Special Devices
Special Devices

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Simulator Special Devices
Design and Installation

• Introduction
  • Simulated Instruments
  • Radiation Monitors

• History Simulated Radiation Monitors
  • Past Projects
  • Recent Developments

• New Embedded Processor
  • Advantages
  • Development Phases

• Other Special Devices

• Conclusion
Introduction

• Simulation Advantages
  - Lower Cost
  - Expanded Instructor Actions (Malfunctions, Remotes, Overrides)
  - Handle Simulator Modes Smoothly (Reset, Snap)
  - No Need for Power Relays or AC Outlets (for power source)
  - No Expensive Modifications for Exam Security Needs
  - Lower Maintenance Cost

• My focus is on Victoreen brand Radiation Monitor Instrumentation

(Other simulated instrumentation: keyboards, H2O2 Analyzers, Annunciators, General Atomic RM-1000 and RM-2300, and GE Numacs.)

The next slide is a photo of the Victoreen 942A radiation monitor.
Introduction
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History of Simulated Radiation Monitors

• Standardize embedded processor
  - Capable processor
  - DIO and AIO capable
  - Interface capable (RS232, Ethernet, I2C (Inter-Integrated Circuit))

• Maintain model flexibility
  - Firmware frees host of tedious tasks
    - Digital display number formatting (from a float)
    - Bar graph construction (from integers)
    - DORT requirements
    - Self-test requirements
  - Maintain full host model control of instrument simulation
History of Simulated Radiation Monitors

Started designing with PC104 format which provided choice of a wide range of PC embedded processors, and a choice of many IO boards that can be stacked on top of the processor board. Hence the word “stack” you’ll be hearing in this presentation. Each stack talked via Ethernet to the simulator.

For the Victoreen radiation monitor, CORYS chose 586 processor board and a 96 digital input output board (DIO). One Victoreen has 92 IO signals.

- Past Projects
  - Victoreen Model 942A for Perry
    - Replaced 39 simulated analog instruments
    - The hardware design of the simulated instrument include two scanner IC’s providing 64 output bits in local memory, or 8 seven-segment displays depending on the chosen mode.
    - During testing, CORYS found each stack could drive 3 instruments
    - Added 13 stacks to the simulator Ethernet network, to drive a total of 39 instruments

The next slide shows the PCB CORYS delivered for the Victoreen Model 942A.
History of Simulated Radiation Monitors
History of Simulated Radiation Monitors

Victoreen Model 946A for VC Summer
- Replaced 5 stimulated instruments with simulated Victoreen Model 946A UDRs
- Added 2 stacks handling 3 and 2 instruments respectively

Upgrades were done to account for Model 946A differences from Model 942A:
1. Digital display (three range fixed point number)
2. Bar graph spans 8 decades vice the 6 of the 942A model

CORYS designed a new PCB that could handle either model as a different build, driven by different firmware. The PCB mounted to either simulated face plates or the Fluke Biomedical face plates provided by the customer.

The next slide is a photo of the Model 946A Victoreen radiation monitor.
History of Simulated Radiation Monitors

Model 946A-200
History of Simulated Radiation Monitors - Upgrades

- Victoreen Model 942A for Beaver Valley Unit 1
  - Replaced 2 simulated analog instruments
  - Added two stacks, one of which was spare

- Last year, Beaver Valley Unit 1 replaced 4 more simulated analog units utilizing the one spare channel and 3 channels of the spare stack from the first job.

- Victoreen Model 946A for Turkey Point
  - Replacing 4 stimulated instruments

Turkey Point exercised the option to upgrade the stack to a new embedded processor, the Arduino Nano.

This year, Turkey Point is planning to replace 20 more stimulated units.

Beaver Valley is now adding 10 more replacements of simulated analog instruments using the new Arduino Nano design.
History of Simulated Radiation Monitors - Upgrades

- Reasons for Upgrade
  - PC104 stack becoming obsolete – still active, but
    - Cost going up
    - Delivery times extended
    - Inventoried obsolete parts will run out in 2 years.
  - Time to consider replacement
    - CORYS had already begun using Arduino for other projects in Power and Transportation
    - Arduino costs much less, it’s fast, and energy efficient
    - Since the programming is C, porting the Victoreen application is almost direct
    - The 25 signal ribbon cable for DO’s and 8 signal ribbon cable for DI’s are eliminated
    - The interface wiring is reduced to RS232 cable, simplifying installation

We now focus on this upgrade.
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New Embedded Processor

• Prototype Development
  - Plan is to plug in a piggyback PCB to the existing Victoreen simulated PCB, replacing the ribbon cables by a direct connection
  - Expand the Nano IO with two 16-bit IO expanders
    - Allows for 25 Digital Outputs to the existing scanner IC’s on the Victoreen PCB
    - Accommodates the 8 Digital Inputs for the switches on the Victoreen PCB
  - Make a list of all signals in both connectors (50 pin and 16 pin), specifying the new terminations to the IO expanders on the Arduino
  - Hand wire a prototype as seen in the next slide
New Embedded Processor

- Arduino Nano
- RS232
- Power
- Interface Signals to/from Victoreen PCB
- IO Expanders
New Embedded Processor

• New design duplicates all functionality of the PC104 hardware
  - 24 VDC to 5 VDC converter
  - Arduino Nano processor
  - DIO handling (two 16-bit IO expanders)
  - Interface to the simulator host (RS232)

• Testing results were very positive, as shown on the next slide
New Embedded Processor
New Embedded Processor

- PCB layout, using Sunstone’s free download software, PCB123
  - First, a schematic is drawn, replicating the hand wiring of the prototype
  - The 16-bit DIO expander IC’s are surface mount devices, much smaller than the through-hole parts used in the breadboard
  - The DC-DC converter, the RS232 port, and the Arduino Nano were all purchased as pre-built modules, simplifying and speeding the design
- The following slide shows the schematic
New Embedded Processor

- As the schematic is drawn, parts placed on the schematic also appear on the layout.
- As the schematic develops, the parts are manually positioned on the PCB, and connecting paths are manually drawn on the layout drawing.
- The following slide shows the finished layout.
New Embedded Processor

- Interface
- Signals from Victoreen PCB
- Power
- Arduino Nano
- IO Expanders
- RS232
- Signals to Victoreen PCB
New Embedded Processor

- Also available is a 3D image of the PCB which may be moved around and zoomed to check for errors
- The following slide shows the 3D image
New Embedded Processor

- Signals from Victoreen
- Power
- Arduino Nano
- IO Expanders
- RS232
- Signals to Victoreen
New Embedded Processor

• Lastly, as the parts are placed on the schematic, they are also placed in the Bill of Materials which is shown on the next slide. If all the parts are from Digi-Key, a price can be totaled for the PCB.
# New Embedded Processor

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**Total**

- **15**
- **$228.92**
- **90**
- **$215.79**
New Embedded Processor

- The next slide shows the prototype and the finished PCB.
New Embedded Processor
New Embedded Processor

• Lastly, a video showing the speed of the new Arduino embedded processor. It and the old stack are running DORT, a test built into the firmware of these devices.
New Embedded Processor
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Other Special Devices

• Whittaker Rod Counters – Front PCB with custom buttons

Old

New
Other Special Devices

• Whittaker Rod Counters – Main Processor, 32 bit ARM Cortex-M4
Other Special Devices

- Pneumatic meters – replaced with servo gears and ATMega MCU
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Conclusion

• Thanks for attending this presentation of some examples of simulated instruments CORYS has done.
• Thanks to Stan Chan for this teaming effort.
• We are exhibiting some devices here at the conference. Please come and see us.
• Are there any questions