EDOC401

# EXOGAM PROJECT

# Autofill Specification

Edition 1.1
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Version 1.1 introduces an extra capability over the previous Eurogam version. The Exogam Ge detectors will have a Pt100 temperature sensor onboard. To make use of this an extra interface board will be added and new software will need developing. There will also be the capability to disable data acquisition during fills if necessary.

# 1 INTRODUCTION

This document is an updated version of the Eurogam Autofill Specification document. There are several changes which relate to the differences between Exogam and Eurogam, but also a re-working of some aspects of the design. However, there are no changes to the fundamental functionality of the system. It is intended to keep intact all the basic design characteristics that were agreed upon previously. Any hardware and software changes are designed to provide improvements in system performance, substantial reduction of cost together with minimising the development effort.

The philosophy of the computer controlled autofill system is one which is intended to make it possible to ensure that the cryostats of a large variable number of germanium detectors on the Exogam array are filled at defined times and that the correct human intervention happens when necessary.

The Autofill is a simple feedback control system,the purpose of which is to ensure that the detectors in the Exogam array are cooled with liquid nitrogen. Filling of LN2 takes place at fixed programmable intervals and is stopped when exhaust nitrogen is detected. The filling operation is performed by activating solenoid valves through which the LN2 is allowed into the detector. Exhaust nitrogen is registered by a temperature sensor whose value is fed back to the computer. The software specified in this document will implement this control system and provide the operator with easy means to intervene in the fill operations.

In addition to filling the detectors at predefined times the autofill must detect malfunctions like overfilling (e.g a valve is stuck open), underfilling (the detector is not full when fill operation should have finished), give an audible alarm when any of these faults occur and also be able to detect if the power to a detector is turned off due to overheating (bias shutdown).

The detector temperature will also be used to detect detectors warming up, and hence try a fill. If the fill does not lower the temperature, then more drastic action is necessary.

The normal filling operations can be interrupted from the computers console terminal, or the computer can be overridden to allow manual filling via switches.

## 2 HARDWARE

The computer system will be PC-based and may be either a standard base unit or (perhaps better for the array racking) an industrial rack-mounted chassis. The computer interface consists of sets of 3 ISA I/O cards, interfacing to the valve and sensor interface electronics. Each set of cards is capable of supporting 24 detector fill channels. A PC monitor may be situated in the experiment area for local access, and the system will be remotely accessible via the LAN. The autofill system will report to the main data acquisition exception handler when faults occur.

A fourth interface card will be used to interface to the detector temperature sensor. This will take the form of a second ADC card to interface to a 16 channel RTD interface board.

The computer base unit will contain the following set of cards:

- 32 differential channel ADC card (Computerboards CIO DAS 6402/12)
- 32 channel SPST electromechanical relay output card (Keithley PIO-32OUT)
- 32 channel TTL digital I/O card (Computerboards CIO DIO48)
- 8 channel ADC card (Computerboards CIO DAS 1602/12) + RTD card

The sensor and solenoid valve interfaces are designed and built at York University. They will contain all the necessary electronics to condition the signals from the sensors before they go to the ADC card(s) and will also contain conditioning circuitry to convert the output relay signals so that they can drive the solenoid valves. The TTL IO card(s) will sense the bias shutdown signal from the High Voltage Control, and thus avoid filling detectors which have had the power switched off. One channel of the TTL digital input card will also read the state of the **manual fill switches** on the front of the manifold control unit. It will also have one or more channels reserved for signals to be used for inhibiting (whilst detector are filling) data acquisition or a dewar fill.

These cards **must** be present for the system to work.

The interface unit contains LEDs to indicate "vital signs", and switches to allow manual override. It connects to the IO cards with short lengths of ribbon cable. Connections to the solenoid valves require cables carrying mains voltages to be routed from the rear. These will be available in groups of eight, and six will be for normal connection to the primary valve of 6 detectors. One is intended to give control over a manifold shutoff valve to provide a fail-safe in case of other valves freezing. The 8th will be used to control the manifold output valve (which also is fitted with a sensor).

*Additional requirement*: The IO cards will be configured to respond to specific available addresses in the PC IO address space.
Allocation for more than one set of cards will be defined in case the need arises.

# 3 SOFTWARE

It is intended to use the Linux operating system which provides a familiar Unix-style environment. It has the capability of easy configuration of access security, reliability and technical features that make IO ports easily accessible for our code.

The autofill control program provides a user interface that makes it easy to get an overview of the state of the detectors, and also facilitates quick and safe intervention if the system needs attention from authorised personnel in the experimental area.

A common block of data (hereafter referred to as the database) serves as communication between the tasks. The database contains state variables and configuration data for all the detectors in the array. There are separate tasks to drive each IO card, and tasks for fill control, user interface and logging/supervision.

## 3.1 Access rights

For Eurogam, intervention in the filling cycle was defined to only take place from a console terminal placed in the experiment area near the array. Users logged on from elsewhere could only **view** the state of the system. The same applied to non-privileged users who logged on at the console terminal.

For Exogam, access to the array will be limited, and a revised login capability definition may be required. The system access constraints will be configurable at the network access and userid level as deemed necessary at the time.

## 3.2 Recovery

The system must keep a backup of the detector states on disk. This will be on a local disk and/or on a remote file server (accessed via ethernet). Two backups will be kept, one updated after **every** change in the detector states, the other done at fixed intervals. The primary backup will only be done for the affected detector(s), whilst in the second case the complete database will be written onto the disk. On startup the system should first try to read configuration/state from the primary backup, if that fails try the secondary backup and as a last resort read the original data file as it was generated.

## 3.3 Configuration

The configuration of the detectors is kept in a file for maximum flexibility.

Configuration parameters:

- physical position in array (1 -"N")
- exhaust sensor ADC card address and channel number
- detector valve Relay output card address and channel number
- bias shutdown digital input card address and channel number
- detector temperature sensor card address and channel number
- manifold connection number
- sensor reference voltage (volts)
- maximum fill time (seconds)
- valve closure delay time (seconds)
- preset fill times

There will be a similar set of configuration parameters for each **manifold**. These will include:

- exhaust sensor ADC card address and channel number
- input valve digital input card address and channel number
- output valve Relay output card address and channel number
- sensor reference voltage (volts)
- maximum fill time (seconds)
- valve closure delay time (seconds)

These values will be edited into a file initially and only the preset fill times can be changed without editing the file again.

The configuration is edited into a file as text using any available editor. This text file is then preprocessed, error checked and finally used as input for a program that generates a **binary** configuration/data-base file. With this approach one allows a free format for the source configuration combined with the advantage of knowing the file position for each detectors data. The latter will be used to limit backup to only the detectors which have actually had their states changed. This will save having to write back the whole database.

### 3.4 State variables detector

The system maintains the following information for each detector

- most recent ADC value (volts)
- most recent temerature value (degK)
- time of last valve opening/closure
- time of next fill
- fill delay
- open/closed status for valve
- status: overfull, underfull, manifold error, filling, delayed, purging, avoided, bias shutdown.

### 3.5 State variables manifold

The system maintains the following information for each manifold

- most recent ADC value (volts)
- time of last valve opening/closure (seconds since reference)
- number of open detector valves
- number of overfull detectors (used for fill inhibit)
- open/closed status for both input and output(purge) valve
- status: overfull, underfull, purging.

### 3.6 Global state variables

- number of filling detectors
- overall system state (OK, CRASHED, FILL ERROR, FILLING, MANUAL FILL)

### 3.7 Fill cycle

The next fill time for each detector is continuously compared to current time, and the valve opened if due. The valve is kept open until exhaust nitrogen is detected or the maximum fill time exceeded. If the last condition is erroneous the **underfull** error is indicated. If nitrogen is detected after a fill is completed (allowing for closure delay) the **overfull** error is indicated. If a detector is overfull the manifold input valve is closed and further filling from that manifold is aborted. The underfull and overfull errors are also possible when purging the manifold. The overfull error inhibits further use of the manifold while it persists.

Criteria for opening and closure of valves: The manifold output valve sensor is monitored to ensure that the manifold is purged of air when detector filling starts. Thus a fill will include the following steps:

- Open manifold input AND output valves
- Wait until manifold full - or timeout
- Open detector valve(s)
- Close manifold output valve
- Wait until detector(s) full - or timeout
- Close detector valve(s)
- Close manifold input valve (if not used by other detectors)

### 3.8 Error handling

Errors and time of errors is recorded. Faults that need recording are e.g. overfull and underfull. **All** errors, including system errors (e.g. AD conversion timeout) are reported to the data acquisition system exception handler. The system is designed such that in the event of software failure, valves are closed (that is if the system error is of a nature that permits a controlled shutdown).

### 3.9 Manual fill

The system detects the switching of the maunal fill key, and inhibits all fill actions when in manual mode. Ongoing fills will be aborted and any software controlled intervention is inhibited.

# 4 USER REQUIREMENTS

The user must give his identifier and password correctly before he is admitted. The non-privileged user (also privileged users operating from non priviledged access points) can only view the system. The user interface provides reliable means for operator intervention in the filling cycle. It is ensured that no valves are operated on by mistake. During manual fill no privileged access will be permitted.

The original Eurogam autofill system had a VT100 style interface. The Exogam version will have a graphical interface in the style of the MIDAS Tcl/Tk acquisition system. The following refers to the VT100 style interface. Equivalents will be provided graphically.

The autofill is operated through a series of short commands which are prompted from a simple command interpreter. The keyboard input software provides a timeout so that the system does not hang on, say, a half completed input line. Some commands (see below) can execute on multiple detectors, in this case a further confirmation (YES/NO) is required. Typing errors provoke meaningful error messages, not an error number. Abbreviated command names are allowed.

There will be a set of auxiliary commands that can be executed in a so called ADMIN mode ( these will not be specified in detail here).

A command line will have the following syntax:

<COMMAND> {arg1} {arg2} {arg3} {arg4} {arg5}

Arguments may be omitted depending on the actual command.

An argument can have one of the following formats:

- A number in the range 1-N, a position identifier. This means that the action prescribed by the command will be executed on the given position **only**.
- A letter A-D, a manifold identifier. The command will be executed for all the positions on the specified manifold. Confirmation will be asked for.
- Range of detector numbers
- Sets of detectors (can be combined freely with ranges)
- The text string "all". The command will be executed for all detectors in the array. Confirmation will be asked for.
- A string on the format "HH:MM", where HH represents **hours** and MM **minutes**.

- A two character number giving seconds, minutes or hours.
- Short special purpose arguments.

The display will indicate errors in the autofill, and by issuing a command the operator will be able to localise and investigate the error. A time of day clock will always be displayed.

Here is a detailed specification for the user commands:

### 4.1 SHOW

This command will be used to investigate the state of the autofill. It can be issued on three different levels.

- Top level. Overview of most important parameters for all detectors
- Manifold level. More detailed view of manifold and its detectors
- Position level. Detailed view of the given position

The operator can force displaying of another manifold or detector without explicitly issuing a new show command. This will be achieved by the use of single keystrokes (e.g arrows). Four different keys will be used to increment/ decrement detector/manifold ids respectively. A key-stroke to toggle between showing manifold and detector will also be provided.

Other non-privileged commands:

### 4.2 HELP

Online help, either general or specific for each command. General topics includes input line syntax, command execution modes and a guide to the display.

### 4.3 ADMIN

Switch to ADMIN mode.

### 4.4 NORMAL

ADMIN mode commmand to switch back to normal autofill mode

## 4.5 QUIT

Logout from the autofill system

**PRIVILEGED COMMANDS** can only be issued from the console by privileged users. These commands can be executed for multiple channels but confirmation is needed before the requested action takes place.

## 4.6 PRESET

Set the prescheduled fill times. This command sets upto 4 fill times. Options for adding to present fill times and clearing old ones are needed. By default the old fill times are written over.

The command will modify the **next fill time** parameter and set it to the first time encountered in the new list of fill times. Any time set by a previously issued FILL command will be lost.

## 4.7 FILL

Set an unscheduled fill. This command sets the next fill to the specified time; omitting the time argument will cause a fill to start immediately. If the specified fill time is beyond any of the prescheduled times, those will be ignored.

## 4.8 DELAY

Delay the next fill. This delays the next fill with the specified number of minutes. The display should indicate when a detector is delayed.

## 4.9 AVOID

Avoid specified detector(s). This command will stop all filling operations on the specified detectors(s) and also prevent alarms from being raised.

## 4.10 UNAVOID

Enable all fill operations (will also re-enable a detector which has been taken out through bias-shutdown). Essentially the opposite of AVOID.

## 4.11 CANCEL

This command will stop an ongoing fill or cancel a delayed fill. Error conditions are unaffected.

## 4.12 CLEAR

Clears errors and warnings.

# 5 TEST REQUIREMENTS

The tests will be carried out at two levels, **power on test** and **monitoring test** are integrated into the autofill control system, their purpose is to detect the faults. The **auxiliary tests** are meant to be used thereafter for further diagnosis and fault localisation. The purpose of the test is to locate the error to a particular card so this can be replaced, and possibly also decide which channels on the card are faulty.

## 5.1 Power on tests

- ADC card
  - read identification pattern
  - verify correct contents in status register after reset
  - do a test conversion
- Relay output card
  - read identification pattern
  - verify that output registers are cleared after reset
- Digital input card
  - read identification pattern

All power on test results will be logged.

## 5.2 Monitoring test

This consists of reporting errors from simple tests that run as part of the task loops for the four IO card tasks, e.g. the ADC conversion status.

## 5.3 Auxiliary test

- One should immediately be able to test the crate for response from the cards. This will be a simple bus-error test that scans for presence of cards. This will detect any bus-errors by reporting the faulty card **not present**. A list of present cards and their type will be displayed.
- Show how a specified detector is connected to each IO card.
- Show the connections to a specified card.
- Show spare channels in the system.