

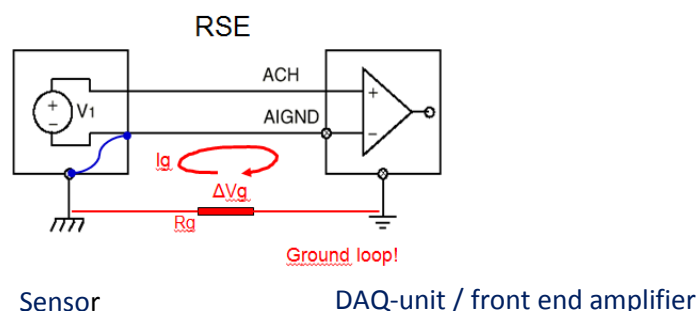
Exam 2017 – solution

Problem 1

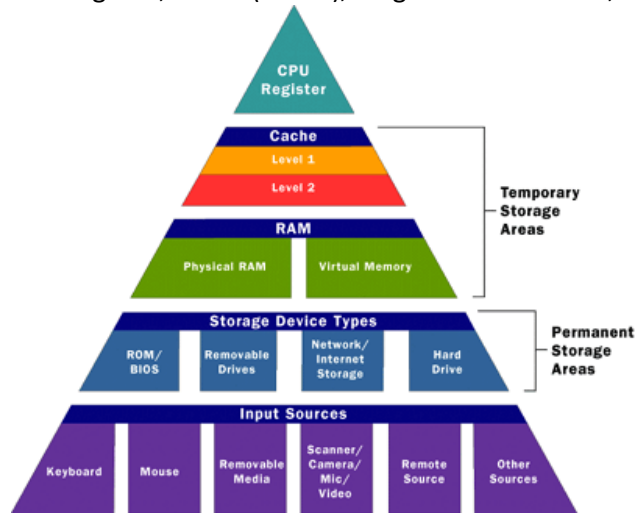
- a) **A point-to-point serial bus, with dedicated bandwidth for each device/slot.** PCIe slots may contain from one to thirty-two lanes, in powers of two (1, 2, 4, 8, 16 and 32). Speed depending on version:
- v1: 250 MB/s (duplex) per lane
 - v2: 500 MB/s (duplex) per lane
 - v3: 985 MB/s (duplex) per lane
 - v4: 1969 MB/s (duplex) per lane
- b) PXI = PCI eXtensions for Instrumentation (PXI). Based on and compatible with CompactPCI. This gives a rugged PC-based platform for measurement and automation systems. PXI gives the ability to expand a system far beyond the capacity of a desktop computer with only a PCI/PCIe bus. One of the most important benefits PXI offers is its integrated timing and triggering features. PXI components: chassis, controller, modules.
- c) RAID (Redundant Array of Independent Drives) split or replicate data across multiple mass storages devices such as hard drives. RAID is used **to increase write/read performance and/or increase safety (using redundancy)**. Different Raid configurations can be used, such as RAID-0, RAID-1, RAID-5 and RAID-10.
- d) Common ADC errors:
- Noise
 - Linearity error
 - Gain error
 - Offset error
 - Quantization (resolution error)
- e) Avoid connecting both sensor(s) and DAQ-equipment to ground; only make ground connection on one side. (Isolation amplifiers, transformers etc. not mentioned during lectures, but is other common techniques).

Ground loop illustration

The blue connection to ground must not be added, since it creates a ground loop (red)



- f) CPU register, SRAM (Cache), magnetic hard-drives, SSD drives (Flash memory).



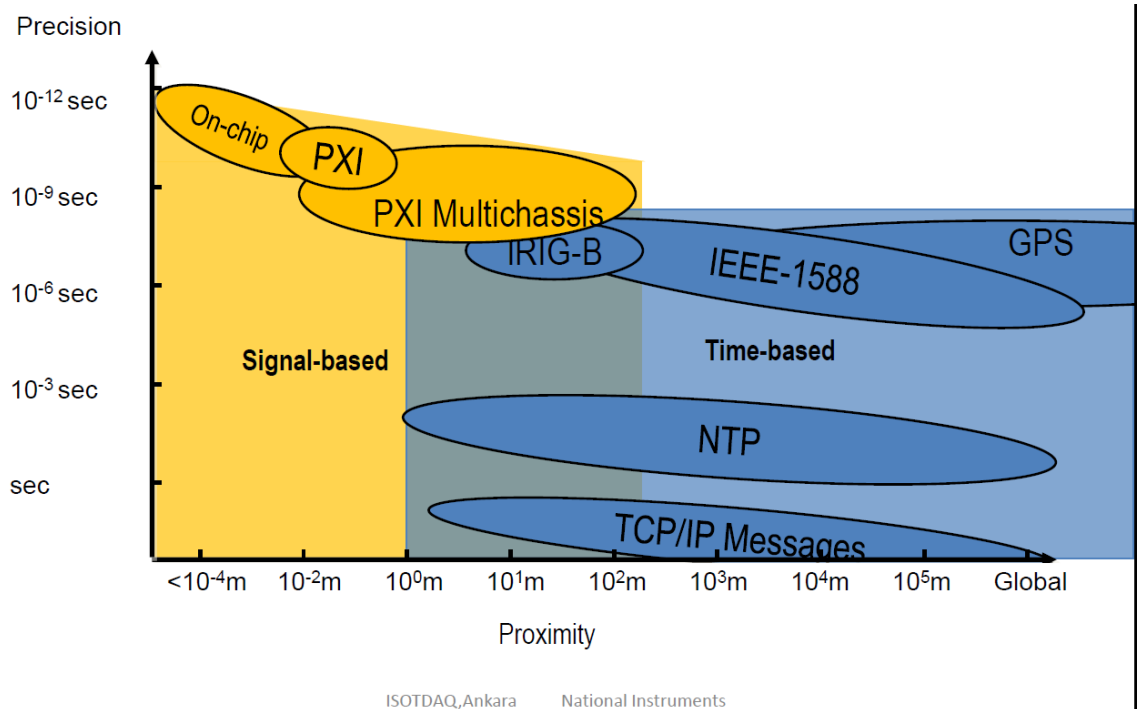
- g) File buffering is handled by the operating system behind the scene and is considered part of file caching within the Windows operating system. If the application continuously saves data to e.g. a hard drive, the operating system usually buffers these data in memory (caching). This makes sense when an application program write small files or I/O blocks to disk, because accumulating data and instead writing larger block of data to disk gives a higher write performance. However, if the write/read speed to/from memory is very high it can be an advantage to bypass the file buffering, in order to avoid additional data copies. Bypassing file buffering can increase write/read speed when using RAID systems.

- h) To avoid the 2.2 TB limitation of the old Master Boot Record (MBR) partitioning scheme.

- i) Some typical characteristics of embedded systems that make them different from PC-based systems:

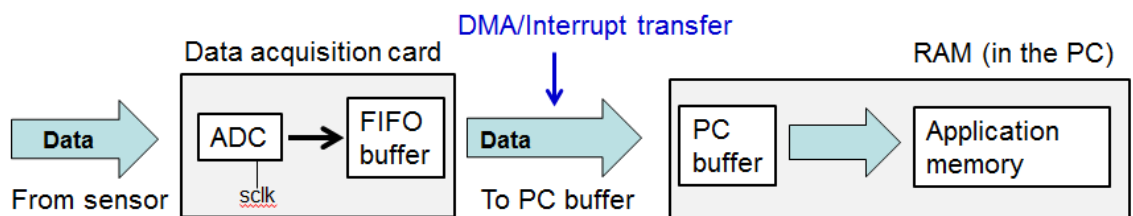
- Single purpose (with very specific requirements).
- Not easily adapted.
- Real-time computing constraints.
- No operating system or small and simple operating systems.
- Fixed amount of memory and limited I/O expansion possibilities.
- Small or non-existent keyboard/mouse or screen.
- Low power requirement.
- Small size requirement.

- j) See the figure below



Problem 2

- Two while loops **synchronized with software timing** (wait function) to run at 50 Hz (20 ms period). The loops run until the user press the run-button to stop both loops.
- The “Producer-consumer” is a **parallel programming** architecture that allows different loops to run at different speeds. **Queues** are used for communication between the loops, and this ensures that no data is lost (due to FIFO buffer in RAM). The “Producer-consumer” allows us to do rapid data acquisition along with slow signal processing and slow write to memory (hard drives) without losing data due to **overwrite errors** (where the software program does not read data from the circular PC buffer quickly enough).



- Batch processing: All available measurements (collected earlier), or a larger sub-set of collected data, are processed at one time. Recursive processing: Measurements are processed as they become available (the required computer storage is kept at a minimum). This means that recursive processing is suitable for real-time signal processing.

- d) The Kalman filter is one of the most widely used estimation algorithms. It is used for random parameters which can be time varying. The Kalman filter is a recursive estimator and it is the optimal minimum mean square error (MMSE) estimator for linear, Gaussian systems.

The Kalman filter produces estimates of the true values of measurements by predicting a value (from a mathematical model), estimating the uncertainty of the predicted value, and computing a weighted average of the predicted value and the measured value. The most weight is given to the value with the least uncertainty.

Problem 3

- a) When the CPU receives an interrupt it stops whatever it is doing and runs a special interrupt handler routine that saves the current machine registers, loads the correct ISR and execute it. When finished it will return to the point it left of before receiving the interrupt request.
- b) **To avoid accidentally changing registers values and change behavior** the AVR has locked registers. For registers like CLK.CTRL, which is a clock mux register, you can accidentally change to a clock source which is not running which causes the microcontroller to halt. This mode can only be recovered by a reset. After unlocking the register it is automatically locked after 4 clock cycles.
- c) **The pull-up configuration is used to give a valid well defined logic level if external devices are disconnected (undriven pin).** (It may also be used at the interface between two different types of logic devices operating at different logic levels and power supply voltages). When the button is not pressed the In register is read as high. When the button is pressed a connection to ground is made, and the In register is updated to logic low, **making it possible to detect a button push.**