Platform Management IPMI
Controllers, Sensors, and Tools

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Enterprise Platforms Group
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Introduction

• Audience: Architects, Technical Managers, Firmware Leads, and Hardware Designers
  – Involved in architecture, component selection, debug, test, or design of server baseboard and peripheral management subsystems

• Focus: IPMI-based implementations
  – Hardware components
  – Hardware and firmware development tools
Disclaimers

• A good starting point
  – … but not a comprehensive list of vendors or available technology
  – Listing of particular vendors and products does not constitute an endorsement by Intel or the IPMI Promoters

• No guarantees on accuracy of information provided
  – Contact vendors directly for complete specifications and availability information

“Architect’s Pick”
Agenda

- IPMI Update & Architecture Overview
- Baseboard Management & Enclosure/Peripheral Controllers
- Sensor Devices
- Putting it all together - design advice and tools
- Summary
IPMI

Intelligent Platform Management Interface

- Defines a standardized, abstracted, message-based interface to intelligent platform management hardware
- Defines standardized records for describing platform management devices and their characteristics

Promoters: Intel, HP, NEC, Dell

Adopters: Over 125 and growing

http://developer.intel.com/design/servers/ipmi
Updated Errata, Conformance Test Suite and 64- & 32-bit .NET/Windows* 2000 Drivers Available

developer.intel.com/design/servers/ipmi

* Other names and brands may be claimed as the property of others.
Other Initiative News

• ASF 2.0
  – Alert Standard Format specification from DMTF
  – Adds authentication to remote power and reset control over ASF 1.0

• PICMG 3.x / AdvancedTCA*
  – IPMI additions for PICMG 3.x support
    – Network function for “AdvancedTCA” commands
    – Slot/Connector type for “AdvancedTCA” boards
ASF/IPMI Typical Applications

IPMI and ASF are complementary and cooperating technologies
## Platform Management Technologies

### System Health & Security Alerts
- Health Alerts (Temperature, Voltage, Fan, etc. -- 128 definable alerts)
- Security Alerts (Chassis Intrusion, LAN Heartbeat, System Password Violation)
- BIOS Messages & Alerts
- OS Hung Watchdog Timer

### Authenticated Remote Control**
- Processor Missing (startup Watchdog)
- Power up/down/cycle/reset
- Boot & Boot Path Options

### Status Info
- System State
- System ASF Capabilities
- Presence Ping/Pong

### Monitoring
- Abstracted Local and Remote Monitoring
- Health Sensor "Present Reading" Access (Temperature, Voltage, Fan, etc.)

### Inventory and Logging
- FRU/Inventory Data Access
- Event Logging

### Extended Out-of-Band Access
- Serial/Modem Access
- Text-based Access
- Inter-Chassis Access
- Multi-level, Multi-user Security

### Extended Alerting
- Alerts to multiple destinations
- Paging via Modem

### Automatic Actions
- Platform Event Filtering (PEF) - Configurable, Event-based automatic recovery & alerts

### Scalability / Extensibility
- Utilizes independent BMC
- "Unlimited" Events & Sensors
- Extensible Sensor/Event Busses

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** IPMI supports multi-user as well as multilevel authentication
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**BMC Features to look for...**

**System Interface**

- **Built-in System Interfaces**
  - For IPMI, three types possible:
    - KCS (Keyboard Controller Style) most popular.
    - BT (Block Transfer) is fastest.
    - SMIC (Server Mgmt. Interface Chip) for implementation via external ASIC or FPGA [not recommended for new designs]

- **“Low glue” connection to chip set**
  - LPC or ISA “X-bus” interfaces commonly used
  - IPMI specifications support memory mapped implementations as well as original I/O mapped

- **System Interface interrupt support**

- **Multiple Built-in System Interfaces**
  - KCS interface hardware can be used to implement an ACPI EC (Embedded Controller) interface
  - Additional interface can support OEM differentiation access, such as from an SMI Handler
BMC Features to look for...

I²C/SMBus Support

• Recommend three Master-Slave interfaces for general purpose server BMC:
  – 5V Master-slave for IPMB
  – 3.3V Master-slave for PCI Mgmt. Bus
  – 5V for Redundant IPMB in modular/blade server applications or M/S interface for LAN / Future

• Supports multiple slave addresses
  – One fixed for I²C broadcast (00h)
  – One programmable for device as IPMI target
  – Second programmable for snoop/SMBus host target

• SMBus and I²C compatibility
  – For PCI SMBus support and sensor device flexibility
BMC Features to look for...

**I²C/SMBus Support**

Multiple private management bus support

- Reduces need for external I²C bus multiplexing
- Hardware-based m/s or slave-only hardware-based interfaces are best
  - Important for LAN Controller interface performance
- ‘Open drain’ or ‘quasi- bi-directional’ I/O can be used to create ‘bit banged’ private busses
  - Mainly useful for sensor devices that do not require extensive polling
BMC Features to look for...

**Flexible I/O**

- **Selectable open-drain or driven outputs**
  - Reduces need for external pullups
  - Can implement ‘bit baged’ private I^2^C/SMBus

- **3.3V Standby operation with 5V tolerance**
  - 5V tolerance on I^2^C reduces cost of IPMB support
  - Supports 5V status and SEEPROMs (e.g. Power Supply FRU)

- **High current outputs (>12 mA)**
  - For direct LED drive
BMC Features to look for...

**UARTs and Interrupts**

- **UARTs with hardware handshake support**
  - For ICMB & IPMI-over-Modem support

- **Multiple UARTs**
  - To support redundant connections for modular server designs

- **Multiple External Interrupts**
  - For asynchronous event capture
BMC Features to look for...

**FAN monitoring & control**

- **Timers or Counters for Tach FAN Speed monitoring**
  - Tach FAN speed can be accumulated using a single counter with a digital multiplexer
    - FAN speed is calculated by accumulating counts per unit time, e.g. 1 second.
    - Time to accumulate FAN speeds scales with number of FANs. I.e. monitoring 8 fans takes 8 seconds.

- **Pulse-width Modulator (PWM) or D/A outputs for FAN Speed control**
BMC Features to look for...

Built-in Analog-to-Digital

- **Need for at least 7 voltages is common**
  - E.g. Processor 1 & 2, 3.3V, 3.3Vaux, 5V, 12V, -12V

- **Many server systems require more**
  - >2 processors, SCSI terminations, bus, cache/chipset, etc.
  - 19 or more is not uncommon!

- **Conversion rate usually not an issue...**
  - A single converter with analog multiplexing works well

- **But accuracy, tolerance, and resolution are**
  - Recommend at least 8-bit resolution, +/-1 bit tolerance, and +/-1% accuracy

Low accuracy paid for with system margins
BMC Features to look for...

**Firmware support**

- **Development and Debug Support**
  - Vendor-provided debug tools
  - Test port or emulator support
  - Commercial high-level language & code debugging tools
  - Commercial RTOS options

- **IPMI Firmware / SDK**
  - Typical SDKs support customer-developed extensions for ‘Value added’ features
  - Vendors may also offer customization services

**Firmware and SDKs yield faster TTM for IPMI-based designs**
BMC Features to look for...

**Extensibility, Headroom, and Low Cost**

- **Low Power Consumption**
  - <50 mA is a pretty good target

- **Scalability**
  - Can one controller fit multiple products?
  - ...Or is it part of a ‘family’ that can?

- **ROM/RAM Upgrade Path**

- **Performance Headroom**
  - Authentication & Encryption for potential future interfaces, e.g. Web, demands compute power

- **External Expansion Capability**

- **Package and Board Space**
  - BGA packaging can provide higher density
  - Watch tradeoffs between package size & overall solution cost

- **Low Unit Cost**
## Management Controllers*

*Other names and brands may be claimed as the property of others.*

```
= new since last presentation

<table>
<thead>
<tr>
<th>Mfr.</th>
<th>product</th>
<th>core</th>
<th>I/F</th>
<th>I²C</th>
<th>A/D serial</th>
<th>system</th>
<th>App</th>
<th>LED drv</th>
<th>special features</th>
<th>IPMI F/W</th>
<th>Avail.</th>
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<tr>
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<td>ARM7/ TDMI</td>
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** Comparators

... Continued next page
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<th>special features</th>
<th>IPMI F/W Avail.</th>
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<td>ARM7/TDMI</td>
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<td>BMC / cPCI</td>
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<td>Qlogic</td>
<td>Zircon</td>
<td>ARM7/TDMI</td>
<td>3 KCS via LPC, ISA</td>
<td>3 m/s</td>
<td>10 ch</td>
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<td>BMC / cPCI</td>
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<td>BMC</td>
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<td>PWM, LCD Module I/F, 4 temp diode</td>
<td>yes now</td>
</tr>
</tbody>
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Baseboard Management Controllers

Qlogic* Zircon UL
– Target applications: 1P/2P Servers
– 32 GPIO (max), 4 Fan tach, 3 PWM
– 128-pin PQFP
– Virtual Storage Interface – supports ‘virtual floppy’
– Universal Serial Interface
  – for serial redirection / headless
– Samples: now, Production: 4Q02

Qlogic Zircon BL
– Target applications: server blades, high-end workstations
– 18 GPIO (max), 2 fan tach, 2 PWM
– 100-pin PQFP
– Virtual Storage Interface
– Universal Serial Interface
– Samples: now, Production: 4Q02

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Baseboard Management Controllers

National Semiconductor* PC87431M “mini-BMC”

- Targets IPMI-based LAN remote mgmt.
  - supports monitoring by local mgmt. s/w via SMBus
  - configurable polling of sensors similar to ASF
- Authenticated IPMI LAN support for:
  - System reset, SMI/NMI, and power control
    - settable ‘Boot Options’
  - FRU, System Event Log, and SDR access
  - Alerting via IPMI/PET SNMP Traps
- “PEF-like” configurable actions on events
  - power control, reset, fault light, NMI/SMI, and alert
- Internal FLASH, RAM, NVRAM
  - up to 512 bytes NV available for OEM use

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Enclosure/Peripheral Controllers

Example Block Diagram

- SAF-TE = SCSI Accessed Fault-Tolerant Enclosures
- SES = ANSI SCSI Enclosure Services
Enclosure Management Controllers

Features to look for...

- **SAF-TE and SES Firmware**
  - Extensible / customizable?
  - Configurable LED definitions?
- **IPMI Firmware / SDK**
  - IPMB Support?
- **Support for external sensors or FRU devices**
  - e.g. FAN & power monitoring

Firmware and SDKs yield faster TTM for Enclosure/Peripheral Controllers
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• Putting it all together – design advice and tools
• Summary
Sensor Devices

Sensors and Monitors with I²C/SMBus

- **Board Temperature Sensors**
  - Temperature sensor in package
  - May include digital outputs for fan control

- **Processor Temperature Sensors**
  - Thermal diode monitors plus built-in temperature
  - May include automatic fan control

- **Hardware Monitors**
  - Voltages for board and processors
  - Processor VID (voltage ID) monitor
  - Temperatures
    - built-in plus remote thermal diodes for processors
  - Fan speeds
  - Digital I/O or PWM for fan speed control

**Focus on dual-processor monitoring**
Sensor Devices

Sensors and Monitors with I²C/SMBus

• Other composite sensor devices
  – Focus on specific areas
    – Disk drive enclosure monitoring
    – Fan monitoring & control and voltage monitoring for processors
    – Fan and voltage monitoring for >2-way systems
  – See examples in backup slides

• Sensor Trend: Automatic Fan Control
  – Noise Reduction becomes more difficult for pedestal servers
    – Need to meet PC Design Guide recommendations and European specs such as “Blue Angel”
  – Need for more granular / gradual speed control
    – Audible FAN Speed Cycling disconcerting to user
  – Need for per-fan or per-zone control
    – Driving all fans to same speed usually produces higher than needed noise level
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I²C/SMBus Application

Design Pointers

- SMBus and I²C not directly compatible
  - Timing and Electricals are close, but not identical
  - But masters and slave devices can be designed to work with both
  - And I²C and SMBus slave devices can typically be used on same bus

- Slave Devices: Only use devices with data integrity checks on IPMB and PCI SMBus
  - Place other devices on ‘Private Management Busses’ behind management controllers or other integrity-checked device

- Masters: Include support for clearing the ‘Stuck 0’ condition

Design for SMBus and I²C compatibility
See IPMI Web Site for more info
I²C/SMBus Application

**Bus Driving**

- **Multiplexing** required when dealing with address option shortages or conflicts
- **Conversion** required when dealing with different bus voltage levels
- **Isolation** required when unpowered devices would ‘short out’ bus
- **Repeater** functionality when driving long busses or many loads (e.g. PCI SMBus)
**I²C/SMBus Application**

**Bus Driving**

Philips Semiconductor*

PCA9516 “5 channel I²C Hub”

- Allows *multiple* additional 400 pF bus segments
- Segments can be individually isolated
- Supports level translation (5V tolerant pins)
- Pins “Hi-Z” when device un-powered.
- Supports multi-master arbitration across the repeater

Possible applications:

Supporting PCI Management Bus on >8 PCI Slots, isolating SMBus to ‘hot-plug PCI’ slots, driving I2C to multiple system boards

PCA9515 single segment I²C Bus Repeater also available

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I²C/SMBus Testing

Testers & Monitors

• Generators and monitors available
  – Standalone and PC Hosted
  – Ready to run software
  – Software libraries and SDKs enable IPMI message parsing

• Some tool vendors our developers have used
  – Microcomputer Control Corporation
    http://www.mcc-us.com/
  – Calibre UK Ltd
    http://www.calibreuk.com/
    – Card also supported in IPMI conformance test suite
  – Telos EDV Systementwicklung GmbH
    http://www.lucit.de/
I²C/SMBus Testing

IPMI Messaging Testing

• **IPMITOOL**
  – simple messaging utility available from IPMI Web Site

• **Debug tools from component vendors**

• **Software from I²C tester vendors**
  – use SDKs to extend tool for IPMI message parsing

• **IPMI Conformance Test**
**IPMI Conformance Test**

- **Automated testing for IPMI v1.5 & v1.0**
  - generates command conformance reports

- **Performs System interface accessible testing**
  - KCS and SMIC interfaces, Watchdog Timer, BMC Sensors
  - System event log (SEL), sensor data record (SDR), and FRU access
  - IPMB, ICMB testing

- **KCS protocol test**

- **IPMI v1.5 LAN, Serial, IPMB, and PCI SMBus test support**

- **Platform Event Filtering (PEF) and alerting**

- **Also usable as debug and development aid**
  - TCL script-based testing is user extensible
  - Examples provided

**Speeds development and conformance testing**
Software and Firmware building blocks

OSA Technologies

- Platform Mgmt.
  S/W and F/W for IPMI & PICMG 3.x
- Modular Architecture
  - Extensible
  - Scaleable across product lines
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Summary

- New initiatives and specifications enable competitive server management features
- Management controllers and sensor devices available to fit your design and feature differentiation needs
- Tests & tools reduce system cost and design effort
- Help available today...
Component & Tool Vendors*

- **Agilent Technologies**
  contact.tm.agilent.com/tmo/datasheets/English/PRMC_ERMC.html, Niki Haines, niki_haines@agilent.com

- **Analog Devices, Inc.**
  www.analog.com/pc & /temp-sensors, Paul Errico - paul.errico@analog.com

- **Dallas Semiconductor**
  www.dalsemi.com

- **Hitachi Semiconductor (America), Inc.**
  semiconductor.hitachi.com

- **Micro Computer Control Corporation**
  www.mcc-us.com, Ed Thompson, ed.thompson@mcc-us.com

- **National Semiconductor Corporation**
  www.national.com/appinfo/tempsensors/ & /advancedio, Hezi Friedman, hezi.friedman@nsn.com

- **Philips Semiconductors**
  www.philipslogic.com/products/i2c, Joe Kochanski, joseph.kochanski@phlips.com

- **OSA Technologies**
  www.osatechnologies.com, Steve Rokov, steve.rokov@osatechnologies.com

- **Qlogic Corporation**
  www.qlogic.com, Mark Byrne-Quinn, mark.byrne-quinn@qlogic.com

- **Texas Instruments**
  www.ti.com

- **Vitesse Semiconductor Corporation**
  www.vitesse.com, Tom Brokaw, brokaw@vitesse.com

- **Winbond Electronics Corporation**
  www.winbond.com.tw, Chad M.C. Wu, mcwu0@winbond.com.tw

* Other names and brands may be claimed as the property of others.
Resource Information

Organizations / Specifications

- **IPMI (Intelligent Platform Management Interface) Specifications**
  - [http://developer.intel.com/design/servers/ipmi](http://developer.intel.com/design/servers/ipmi)

- **SMBus Specifications**
    - [http://www.smbus.org](http://www.smbus.org)

- **I²C Specifications**
  - The I²C-BUS Specification, Version 2.1, January 2000
    - [http://semiconductors.philips.com/](http://semiconductors.philips.com/)

- **DMTF Pre-OS Working Group / ASF Specifications**
  - [http://www.dmtf.org](http://www.dmtf.org)

- **PICMG / AdvancedTCA – PCI Industrial Computers Working Group**
  - [http://www.picmg.org](http://www.picmg.org)

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Questions?

Please remember to turn in your session survey form.
This presentation will be posted September 26th

http://www.intel.com/idf

Attendee password will be sent two weeks after the conference via email.
Backup
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<tr>
<td>Vitesse Semi.</td>
<td>VSC200</td>
<td>R3000</td>
<td>Fibre Channel, SFF-8067, ESI</td>
<td>3 m/s</td>
<td>N</td>
<td>2</td>
<td>ICE/GP FIFO'd ICMB</td>
<td>12mA ICMB Arbitration</td>
<td>yes</td>
<td>now</td>
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<td>VSC205</td>
<td>R3000</td>
<td>SCSI</td>
<td>3 m/s</td>
<td>N</td>
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<td>ICE/GP FIFO'd ICMB</td>
<td>12mA ICMB Arbitration</td>
<td>yes</td>
<td>now</td>
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</tr>
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</table>

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## Example Board Temperature Sensors

<table>
<thead>
<tr>
<th></th>
<th>resol.</th>
<th>acc</th>
<th>addr.</th>
<th>dig. out</th>
<th>pins</th>
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<td><strong>Analog Devices</strong></td>
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<td>AD7416</td>
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<td>AD7417B</td>
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<td>16</td>
<td>temp + 1ch A/D</td>
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<td>temp + 4ch A/D</td>
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<tr>
<td>DS75</td>
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**Processor/ Remote Diode Temperature Sensors**

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<th>Remote</th>
<th>Remote</th>
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<th>pins</th>
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<td>+/- 3</td>
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<td>+/- 3</td>
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<td>FAN ctrl.</td>
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<tr>
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<td>+/- 3</td>
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<td>+/- 3</td>
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<td>Texas Instr. THMC50</td>
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<td>+/- 3</td>
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<table>
<thead>
<tr>
<th>Hardware Monitors*</th>
<th>volt. temp.</th>
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<th>chassis intr</th>
<th>POST RAM</th>
<th>add'l I/F</th>
<th>fan ctrl /special</th>
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<tr>
<td>Philips Semiconductor</td>
<td>Heceta-IV *</td>
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<td>24</td>
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<td>1</td>
<td>FAN Ctrl &amp; Speech</td>
<td>48</td>
</tr>
</tbody>
</table>

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Miscellaneous Sensors and Actuators

Analog Devices* ADM1026
- 3 Channel ±1°C Temp Sensor
- 19 voltage channels
- 8 x Fan Control and Monitoring
- 16 GPIO
- 8k EEPROM
- 48LQFP

Analog Devices ADM1029
- 3 Ch. ±1°C Temp Sensor
- 2 voltage channels
- **Automatic Fan Control** and Monitoring
- Supports Fan Hot Swap
- 24 QSOP

Analog Devices ADM1031
- 2 x Automatic Fan Control and Monitoring
- Fan Fault and Therm Fault indications
- 16TSSOP

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Vitesse Semiconductor* VSC055

I²C Enhanced Backplane Controller
- Designed as a companion component to enclosure management processors
  - I²C bus
  - 8 Fan-speed monitor inputs
  - 8 Programmable PWM outputs
  - 64 12mA, programmable, bi-directional I/O pins with individually selectable one of 7 LED flash rates
  - 32 GPIO pins can be uses as FC-AL port bypass control pins
  - Programmable interrupt control for 64 interrupt sources (I/O, bypass input transitions, and fan speed thresholds)
  - 100-pin PQFP pkg.
- SSC050 is a subset of the VSC055 (e.g. 4 fans & PWM, 40 GPIO, 52 interrupt sources)*

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I²C/SMBus Testing

Testers & Monitors

Microcomputer Control Corporation  http://www.mcc-us.com/
  – MIIC-101K
    – I²C/SMBus Standalone Monitor and Software Analyzer Kit
  – MIIC-102  I²C/SMBus Bus Monitor Plus
    – I²C and SMBus 400 kbps monitoring
    – ISA, PCI, and PC Card interfaces available
  – MIIC-202 iPort/Al
    – RS-232 to I²C Host Adapters with serial port ASCII Interface.
– Software
  – I2C/SMBus Software Analyzer Package
  – iPort Software Development Kit for Windows, Professional Edition

Calibre UK Ltd  http://www.calibreuk.com/
  – ICA90/93LV   PICA90/93LV
    – ISA and PCI I2C-Bus adapters
  – desk-top (parallel port) I²C-Bus adapters
  – Software
    – ICADLL and PICADLL developers I2C-Bus windows programming libraries
    – WINI2C ready-to-run I²C-Bus software

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Telos EDV Systementwicklung GmbH
http://www.lucit.de/

TRACII

- **H/W based, 400 kbps I²C monitor/tracer**
  - Hardware and software filters for logged data
  - EPP parallel port interface
- **SDK supports adding protocol decode software**
- **Can inject as well as monitor**
  - Slow switching between master and slave operation limits use for management controller emulation, however