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PROJECT:	**SOUTHERN AFRICAN LARGE TELESCOPE ROBERT STOBIE SPECTROGRAPH NEAR INFRARED INSTRUMENT**
DOCUMENT TITLE:	**Grating/Filter Insertion Prototype (GFIP) Software Requirements Document**
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1.0 PURPOSE

This document specifies the software requirements for the RSS NIR GFIP. The GFIP is intended to prove the robustness of the NIR optic insertion strategy. It will also serve as testbed for the NIR software concepts. After building up the system, we will do a many-thousand-times "burn-in" of the hardware and software. In addition to the 'burn-in", an important test of software robustness will be to interrupt the operations to simulate the effects of (and recovery from) computer crashes and power failures.

2.0 SCOPE

2.1 Affected project or tasks

2.2 Affected personnel

3.0 REFERENCES

3.1 Applicable industry standards

3.2 Applicable government regulations or standards

3.3 Applicable SSEC documents

4.0 ACRONYMS AND DEFINITIONS

4.1 Applicable definitions, acronyms or abbreviations

4.2 GFIP – Grating/Filter Insertion Prototype

4.3 NIR – Near InfraRed Spectrograph

4.4 PFIS – Prime Focus Imaging Spectrograph

4.5 RSS – Robert Stobie Spectrograph

4.6 SALT – Southern African Large Telescope

4.7 UW-SAL – University of Wisconsin-Space Astronomy Laboratory

4.8 UW-SSEC – University of Wisconsin-Space Science & Engineering Center

5.0 RESPONSIBILITIES

5.1 SSEC or Project Management responsibility

5.2 SSEC QA responsibility

5.3 Project Staff responsibility

6.0 CONTENT

6.1. Architecture

The GFIP control system will be built along the lines of the RSS-VIS (formerly PFIS) baseline control system. The core of the control system will be a table-driven state machine. The main difference will be the new control opportunities offered by the c-RIO hardware. In the c-RIO universe, there are three levels of programming: the PC, the networked chassis controller, and the FPGA in the chassis backplane. We assign these resources as follows:

- PC - Graphical User Interface
- Chassis Controller - State Machine, Data Logging
- FPGA: Interlocks

The GUI will send commands to the state machine and receive state data via LabVIEW "events" or some other NI-standard way of networked inter-process communication. The Chassis Controller will make low-level hardware requests of the FPGA, which will route requests through "hard-wired" FPGA interlock code (similar to the CPLD code in RSS-VIS).

As in RSS-VIS, we will maintain a layer of hardware abstraction down to the lowest possible level. This will make the bulk of the code platform-independent, allowing us to code and test without needing the hardware, and it will ease integration with the RSS-VIS code, which uses an entirely different NI control solution.

6.2. Data Logging

Data logging is important to RSS-NIR because of its critical dependence on environmental control (humidity, temperature, pressure). The GFIP chassis controller will be responsible for logging data. The controller will be on and operating whenever RSS-NIR is in any actively controlled state, even when the Windows PC may be off.

6.3. Control System Hardware

GFIP will be controlled by LabVIEW 8.6 running on Windows XP. LabVIEW will control a National Instruments (NI) Compact-RIO chassis containing:

- NI 9014 Controller
- NI 9871 4-port serial interface
- NI 9403 32-port digital I/O module
- NI 9205 32-channel analog input module

6.4. GFIP Electronics

The GFIP will provide the following electronic resources:

- Signal conditioning for voltage and current
- Optic station indicator
- Optic insertion motor with home, forward limit, and reverse limit indicators
- Optic insertion incremental encoder with index
- Latch rotation motor with home, forward limit, and reverse limit indicators
- Latch rotation incremental encoder with index
- Latch code (made up of two boolean sensors)

- Latch seated indicator

6.5. GFIP Control Data

All items are boolean (on/off) except where noted.

- Power supply voltage - raw (unsigned 16 bits)
- Power supply voltage - volts (float)
- Power supply current - raw (unsigned 16 bits)
- Power supply current - amps (float)

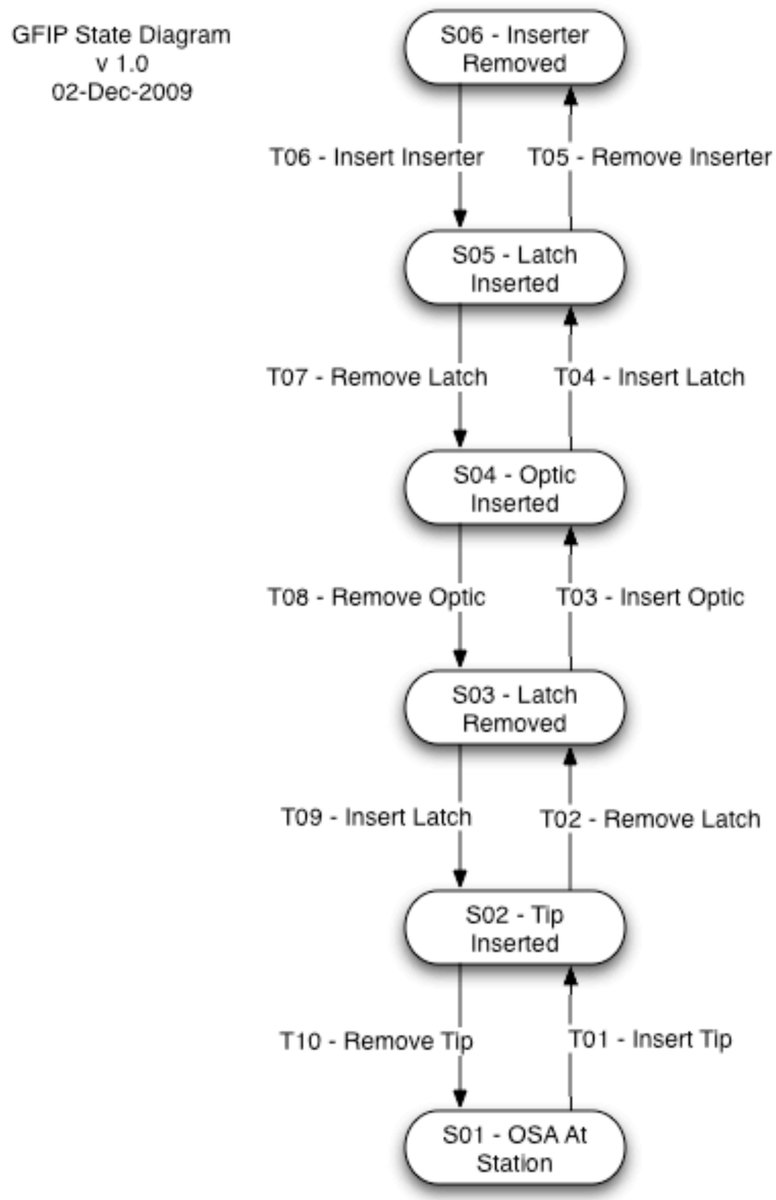
- Optic station indicator
- Optic insertion fwd limit
- Optic insertion rev limit
- Optic insertion home
- Optic rotation position (signed 32 bits)
- Optic insertion index

- Latch rotation fwd limit
- Latch rotation rev limit
- Latch rotation home
- Latch rotation position (signed 32 bits)
- Latch rotation index
- Latch code (2 bits):
  - 0 - error
  - 1 - latch free
  - 2 - latch inserted
  - 3 - latch seated
- Latch seated

- Current GFIP state
- Desired GFIP state
- Optic insertion interlock engaged
- Latch rotation interlock engaged

6.6. State Machine States

See the state diagram below.


GFIP State Diagram
v 1.0
02-Dec-2009
S06 - Inserter Removed
T06 - Insert Inserter
T05 - Remove Inserter
S05 - Latch Inserted
T07 - Remove Latch
T04 - Insert Latch
S04 - Optic Inserted
T08 - Remove Optic
T03 - Insert Optic
S03 - Latch Removed
T09 - Insert Latch
T02 - Remove Latch
S02 - Tip Inserted
T10 - Remove Tip
T01 - Insert Tip
S01 - OSA At Station

The states are given below. Within each state, we list the expected state of the main indicators.

- S01 - OSA At Station (moving to station is another state machine)
  - OSA at station
  - Optic insertion home
  - Latch rotation home
  - Latch code 3 = seated
  - Latch seated
- S02 - Tip Inserted
  - OSA at station
  - Optic insertion encoder steps = TBD ± TBD
  - Latch rotation home
  - Latch code 3 = seated
  - Latch seated
- S03 - Latch Removed
  - OSA at station
  - Optic insertion encoder steps = TBD ± TBD
  - Latch rotation encoder steps = TBD ± TBD
  - Latch code 1 = free
  - Latch not seated
- S04 - Optic Inserted
  - OSA at station
  - Optic insertion encoder steps = TBD ± TBD
  - Latch rotation encoder steps = TBD ± TBD
  - Latch code 1 = free
  - Latch not seated
- S05 - Latch Inserted
  - OSA at station
  - Optic insertion encoder steps = TBD ± TBD
  - Latch rotation home
  - Latch code 3 = seated
  - Latch seated
- S06 - Inserter Removed (observing state)
  - OSA at station
  - Optic insertion home
  - Latch rotation home
  - Latch code 3 = seated
  - Latch seated

Question for reviewers: how do we disambiguate states S1 and S6?

Question for reviewers: do we ever want to operate the inserter without an optic? This will affect the latch logic a lot.

6.7. State Detection

State detection is the process by which the uninitialized state machine examines the available indicators and other sensors to try to recognize the current state of the hardware. Power failures, emergency stops, and even normal power-downs could cause the software. The state detection will be extracted from the indicators called out in the "State Machine States" section above.

6.8. State Machine Transitions

Some transitions have the same name (e.g. Remove Latch) but different T-numbers (T02 vs. T07). This disambiguates the transitions, in case their interlock logic is different.

- T00 - No-op
- T01 - Insert tip (optic insertion motor)
- T02 - Remove latch (latch rotation motor)
- T03 - Insert optic (optic insertion motor)
- T04 - Insert latch (latch rotation motor)
- T05 - Remove inserter (optic insertion motor)
- (observing happens here)
- T06 - Insert inserter (optic insertion motor)
- T07 - Remove latch (latch rotation motor)
- T08 - Remove optic (optic insertion motor)
- T09 - Insert latch (latch rotation motor)
- T10 - Remove tip (optic insertion motor)
- (ready to select new optic)

We will need some miscellaneous functions:

- Detect GFIP state (see below)
- Initialize optic insertion motor
- Initialize latch rotation motor
- Seek optics station (no-op for GFIP)
- Soft Stop (stop gracefully, e.g. stop at next legal state)
- Hard Stop (emergency stop, stops all motion)

6.9. GFIP State Table

The state table is indexed by the current state (left column) and the desired state (top row). The contents of the cell tells the state machine software what to do next, and what state that leaves you in. The state machine iterates over this table, and stops when it reaches the diagonal. On the diagonal, the current state matches the desired state.

	S01	S02	S03	S04	S05	S06
S01	T00/S01	T01/S02	T01/S02	T01/S02	T01/S02	T01/S02
S02	T10/S01	T00/S02	T02/S03	T02/S03	T02/S03	T02/S03
S03	T02/S02	T09/S02	T00/S03	T03/S04	T03/S04	T03/S04
S04	T08/S03	T08/S03	T08/S03	T00/S04	T04/S05	T04/S05
S05	T07/S04	T07/S04	T07/S04	T07/S04	T00/S05	T05/S06
S06	T06/S05	T06/S05	T06/S05	T06/S05	T06/S05	T00/S06

6.10. Commands

The GUI will provide these commands:

- Initialize
- Select states S01-S06
- Select transitions T01-T08
- Stop
- Abort
- Run burn-in procedure
- Start logging data
- Stop logging data

6.11. GFIP Burn-in Procedure

With the state machine approach, a burn-in test is simple:

```
do 10,000 times {
        select state s06
        select state s01
}
```

The burn-in procedure should include instances of power failures, hard and soft stops, and manual fiddlization of the hardware.

6.12. Interlocks

Interlocks will be implemented in the FPGA section of the c-RIO chassis. The interlocks for each state machine transition are essentially a verification that the instrument is in the required start state for that transition.

- Initialize optic insertion motor
    - ???
- Initialize latch rotation motor
    - ???
- T00 - No-op

  - None, always allowed
- T01 - Insert tip (optic insertion motor)
  - Verify state S01
- T02 - Remove latch (latch rotation motor)
  - Verify state S02
- T03 - Insert optic (optic insertion motor)
  - Verify state S03
- T04 - Insert latch (latch rotation motor)
  - Verify state S04
- T05 - Remove inserter (optic insertion motor)
  - Verify State S05
- T06 - Insert inserter (optic insertion motor)
  - Verify state S06
- T07 - Remove latch (latch rotation motor)
  - Verify state S05
- T08 - Remove optic (optic insertion motor)
  - Verify state S04
- T09 - Insert latch (latch rotation motor)
  - Verify state S03
- T10 - Remove tip (optic insertion motor)
  - Verify state S02

7.0 RECORDS

This section should note what records need to be maintained to show compliance with the quality system. Example records include forms, data, test results, training attendance forms, meeting minutes, change notices and inspection reports.