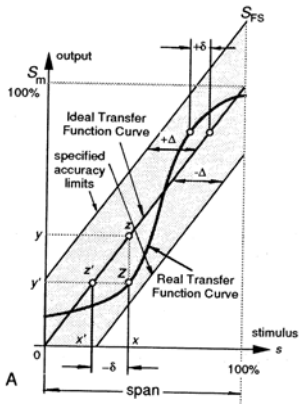
Transfer function

- Span
- Full Scale Output
- Accuracy
  - May be specified as a % of full scale or in absolute terms
  - Eg a pressure sensor has 100kPa input full scale and 10 ohms FSO. We can specify the inaccuracy as 0.5% or 500 Pa or 0.05ohms



Transfer Function: Calibration Error

- This is inaccuracy permitted by the manufacturer when the sensor is calibrated in the factory
- Systematic in nature, affects all future measurements

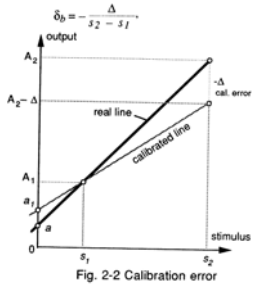
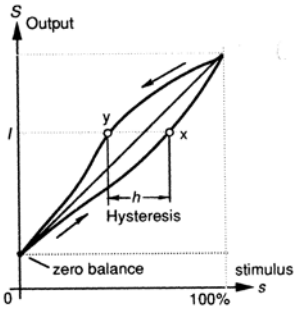


Fig. 2-2 Calibration error

Hysteresis

- Deviation in sensor output when it is approached in opposite directions



Non-linearity

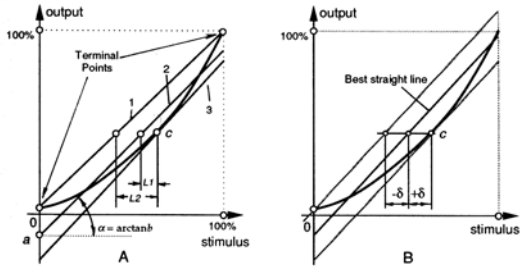
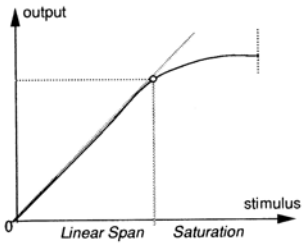


Fig. 2-4 Linear approximations of a nonlinear transfer function (A); and independent linearity (B)

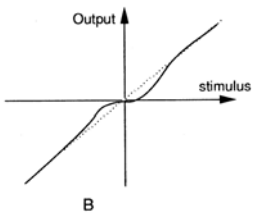
Saturation

- Even if the transfer function is linear, at some level of input stimulus, its output will no longer be responsive
- There may be the risk of physical damage the sensor



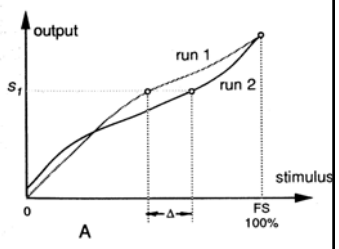
Dead Band

- Dead band is the insensitivity of the sensor to a range of input signals.



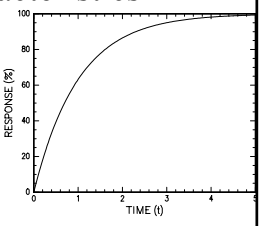
Repeatability

- Repeatability error is caused by the inability of the sensor to represent the same value under identical conditions.
- Causes include thermal noise, temperature drift, build up of charge, material plasticity

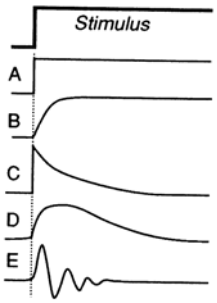


Dynamic Characteristics

- A sensor does not change its output state immediately when an input parameter change occurs.
- The response time is the time it takes for the sensor output to reach a final settled state (within a tolerance band)
- $S = S_m(1-\exp(-t/\tau))$; S_m = steady state output, t is time, τ is the time constant

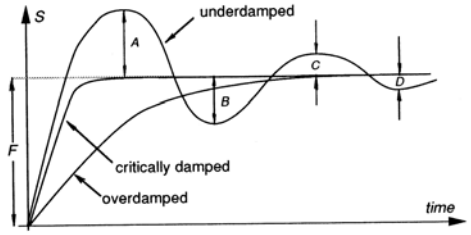


Types of Dynamic Response

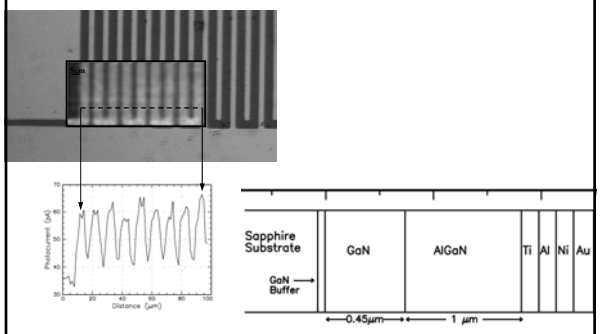


- A: unlimited upper and lower frequencies
- B: Limited upper cut off frequency
- C: Limited lower cut off frequency
- D: first order upper and lower cutoff frequency
- E: Narrow bandwidth response

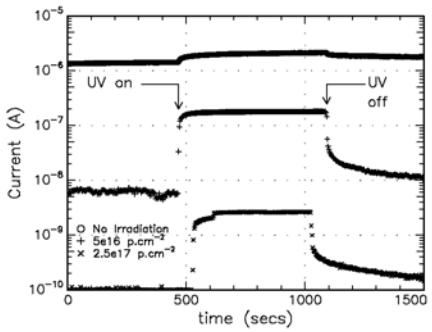
Damping : Eg Temperature Controller



Example: A GaN based UV detector



Response Function of UV detector



Environmental Factors

- Storage Conditions
  - Eg, lowest and highest storage temperatures
- Short and long term drift
  - short (minutes, days) ; usually environment
  - long(months years) usually materials related
- Temperature
  - Specified range over which specifications are met; sometimes compensated for by internal sensors
- Self- heating error.
  - Eg thermistors.

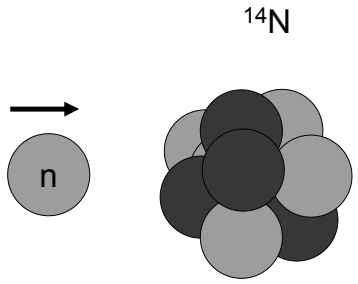
Summary of Sources of Error or Uncertainty

- Characterisation Errors
  - Eg DC offset, calibration errors,
- Dynamic Errors:
  - Eg a static sensor used in a dynamic environment
- Environmental errors;
  - eg self heating
- Insertion errors:
  - the sensor disturbs the system being measured
- Application errors:
  - incorrectly placing sensors, eg blood pressure monitor, ECG monitor.

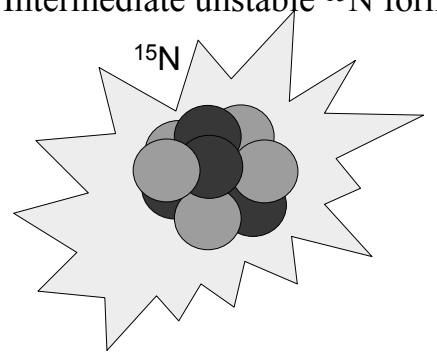
Case Study: SNUPA

- Basic Physics:
  - When a neutron hits a nucleus it can cause it to decay and emit a gamma ray
  - The Gamma ray is characteristic of the type of atom hit. When ^{14}N is struck a characteristic g ray is emitted at about 10MeV

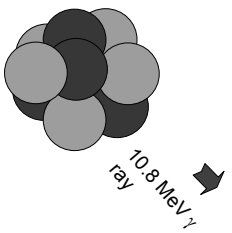
Neutron impacts on ^{14}N nucleus

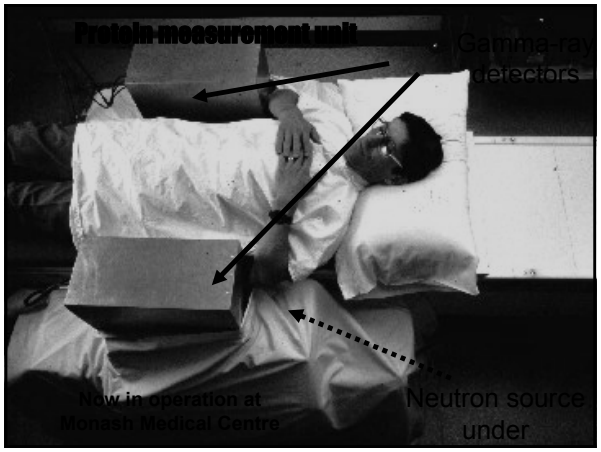


Intermediate unstable ^{15}N forms



^{15}N decays emitting an energetic γ– ray





Bomb beat security scan

By DAVID WILSON, MARYANN STENBERG

Thursday 3 March 1994

Thursday, 3 March 1994

Adelaide.

The device used in yesterday's terrorist-style bomb attack on the Adelaide headquarters of the National Crime Authority appears to have slipped through sophisticated detection equipment.

The letter-bomb attack, which was condemned by the Prime Minister as "a wicked and evil thing", rocked the NCA offices about 9.15am, killing a senior detective and injuring four other NCA staff.

The bombing has sparked an investigation by a special police taskforce drawn from the NCA and the Australian Federal Police, with officers from the South Australian Police.

The Justice Minister, Mr Kerr, said the NCA would not be intimidated by the attack. "I assure the Australian public that the Government and the NCA's resolve to fight organised crime will only be strengthened as a result of this cowardly attack on innocent people," he said.

The head of the NCA, Mr Tom Sherman, said: "This is a very serious attack on the authority and its staff members and it will not be tolerated."

Detective Sergeant Geoffrey Leigh Bowen, 36, is believed to have been handling the letter after it had been examined, scanned and cleared by security staff at the NCA offices in Waymouth Street in the city centre.

He was killed when the explosion gutted an office on the 12th floor of the building. A second man, an NCA lawyer, originally from Ballarat, was critically injured. He was in a stable condition last night in an Adelaide hospital.

Mr ******* said that despite the sophistication of the authority's vetting procedures, there were some explosives, including plastic devices, that could not be picked up by scanners.

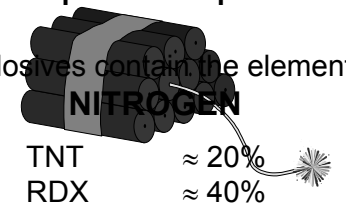
He said there was no reason to suspect any lapse in security procedures. "As I understand it, most of the scanning devices — and I'm not a world expert in these matters — focus on what I'd call ferrous elements," he said.

"But there are some plastics ... which can't be picked by such devices."

Security was immediately tightened at NCA offices around the country in response to the attack. Security has also been increased for members and staff of the joint parliamentary committee monitoring the NCA.

Principle of Operation

- Explosives contain the element **NITROGEN**

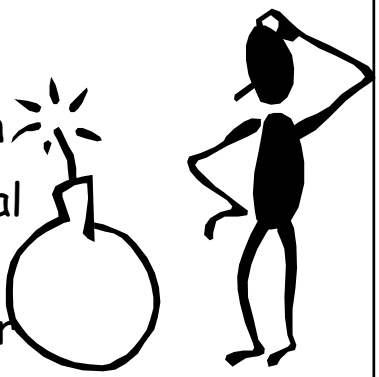


TNT	≈ 20%
RDX	≈ 40%

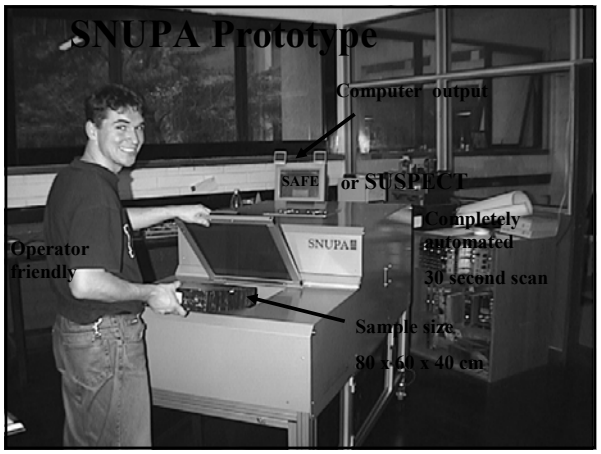
We detect the nitrogen using nuclear techniques

SNUPA

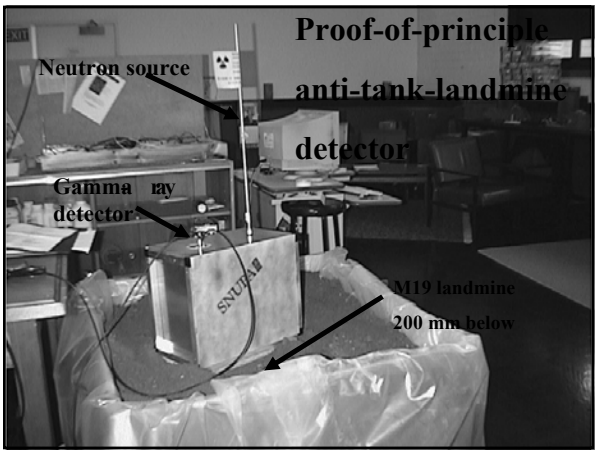
Slow
Neutron
Universal
Parcel
Analyser



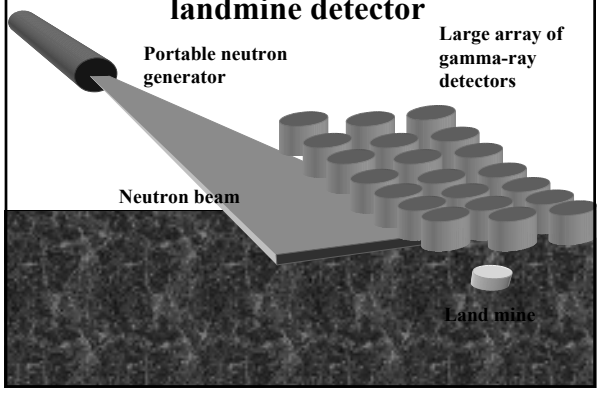
SNUPA Prototype



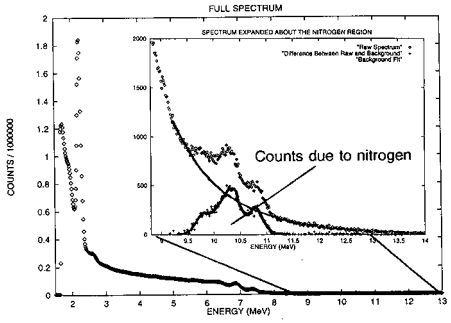
Proof-of-principle anti-tank-landmine detector



Proposed anti-personnel landmine detector



Its not as easy at it looks at first



Summary : You should know:

- Definition of Sensors
- Sensor Classification
- The Transfer Function

  Span Full scale output Accuracy
  Calibration Error Hysteresis
  Non-linearity Saturation
  Repeatability Dead band
- Dynamic Characteristics
  - Response time, frequency response
  - Damping.
- Sources or error and uncertainty
  - which are likely to degrade sensor reliability and performance.