Contribution ID: **32** Type: **Poster**

Development of a Custom On-line Ultrasonic Vapour Analyzer and Flowmeter for the ATLAS Inner Detector, with Application to Cherenkov and Gaseous Charged Particle Detectors.

Wednesday, September 24, 2014 5:33 PM (1 minute)

Sound velocity measurements can simultaneously determine gas composition and flow. We have developed ultrasonic analyzers with custom microcontroller-based electronics, currently used in the ATLAS detector control system, with numerous applications.

Three instruments monitor C3F8 and CO2 coolant leak rates into the nitrogen envelopes of the ATLAS silicon microstrip and pixel detectors. Two instruments aid operation of the new thermosiphon coolant recirculator. One monitors air leaks into the low-pressure condenser. The other measures return vapour flow, and can measure C3F8/C2F6 blend composition, should this be needed to protect the silicon under increasing LHC luminosity. We describe these developments.

Summary

Precision ultrasonic measurements can simultaneously determine gas flow and mixture composition, exploiting the phenomenon that sound velocity in a binary mixture at known temperature and pressure depends uniquely on the concentrations of the components. We have developed ultrasonic analyzers with custom electronics, currently used in the ATLAS DCS, having potential not only in Cherenkov and gaseous trackers, but also in the analysis of hydrocarbon mixtures, diving and anaesthetic gas mixtures.

Five ultrasonic instruments are presently incorporated into the ATLAS DCS, operating with a Poweredge R610 supervisory computer running WINCCOA®, which provides the graphical user interface and database access. One analyzer has been used, since January 2010, to monitor C3F8 coolant leaks into the N2 envelope of the pixel detector. Individual leaking circuits have been identified through C3F8 concentration changes of <5.10-4. Similar analyzers monitor the N2 envelopes of the silicon microstrip tracker and the new pixel B layer, respectively, for C3F8 and CO2 coolant leaks.

Custom electronics, based on Analog Devices ADuC and Microchip dsPIC33F microcontrollers, generates 50kHz ultrasound 'chirps' and synchronously starts a 40MHz transit time clock, which is stopped by an above-threshold sound pulse after amplification in an INA217 instrumentation amplifier. HV transducer bias is provided via inexpensive custom DC-DC converters. Time-stamped bidirectional transit times, vapour temperature and pressure are pipelined at up to 100Hz from FIFO memories - over RS232, or Ethernet using MODBUS over TCP/IP - for rolling-average flow and mixture analysis in the supervisory computer. Measured sound velocities are compared with look up tables of sound velocity vs. mixture ratio (generated from measurements in calibration mixtures or theoretical predictions at the process vapour temperature and pressure) for on-line calculation of the mixture ratio.

The compressor-based C3F8 evaporative cooling system of the ATLAS silicon tracker is being replaced with a thermosiphon exploiting the hydrostatics of the 92m shaft to the experimental cavern. At 60kW dissipation 1.2kg/s of vapour will return to the surface condenser. The flow will be calculated from sound transit time differences in opposing directions angled at 45° to the stream. Although the thermosiphon will initially operate with C3F8, the coolant may be changed to a blend containing 20-25%C2F6, to better protect the silicon against

thermal runaway under increasing LHC luminosity. This instrument can measure C2F6/C3F8 blend composition with a precision of ~3.10-3. Another instrument will monitor possible air ingress to the condenser, which will operate below atmospheric pressure. When air concentration exceeds a predetermined threshold it will be automatically vented via a vacuum system, to maintain condenser performance.
Although ultrasonic binary vapour analysis was first used for the N2/C5F12 radiator of the SLD Cherenkov Ring Imaging Detector and subsequently adopted in all major RICH detectors, including DELPHI, COMPASS and LHCb, none of these applications exploited simultaneous flowmetry and vapour analysis in the same instrument.
We foresee future custom electronics with wireless connectivity, with flow and mixture analysis made in new firmware in system-on-chip implementations.

Primary authors: Dr HALLEWELL, Gregory (Centre de Physique des Particules de Marseille); Mr KATUNIN, Sergey (PNPI St Petersberg)

Co-authors: Mr HASIB, Ahmed (Department of Physics and Astronomy, University of Oklahoma); Dr BITADZE, Alexander (SUPA University of Glasgow); Dr ROZANOV, Alexandre (Centre de Physique des Particules de Marseille); Dr DIGIROLAMO, Beniamino (CERN); Mr PEARSON, Benjamin (Department of Physics and Astronomy, University of Oklahoma); Dr DETERRE, Cecile (Deutsches Elektronen-Synchrotron Hamburg); Ms ROSSI, Cecilia (Academy of Sciences of the Czech Republic, Prague); Mr DEGEORGE, Cyril (Department of Physics, Indiana University,); Dr ROBINSON, David (Department of Physics and Astronomy, University of Cambridge); Mr LOMBARD, Didier (CERN); BOZZA, Gennaro (CERN); Mr BOYD, George (Dept of Physics and Astronomy, University of Oklahoma); Mr FAVRE, Gillles (CERN); Mr GODLEWSKI, Jan (CERN); Mr BERTHOUD, Jonathan (CERN); Mr BOTHELO-DIREITO, Jose (CERN); Dr NAGAI, Koichi (Department of Physics, University of Innsbruck); Mr ZWALINSKI, Lukasz (CERN); Mr DOUBEK, Martin (Czech Tecnical University, Prague); Prof. STRAUSS, Michael (Department of Physics and Astronomy, University of Oklahoma); Mr MATHIEU, Michel (Centre de Physique des Particules de Marseille); Mr BATTISTIN, Michele (CERN); Dr BOUSSON, Nicolas (CERN); Mr LANGEVIN, Nicolas (Centre de Physique des Particules de Marseille); Mr CRESPO-LOPEZ, Olivier (CERN); Mr BONNEAU, Pierre (CERN); Dr BATES, Richard (SUPA, University of Glasgow); Mr BERRY, Stephane (CERN); Dr MCMAHON, Stephen (STFC Rutherford Appelton Laboratory, UK); Prof. VACEK, Vaclav (Czech Technical University, Prague)

Presenter: Mr KATUNIN, Sergey (PNPI St Petersberg)

Session Classification: Second Poster Session

Track Classification: Systems