

# AUTOMATION LAB

Lab details V1.0



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CENTRE FOR IT IN BUILDING SCIENCE (CBS)

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### Automation Lab

India's building energy use accounts for 33% of the nation's energy use, and this is growing by 8% annually (Climate Works, 2010). The largest floor-space growth is in the commercial (office, hospitality, retail, hospitals) and residential sectors (IPC, 2011). Given the explosive growth in floor-space, and increased intensity of energy use and service level requirements in the commercial sector, India must address efficiency in this sector.

The main aim of the lab is to develop and field test integrated communications and control technologies across building systems. Systems include advanced lighting, HVAC, and plug-load controls that: minimize energy use; respond to changes in occupancy and environmental factors; improve their functionality, reliability, and operational insight; integrate sensor data across building systems; and enhance occupant comfort.

Figure 1: Building Management System (BMS)

The lab also developed a plug-load controller, Smart Strip, for ubiquitous sensing and control of building loads.

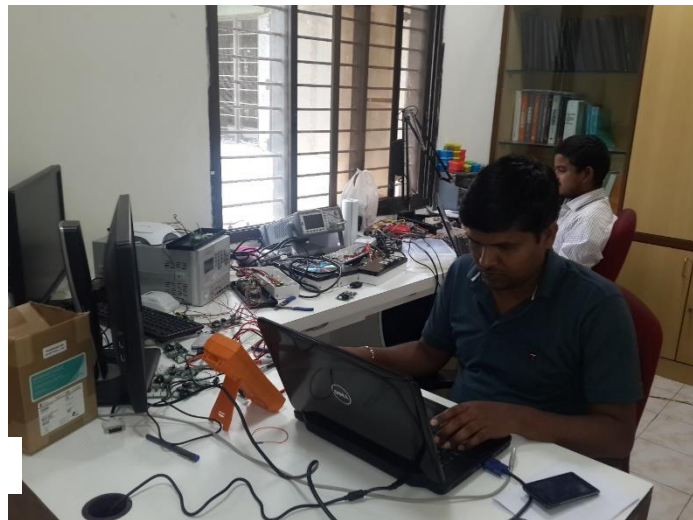


Figure 2: Building Automation & Controls Research Lab, CBS



Figure 3: Smart Strip, end product from the CBS

## 1.1 Instrumentations Available in the Lab

### 1.1.1 34970A Data Acquisition / Data Logger Switch Unit

#### Features

- 3-slot mainframe with built-in GPIB and RS232 interfaces
- 6 1/2-digit (22-bit) internal DMM, scanning up to 250 channels per second
- 8 switch and control plug-in modules to choose from
- Built-in signal conditioning measures thermocouples, RTDs and thermistors, ac/dc volts and current; resistance; frequency and period
- 50k readings of non-volatile memory holds data when power is removed
- Hi/LO alarm limits on each channel, plus 4 TTL alarm outputs
- Free BenchLink data logger software to create tests without programming



### 1.1.2 NI cDAQ-9184 NI CompactDAQ 4-Slot Ethernet Chassis

#### Features

- Choose from more than 50 hot-swappable I/O modules with integrated signal conditioning
- Measure up to 128 channels of electrical, physical, mechanical, or acoustic signals
- Stream continuous waveform measurements with patented NI Signal Streaming technology
- Simplify setup with zero configuration networking and a built-in web-based configuration utility
- Access 4 built-in 32-bit counter/timers through a digital module like the NI 9401 or NI 9402
- Measure in minutes with NI-DAQmx software and automatic code generation using the DAQ Assistant



### 1.1.3 NI cRIO-9076 Integrated 400 MHz Real-Time Controller and LX45 FPGA

#### Features

- Rugged, embedded control and monitoring system with -20 °C to 55 °C operating temperature range
- 400 MHz industrial real-time processor for control, data logging, and analysis
- 4-slot LX45 FPGA chassis for custom I/O timing, control, and processing
- 10/100BASE-T Ethernet port, USB 2.0 port, and RS232 serial port for connection to peripherals
- Single 9 to 30 VDC power supply input



### 1.1.4 NI myDAQ Device Portable Measurement and Instrumentation Device

#### Features

- Compact, portable, and USB-powered educational device for use anywhere, anytime
- Single device provides 8 plug-and-play computer-based lab instruments
- Data acquisition engine with analog inputs/outputs and digital lines
- Extend capabilities by programming with NI LabVIEW software
- Simulate and compare with NI Multisim SPICE software



### 1.1.5 NI myRIO Embedded Student Design Device

#### Features

- Affordable tool to teach and implement multiple design concepts with one device
- 10 analog inputs, 6 analog outputs, 40 digital I/O lines
- Wireless, LEDs, push button, accelerometer onboard
- Xilinx FPGA and dual-core ARM Cortex-A9 processor
- Programmable with LabVIEW or C; adaptable for different programming levels



### 1.1.6 Quanser QNET HVAC Add-on Board for Teaching Thermodynamics and Control with NI ELVIS

#### Features

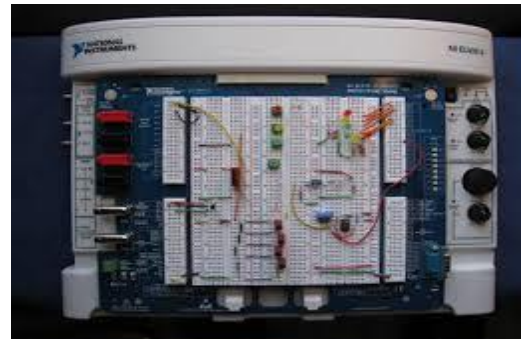
- Illustrate the fundamentals of thermodynamics by designing a control plant to regulate temperature
- Build intuition by taking models from simulation to implementation using one software platform
- Save time with comprehensive curriculum that enables a deep understanding of engineering principles



### 1.1.7 NI ELVIS II, NI ELVIS II+ Modular Engineering Educational Laboratory Platform

#### Features

- Integrated suite of 12 instruments
- 100 MS/s oscilloscope option (NI ELVIS II+)
- Includes Basic Breadboard for Circuits and Electronics
- Complete integration with NI Multisim for teaching circuits concepts
- Extend your lab with companion products from Quanser, Freescale, Emona, and more



### 1.1.8 Power Quality Clamp Meter - Fluke 345

#### Features

- **Current**
  - DC, DC rms, AC rms : All measurements dc and 15Hz to 1 kHz. Amps rms is a true rms measurement (ac + dc)
  - Maximum overload : 10,000 A or RMS x frequency < 400,000
  - Harmonics : All measurements up to 30th harmonic (40th harmonic for 15 Hz to 22 Hz)
  - Frequency range F0 : 15 Hz to 22 Hz and 45 Hz to 65 Hz vac rms > 10A
  - Measuring range : 0 – 2000 A dc or 1400 ac rms
- **Voltage measurement**
  - DC, DC rms, AC rms : All measurements dc and 15 Hz to 1 kHz  
Volts rms is a true-rms measurement (AC + DC)
  - Maximum overload : 1,000 V rms





- |   |  |
|---|--|
| Measuring range                         | : 0 – 825 V dc or ac rms   |
| Harmonics                               | : All measurements up to 30th harmonic   |
| Frequency range F0                      | : 15 Hz to 22 Hz and 45 Hz to 65 Hz; Vac rms > 1V                                    |
| • <b>Power (single and three phase)</b> |  |
| Watts measurement                       | : 0 – 1650 kW dc or 1200 kW DC, DC rms, AC rms                                       |
| • <b>Frequency Measurement</b>          |  |
| Accuracy                                | : 15 to 22 Hz ± 0.5 % rdg<br>40 Hz to 70 Hz ± 0.5 % rdg<br>15 Hz to 1000 Hz ± 1% rdg |
| • <b>Inrush current</b>                 |  |
| Function                                | : All measurements dc and 15 Hz to 1 kHz   |
| Ranges                                  | : 40, 400 and 2000 A   |

### 1.1.9 *Fluke Ti125 Industrial-Commercial Thermal Imager*

#### Features

- IR resolution (FPA size) : 160 x 120 FPA Uncooled Micro bolometer
- Spectral band : 7.5 µm to 14 µm (long wave)
- Capture or refresh rate : 9 Hz or 30 Hz versions
- NETD (Thermal sensitivity) : ≤ 0.10 °C at 30 °C target temp (100 mK)  
0.10 °C at 30 °C target temp (100 mK)
- FOV (Field of view) : 22.5 °H x 31 °V
- IFOV (Spatial resolution) : 3.39 mRad
- Temperature : -20 °C to +350 °C (-4 °F to +662 °F)  
(Not calibrated below -10°C)
- Temperature measurement accuracy : ± 2 °C or 2 % (at 25 °C nominal, whichever is greater)



### 1.1.10 CMA 6 Albedometer

#### Features

- Spectral range (overall) : 285 to 2800 nm
- Sensitivity : 5 to 20  $\mu\text{V}/\text{W}/\text{m}^2$
- Response time : < 18 s
- Zero offset A : < 10  $\text{W}/\text{m}^2$
- Zero offset B : < 5  $\text{W}/\text{m}^2$
- Directional response : < 20  $\text{W}/\text{m}^2$   
(Up to 80° with 1000  $\text{W}/\text{m}^2$  beam)
- Temperature dependence : < 4 %  
of sensitivity
- Operating temperature : -40 to +80 °C
- Maximum solar irradiance : 2000



### 1.1.11 Testo 480 - High-end VAC measuring instrument

#### Features

- Temperature - Pt100 : -100 to +400 °C
- Temperature - Type K TC : -200 to +1370 °C
- Humidity – Capacitive : 0 to 100 %rH
- Velocity - Vane anemometer : 0.6 to +50 m/s  
(vane anemometer  $\varnothing$  100 mm) 0.1 to +15 m/s
- Velocity - Hot wire anemometer: 0 to +20 m/s
- Ambient CO<sub>2</sub> : 0 to 10000 ppm CO<sub>2</sub>
- Comfort level measurement : 0 to +5 m/s
- Differential pressure : -100 to +100 hPa  
(internal sensor) – Piezoresistive 0 to 100000 Lux
- Absolute Pressure : 700 to 1100 hPa  
(Internal sensor and external probe)
- Radiation temperature, Globe : 0 to +120 °C



### 1.1.12 U30 USB Weather Station Data Logger

#### Features

- Normal operating range of -20°C to 40°C
- 5 sensor inputs & option to expand to 10
- Smart Sensor compatible with most Onset smart sensors, except for the S-BPA, S-TMA and S-THA
- Data Channels: Maximum of 15 (some sensors use more than one data channel)
- Alarm Output Relay: Can be configured to be activated, deactivated or pulsed on user-defined sensor alarms. The relay can be configured as normally open or normally closed, and is rated for 30 V and 1 amp max





### 1.1.13 Testo 815 - Sound level meter

#### Features

- Measuring range : 32 to 130 dB
- Frequency range : 31.5 Hz to 8 kHz
- Accuracy :  $\pm 1.0$  dB
- Resolution : 0.1 dB
- Measuring rate : 5.0 s



### 1.1.14 CR1000 Measurement and Control Data logger

#### Features

- Maximum Scan Rate : 100 Hz
- Analog Inputs : 16 single-ended or 8 differential individually configured
- Pulse Counters : 2
- Switched Excitation Channels : 3 voltage
- Digital Ports1 : 8 I/Os or 4 RS-232 COM2
- Communications/Data Storage : 1 CS I/O Port, 1 RS-232 Port, 1 parallel peripheral port
- Switched 12 Volt : 1
- Input Voltage Range :  $\pm 5$  Vdc
- Analog Voltage Accuracy :  $\pm(0.06\%$  of reading + offset), 0° to 40°C
- Analog Resolution : 0.33  $\mu$ V
- A/D Bits : 13



### 1.1.15 Yokogawa WT330 Series Digital Power Meter

#### Features

- Basic accuracy: 0.1% of Reading
- DC measurement: 0.5 Hz to 100 kHz frequency range
- Measures all AC and DC parameters
- Compact design (half-rack size)
- Standard USB, and GPIB or RS232 Interfaces
- Low current measurements down to 50 micro-Amps (WT310 only)
- High current measurements up to 40 Amps RMS (WT310HC only)
- High-speed data update (up to 10 readings per second)
- Simultaneous Normal and Harmonic measurements
- Optional Ethernet interface
- WTVIEWERFreePlus Software included
- Split Phase and Three Phase measurements with the WT300 series

