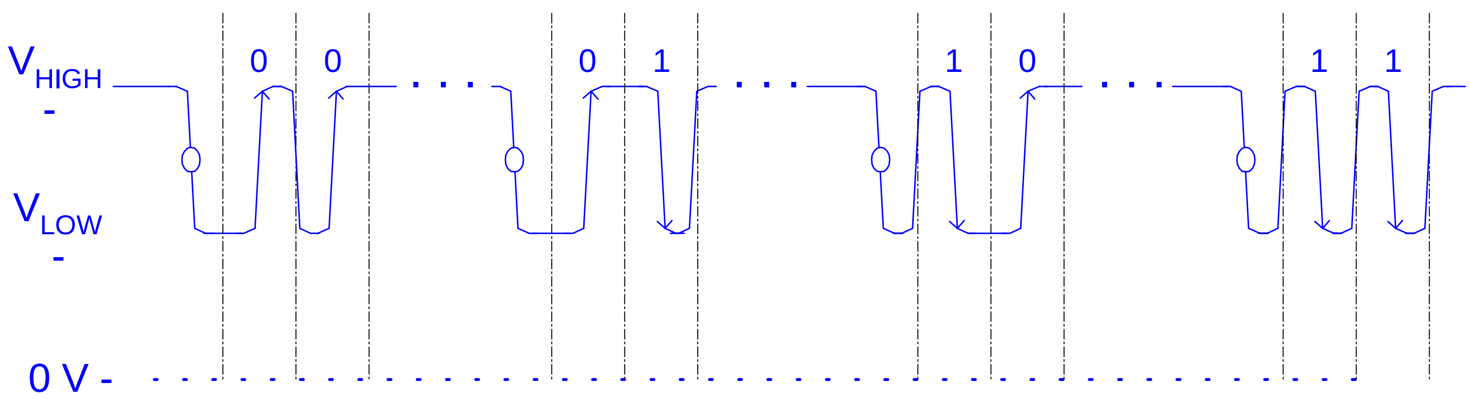
Signal Class Command and Response Phases



Power Class Command, Response and Power Phases

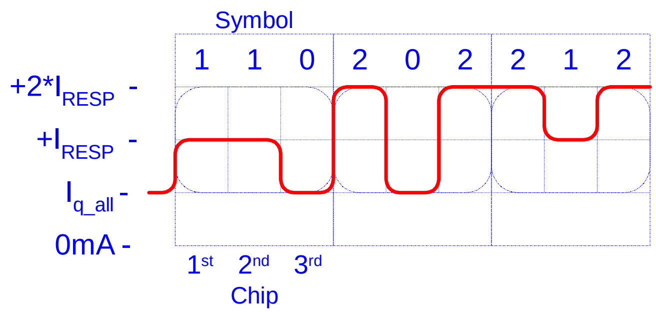
DSI3 Command Format

- Manchester encoded command format improves error detection
- Transmission
  - A Manchester Encoded Command is impressed onto the bus using two voltage levels V_{HIGH} and V_{LOW}
- Reception
  - The slaves track the bus voltages V_{HIGH} and V_{LOW}
  - Transition polarities are decoded into bits
- Command lengths consist of 1-bit to over 20-bits



DSI3 Response Format

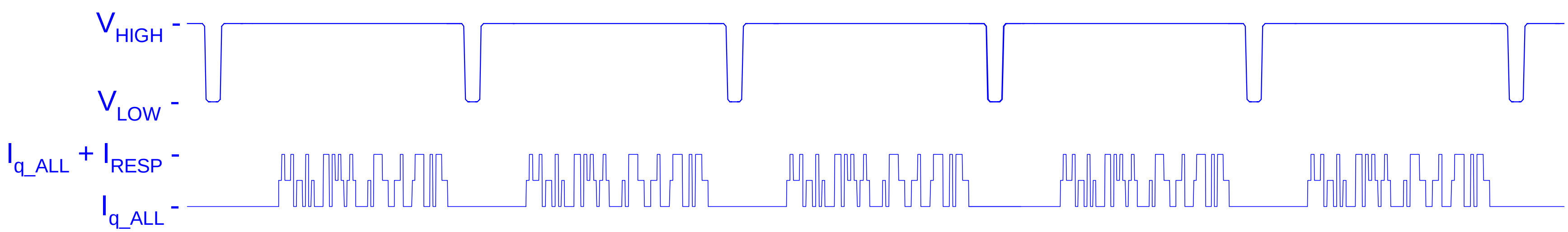
- Source coded 2-level response current improves the bandwidth utilization for source data
- Transmission
  - Data nibbles are encoded onto 3 distinct current levels
  - 3 consecutive time periods form a “chip”
  - 3 chips comprise symbol
- Reception
  - The response current levels and transitions are tracked by the master
  - 3 consecutive chips are decoded into symbols
  - Symbols are converted into packets of 4 data bits
- Response lengths from 4-bits to over 20-bits per response packet



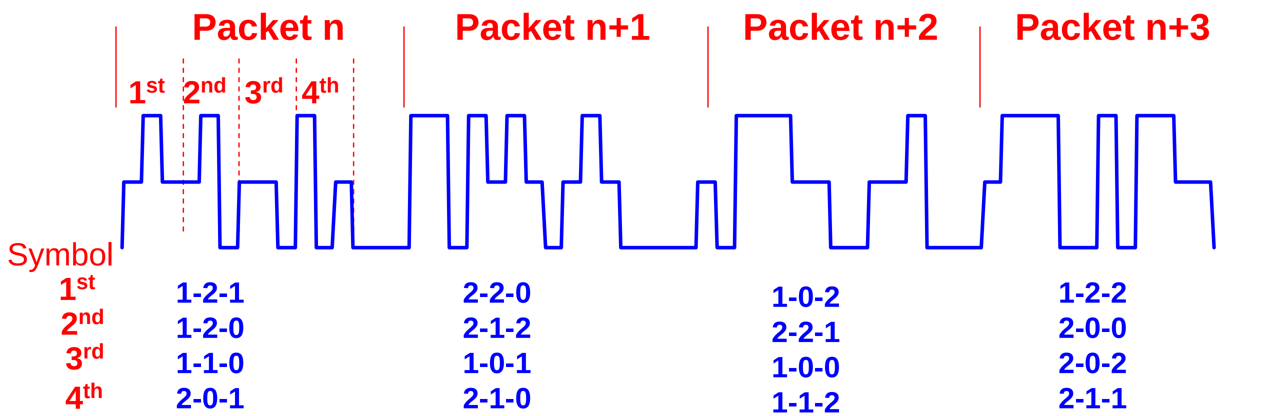
Each symbol encodes four data bits

DSI3 Periodic Data Collection Mode

- Signal Class
  - Broadcast Read Command
  - Periodic Source Data Response – one, or multiple slaves



- Example: Multiple Slave Response Packets
  - Symbol encodings for four 16-bit response packets

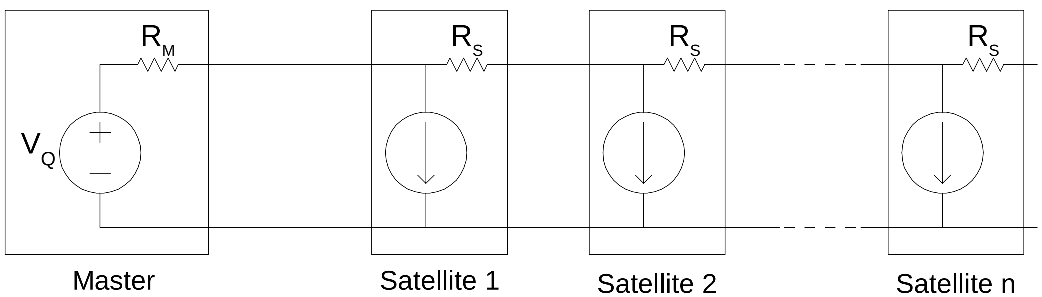


DSI3 Advanced Features

- Background Diagnostic Mode
  - Innovative bi-directional communication method interleaved with Periodic Data Collection Mode
  - Master to slave bandwidth allocations can be adjusted to meet application requirements
  - Target functions are fault reporting and functional safety
    - Read error counters and status flags without disrupting normal periodic data collection activities
    - Manage complex sampling schemes like multi-rate sampling of sensor clusters with continuous diagnostics
- Discovery Mode
  - Innovative address assignment method for automatic system configuration
  - Eliminates the need for bus switches
  - Reduces system costs

DSI3 Discovery Protocol

- An innovative power-up address assignment method which does not require bus switches
  1. Slaves connected in a daisy chain through high side sense resistors
  2. After applied power, all slaves set their address counters to 'One'
  3. The master transmits a unique Discover command
  4. After a specified time, all slaves activate their response current
  5. All slaves monitor the current through their sense resistor
     - If a slave does not detect any response current through its sense resistor, it is the last device on the chain and sets its address to the current value of the address counter. After a specified time, it deactivates its response current and does not re-activate it until Discovery has completed.
     - If a slave detects current through its sense resistor, it deactivates its response current and increments an address counter
  6. Steps 3 through 5 repeat until all slaves have accepted an address



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DSI3 Optimized Data Collection Capability

- DSI2.5 — 112 kbps effective
  - Two packets per 250us: 10 data bits, 4 error detection bits
  - Four packets per 500us: 10 data bits, 4 error detection bits

- PSI5
  - PSI5 P10P-500/3L — 66 kbps effective
    - Three packets per 500us: 10 data bits, 1 error detection bit, Manchester coding
  - PSI5 P10P-500/4H — 88 kbps effective
    - Four packets per 500us: 10 data bits, 1 error detection bit, Manchester coding

- DSI3 — 320 kbps effective
  - Four Packets per 250us: 16 data bits, 4 error detection bits
    - Based on a 4uS chip rate (3uS to 5uS chip rates are typical)
  - Many other combinations are possible including mixed rate sampling

Note: Effective bit rates are based on actual number of bits per unit time including only data bits and error checking bits.

DSI3 Optimized Communication Capability

- DSI2.5
  - Full Duplex
  - 200 kbps master to slave communication
  - 200 kbps slave to master communication
  - Approximately 8000 command and response exchanges per second (Standard Long Command)

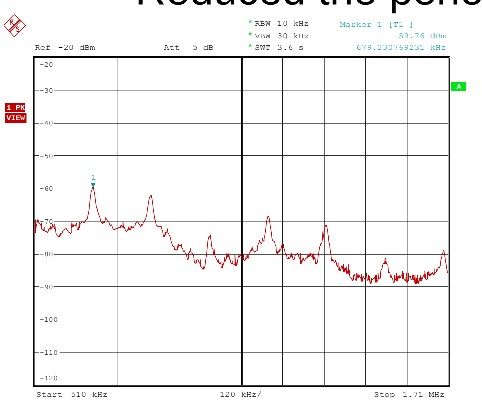
- PSI5
  - Half Duplex
  - 2 kbps master to slave communication
  - 125 kbps slave to master communication (option for 189 kbps)
  - Approximately 133 command and response exchanges per second (Short Command)

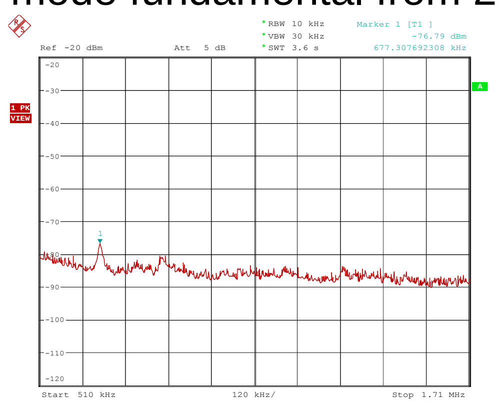
- DSI3
  - Command and Response Mode (Power or Signal Class)
  - Half Duplex
  - 125 kbps master to slave communication
  - 256kbps slave to master communication
  - Approximately 2000 command and response exchanges per second (Standard 32-bit command)

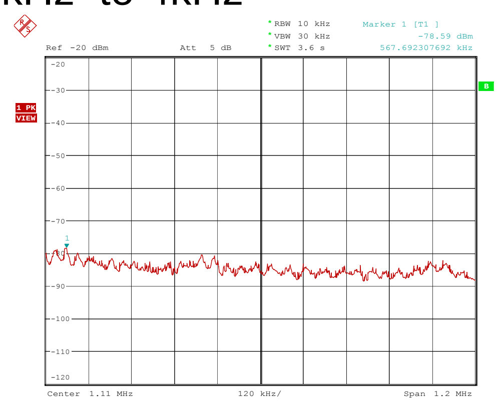
Notes: Bit rates are raw bit rates
Command and response exchanges per second account for protocol overhead

DSI3 EMC Improvements

- DSI3 utilizes new concepts designed to improve EM compatibility
  - Reduced frequency and time duration in initialization
    - Lowered the Periodic Data Collection Mode fundamental frequency of voltage fluctuations
    - Reduced the start-up time of a pre-configured system to 10mS
  - Greatly improved single-ended performance
    - Utilized wave shape control
    - Removed 200kHz harmonics
    - Reduced the periodic mode fundamental from 200kHz to 4kHz







Single-ended control
Single-ended DSI2

Differential control to reduce common mode noise
Present DSI2

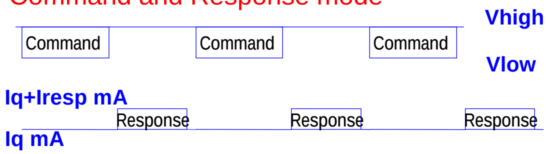
Single-ended control with wave shape control and without 200kHz harmonics
Emulated DSI3

DENSO freescale semiconductor TRW DSI

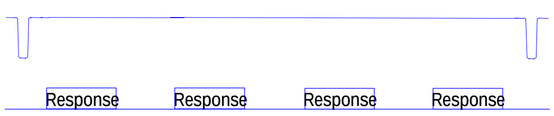
DSI3 Scalability Improvements

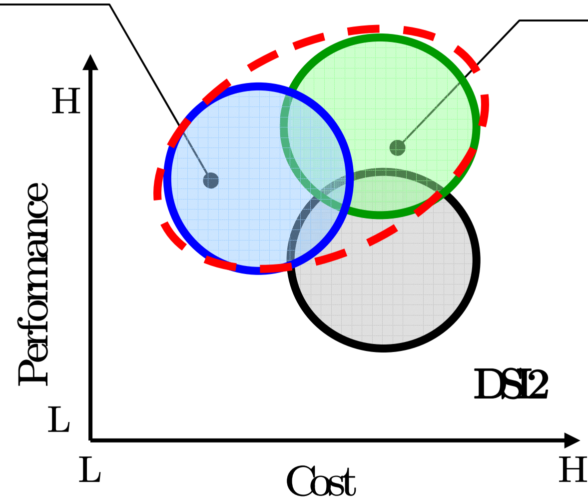
Signal Class for periodic sensor applications

- Command and Response mode



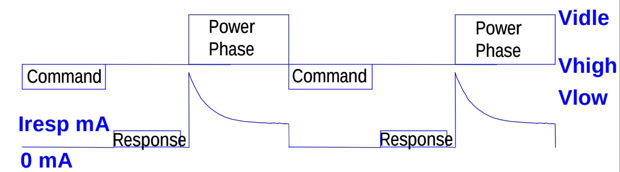
- Periodic mode





Power Class adds actuator and control applications etc.

- Command and Response mode



Class	Command	Response Raw Bit Rate[1]	Response Eff. rate Bits /Sec[2]	Power phase	Application
Signal	Startup: 125kbps Normal: 8kbps	267kbps to 445kbps	240kbps to 400kbps		Constant quiescent current applications
Power	125kbps	267kbps to 445kbps	120kbps to 200kbps	✓	Intended for actuators or data sources for which power consumption is variable

1) Based on chip rate with 3-chips per symbol and 4-bits per symbol
2) Includes only Data bits + CRC check bits per unit time (i.e. start bits, timing gaps etc are not included)

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Automotive Sensor Interface Comparison

		DSI2	DSI3 (Signal Class)	PSI5
Emission Countermeasures		Utilizes slew rate control. May use differential drive and impedance matching with high accuracy.	Utilizes single-ended drive with wave shape control	Uses single-ended drive with slew rate and/or wave shape control
Immunity Countermeasures		Requires external components	Minimizes external components required	Requires external components
Energy Supply		Separates power source from communication	Constant power source	Constant power source
Operational Voltage		≥8V	≥5V	≥5V+3.5V sync
Bus Configuration		Supports daisy chain, parallel and universal connection	Support daisy chain, parallel and universal connection	Supports daisy chain, parallel and universal connection
Dynamic addressing number		15	255	6
Data Sources / Bus Typ. Airbag Application		4 / 500us	4 / 250us	3 / 500us
Data Rate	Master to Slave	~200kbps	~125kbps	2kbps
	Slave to Master	~200kbps	~445kbps	125k (189k) bps
Bus switch for dynamic addressing		Required	Not required	Required

Automotive Sensor Interface Comparison

	DSI2	DSI3 (Signal Class)	PSI5
Expansion to actuator systems	Power source time divided from communication, allowing for high current actuators	Optional Power Phase: Power source time divided from communication, allowing for high current actuators	Power source combined with communication, limiting source current capability
	Efficient run-time master to slave communication	Optimized run-time master to slave communication	Slow run-time master to slave communication
Expansion to low voltage, fast startup systems (Powertrain)	Low voltage operation limited to > 6V even with large energy extraction at slaves.	Low voltage operation (5V) possible. Energy extraction possible at slave to further reduce voltage	Low voltage operation (5V) possible.
	Startup < 5ms with pre-programmed devices. Slave identification transmission interleaved with data transmissions using efficient run-time master to slave communication.	Startup < 5ms with pre-programmed devices. Slave identification transmission interleaved with data transmissions using optimized run-time master to slave communication. .	Startup < 5ms with pre-programmed devices. Slave identification transmission interleaved with data transmissions using slow run-time master to slave communication.

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DSI Consortium Status

- Organization:
  - Founders : DENSO, Freescale, TRW
  - New Member Recruitment: In process

- SPEC :
  - ✓ DSI2 Available for download now
  - ✓ DSI3 Founder Draft in December 2009
  - DSI3 Founder + New Member Draft in June 2010
    - On track for end of June

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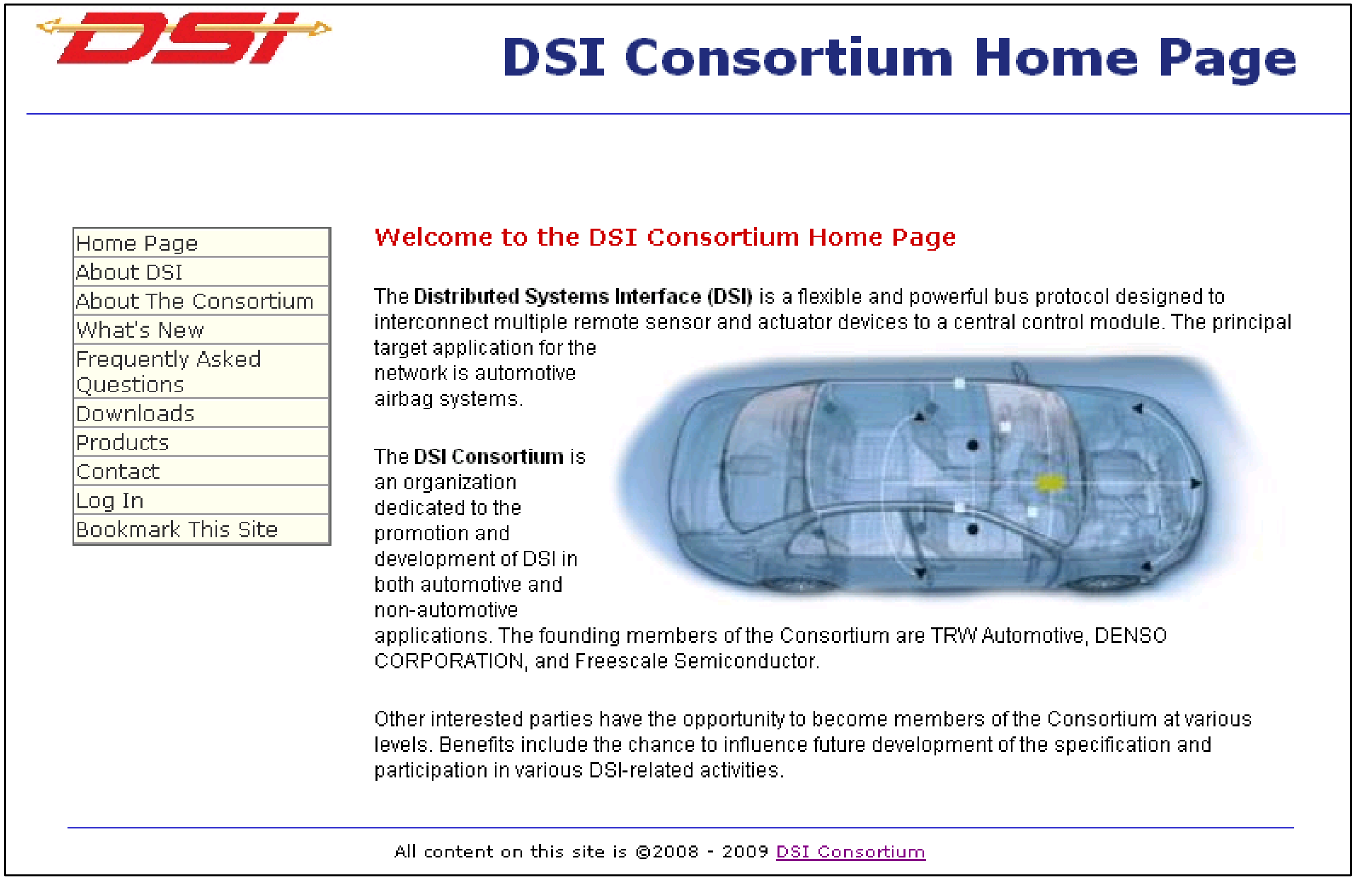
DSI3 Summary

- DSI3 is the 3rd generation DSI system developed primarily for automotive sensor interfaces
- DSI3 builds upon the benefits of existing automotive sensor interfaces to provide an optimized balance of cost, performance and safety
  - Bandwidth Optimizations
    - Increase data rates for sensors
    - Maintain an efficient master to slave communication bandwidth to support fast startup and expansion into actuator applications
  - Safety Features
    - Increase functional safety with an innovative bi-directional communication interleaved with periodic data collection
  - Cost Reductions
    - Reduce system cost with an innovative address assignment method , eliminating the need for daisy chain switches
    - Improve EMC performance, reducing the need for external circuitry
- DSI3 provides scalability for expansion into other automotive applications including body and powertrain
  - Run-time command and response mode
  - Optional power phase for high current actuators
- DSI3 is maintained as an open standard as previous DSI versions

Questions & Answers



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