Remote Hardware Calibrate for the Three Crystal Ultra-low Background Germanium γ-ray Detector at 4600 level Counting Facility

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Introduction

Laurentian University operates an ultra-low background counting facility at the 4600 level in the Inco Creighton mine for selecting materials whose thorium and uranium content is in <10 ng/g (ppb) range. A three crystal ultra-low background (ULBT) germanium γ-ray detector from the University of Guelph was set up in this laboratory to count samples up to a volume of 20 l to determine thorium and uranium concentrations in the sub-ppb range. A three week counting time is required to determine 0.1 ppb concentrations. The ULBT detector was shielded on all sides by 5 cm thickness of high purity copper surrounded by 25 cm thickness of lead in order to attenuate the photon flux from the ambient radioactivity in the rocks and from radon in the air.

The following is a report on the remote hardware calibrate option implemented for doing remotely the daily energy calibrations required for operating the ULBT detector for assaying materials with thorium and uranium concentrations at the 100 pg/g level.

The need for the daily energy calibrations

Individual γ-ray spectra from the three germanium crystals in the ULBT detector are recorded in the energy range from 70 keV to 4 MeV. A supervisory program automatically saves the spectra in a preset interval, usually every 24 h as counts per channel. The spectra are then normalized to the same energy calibration by determining keV per channel and the zero intercept of the individual spectra. The normalized spectra are then added together to generate a sum spectrum from the three crystals for the assay of thorium and uranium concentrations in the material.

For normalizing the individual γ-ray spectra from the three germanium crystals in the ULBT detector precise energy calibration of the spectra is required in order not to degrade the γ-ray energy resolution of the detector in the sum spectrum. For summing the raw spectral data without normalization the energy stability of the counting system is not satisfactory over a three week counting period due to the combined zero and gain drifts of the counting electronics.

Operating experience gained with the ULBT detector showed that energy calibrations need to be performed at least once a day in order to realize the intrinsic energy resolution of the three crystals in the sum spectrum generated at the end of the three week counting period. Energy calibrations performed once a week were not satisfactory.

The need for calibrations using an external source

With boil-off nitrogen from a liquid nitrogen tank flushing the counting cavity for radon suppression the intrinsic background count rate in the ULBT detector was only 0.03 counts per second per crystal over the entire spectrum. In a 24 h counting period the individual spectra do not exhibit any γ-ray peaks if the thorium and uranium concentration in the sample material is below 1 ppb. Therefore, energy calibrations of the individual spectra cannot be obtained using the γ-ray peaks internal to the spectra.

For this reason energy calibrations are required from a radioactive source which can be periodically introduced into the shielded counting cavity during the three week counting period.

Details of external source for energy calibration

Aged thorium metal was chosen as the source for this purpose to provide the characteristic γ rays with energies at 239 keV, 583 keV, 911 keV, and 2614 keV. A piece of approximately 100 mg thorium metal at the end of a steel wire inserted into the counting cavity along the horizontal cold finger of the detector cryostat positioned centrally below the end cap of the ULBT detector was found to give about 1 cps at the 2614 keV full-energy peak in the spectra from each crystal.

Remote control for the calibrations

It was not cost effective for a person to go daily to the 4600 facility just to do the energy calibrations because of the remoteness of the site. Therefore, a motorized system was designed for inserting or withdrawing the source into the shielded counting cavity of the ULBT detector. The motorized system can be operated by commands given through a personal computer (PC) using a program written in Visual-Basic language. The details are given in appendix 1.

The PC at the 4600 facility can be operated remotely from anywhere using another PC and a telephone line employing remote control software[1].

Installation and system performance

The entire system was installed in December 1996 at the 4600 facility. It was tested during the period January - March 1997.

Remote PCs were used from the site office OCB as well as the apartment at Sudbury. In addition a PC was used from Guelph as well.

All systems performed as designed. Daily energy calibrations could be performed remotely for the ULBT detector both on site and off site. Attempts are being made to automate the system so that the calibrations can be made part of the supervisory software which saves automatically the spectra from the samples being assayed for thorium and uranium.

References

1. P. Jagam and J. Law, 1994. SNO-STR-94-003: Communications and control of a remote PC for gamma-ray spectrometry.

Appendix 1. Reg Michaud, 1996. Stepper motor control

Stepper Motor Control

The stepper motor control is done by toggling the appropriate parallel port data pins using quick basic programing. Pins 2 to 9 of a parallel port of a computer are data pins and can be individually controlled to produce a 5 volt DC or GND level voltages. On this principle a stepper motor may be controlled by applying pulses to propper coil phases and stepped either forward or reverse with proper sequencing of pulse duration and number of pulses. A buffer is recommended when using any comm port or parallel port to produce control signalling as to avoid blowing up your computer. Most computer peripheral ports can only sink or source
14 mA which is not much! I used a TTL 7408 and chip to provide buffering. Though this is not a true buffer chip I used it because it was what I had in my trunk of spare parts laying around the house.

The stepper motor was one that requires 12 VDC at 200mA to opperate therefore I needed to boost the 5VDC 14ma signal from the computer port. To do this the buffered control signal is applyed to SSR's (solid state relay) inputs. As each SSR receives it's on signal from the computer the output of the SSR allows 12VDC 200mA to flow through. Hence giving the stepper what it requires to create a step forward!

The quick basic program which is very crued but effective counts forward and toggles the ports data pins as pin 2,3,4,5 to step the motor backwards the program counts backwards data pins 5,4,3,2. Erik Seattler has used bit shifting to accomplish this task in the QBasic progam.

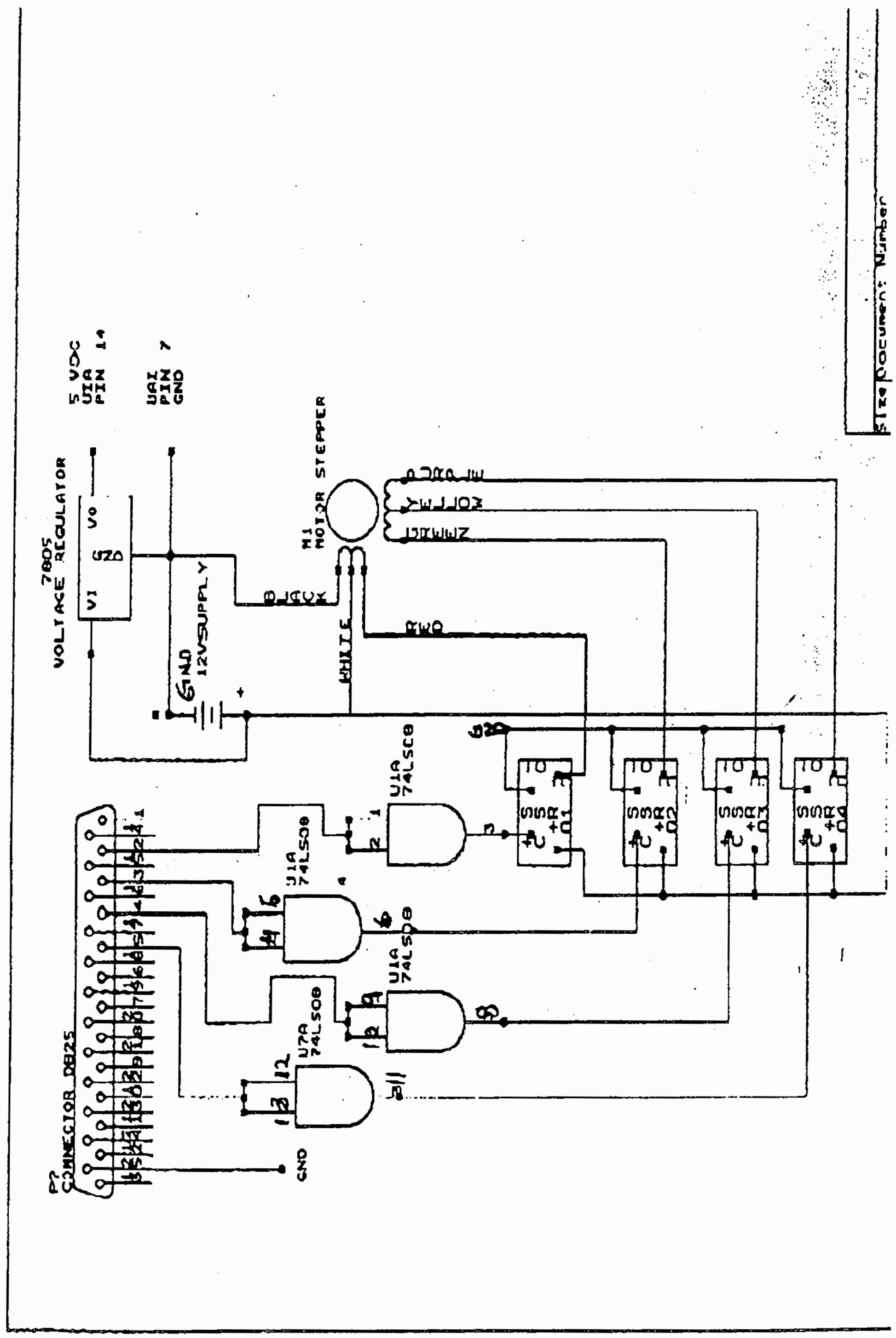
To run the stepper just open the windows program manager and double click on the stepper folder. This will open the Qbasic program. Do a "file", "open" and choose Stepper.bas. Once it is loaded do a "run","Start" The Program will then run and is self explanitory. Once finished do a "file", "Exit" And you Are done!!

The running of a Qbasic program may sound cumbersome but it is!!! Perhaps some day a full executalbe visual basic program running in the windows enviroment will come on line. Untill then we must live with QBasic to opperate the callibration of 4600 research lab.

I would like to thank Erik Seattler for Qbasic programing skills in the development of the software.....THANKS

Reg Michaud

```
DECLARE SUB stepper ()
REM Run the stepper Motor through the Printer Port

COMMON SHARED outbits AS INTEGER
outbits = 1

CLS
LOCATE 10, 10
PRINT " Stepper Motor Control Program.  E. Saettler & Reg Michaud, October 23/
"
PRINT "                        Press any key to continue..."

repeat:
  GOSUB stepper:
  LOCATE 22, 1
  INPUT "        ****** Enter any key to continue, (Q) to quit  ****** :"; a$
  IF a$ = "Q" OR a$ = "q" THEN OUT &H378, 0: GOTO byebye:
GOTO repeat:

byebye:
SYSTEM
END

stepper:
  nsteps% = 0
  CLS : LOCATE 5, 1
  PRINT "          Stepper Motor Control BY E. Sarettler & Reg Michaud, Oct  "
  LOCATE 7, 1
  PRINT "       *** Please use the (Q) to quit as this resets the port  ***"
  LOCATE 14, 1
  INPUT "       (I) put source in castle  **** OR ****  (O) out of castle: "; o
tion$
  IF option$ = "I" OR option$ = "i" THEN nsteps% = 136
  IF option$ = "O" OR option$ = "o" THEN nsteps% = -136
  IF option$ = "Q" OR option$ = "q" THEN OUT &H378, 0: RETURN
  FOR i = 1 TO ABS(nsteps%)
    IF nsteps% > 0 THEN
      outbits = outbits * 2
      IF outbits >= 16 THEN outbits = 1
    ELSE
      outbits = outbits / 2
      IF outbits < 1 THEN outbits = 8
    END IF
    PRINT outbits
    OUT &H378, outbits
    tstart = TIMER
    Telapsed = 0
    WHILE Telapsed < 1!
       Telapsed = TIMER - tstart
    WEND
  NEXT
RETURN
```


7805
VOLTAGE REGULATOR
VI
GND
VO
5 VDC
U1A
PIN 14
U1A
PIN 7
GND
GND
12VSUPPLY
M1
MOTOR STEPPER
BLACK
WHITE
RED
GREEN
YELLOW
U1A
74LS08
U7A
74LS08
CONNECTOR DB25
GND
Size
Document Number