GUN SYSTEMS CONTROL UNIT TEST SYSTEM

REAL-TIME SIMULATION OF GATLING GUN FOR CONTROL UNIT TESTING

Client

General Dynamics, Burlington, VT

Contact

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Problem Scope

Develop a test system to provide operation, control, and modeling behavior of a Gatling gun to test the Gun Systems Control Unit (GSCU). The test system must be capable of modeling the gun behavior when "stimulated" by the GSCU and be capable of outputting the gun signals back to the GSCU. Additionally, the system must provide the capability to simulate inputs from the GSCU if not present during development.

All signals including the 1553 MIL-STD bus traffic messages must be captured for review, analysis, archival, and presentation. Operator must be able to view the "simulation" of the model during development. Model execution required 2 kHz deterministic loop rates.

Specifically, the challenge was to provide a flexible, user friendly tool to allow operators to configure multiple testing models, execute those models, and collect the resulting data. Resulting data consisted of discrete, hard-wired I/O, modeled parameters, and 1553 message traffic. The challenge was to first be able to handle the bandwidth necessary to collect all the data, and then to correlate and combine the different data sources into a coherent, easily viewable format.

Only hardwired test boxes were previously available for this type of testing.

Viewpoint's Solution

- Gun Simulation running LabVIEW-RT 7.0 on a PXI platform with RT controller.
- National Instruments 6508 for discrete digital I/O modeling.
- National Instruments E-Series DAQ for clocking signal to pace the RT-Model code.
- Condor cPCI-1553M Bus Controller.
- Condor PCI-1553M Remote Terminal.

Technical Highlights

- Optimized RT code to ensure model simulation and data capture occur deterministically at 2 kHz.
- TCP/IP from RT-PXI system to Host PC to download model setups and capture data.
- Provided accurate timing response.

Description

The GSCU Test system consists of two major components; the Gun Model RT System and the Software Test Bed (SWTB) application for creating, editing, running, and reviewing tests and results.

Gun Model RT System

In order to develop a control unit for a Gatling gun, the developer ideally would be connected to a gun. This is necessary to provide the "gun response outputs" to the control unit in a closed loop fashion. The controller provides stimulus to the gun and monitors the feedback from the gun in order to close the loop.

Since it is not practical to actually use a gun for control unit testing, a National Instruments PXI system with an RT-Controller running LabVIEW-RT 7.0 was used to model the gun. This provides a robust, deterministic platform to not only execute the gun model, but allow the operator to simulate inputs to the "gun" and generate outputs to the controller.

The system has the capability to run a "normal" model simulating the gun behavior under expected operating conditions or it can be set up to exhibit alternative behavior. Faults can be injected in both the input to the model, which can be likened to a control unit fault or faults can also be generated from the model, signifying gun faults. This allows the developer to see how each side of the system would respond to fault conditions. Some examples of faults might be a gun jam or a proximity switch failure.

The heart of the gun model is a time-critical loop (TCL) executing at 2 kHz. Separate parallel threads are used on the RT system; one for the TCP/IP communication to the host application for model control and operator override capability; and one for the TCL.

The following is a listing of the tasks that occur in the TCL.

1. Command queues are checked for command operations from the host application
2. Discrete Inputs are read.
3. Model is evaluated (if running).
4. Discrete outputs from model are output.
5. 1553 messages are updated.
6. All data is passed back to the host for real-time updates and data storage.

Software Test Bed (SWTB)

The SWTB application allows the user to create all the gun model test sequences through a combination of tools:

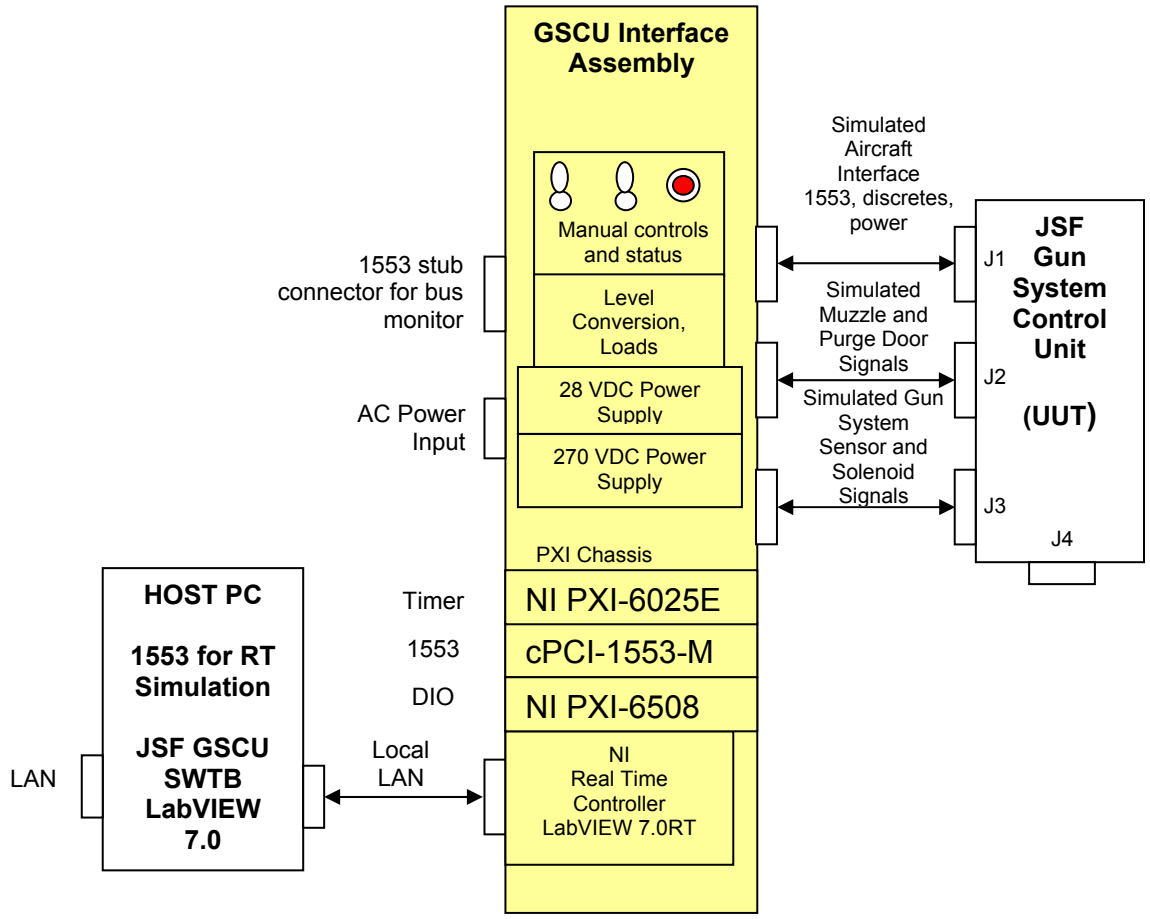
1. Gun parameters settings.
2. 1553 message timing setup.
3. Event editing.
4. Gun magazine creation.

These parameters are used to create a test sequence that is downloaded to the RT system. Complex sequences of events can be created. There are four types of events:

1. Simulated Input
2. Output
3. 1553 Output
4. 1553 Message Update

The event scheduling flexibility allows for the developer to create real-world scenarios to test the GSCU that were not previously possible. In addition to event scheduling, a subset of output signals that would normally come from the actual gun are modeled and generated using specific algorithms and user-defined gun parameters. This, combined with the concept of the ammunition magazine, creates a comprehensive view of the activity that occurs both from the gun and controller perspective.

Hardware Block Diagram



Diagrams

The Model Editor

The Model Editor screen (Figure 1) is used to create a model that will simulate gun behavior. All events can be generated and the simulation is run on the host PC to allow the operator to see the results of the model execution without actually running it on the PXI-RT system.

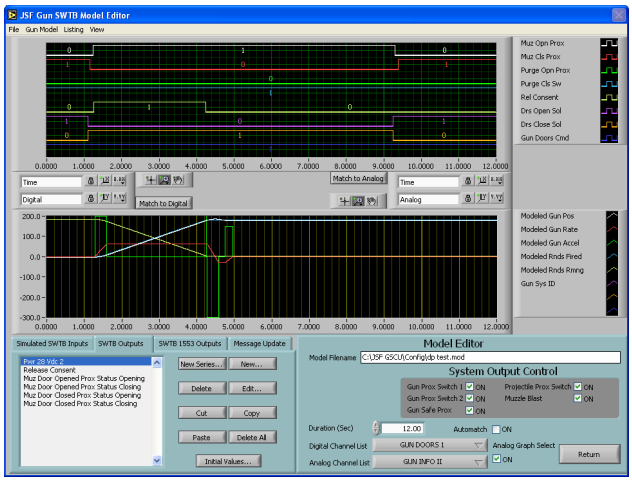


Figure 1 - Model Editor

Event Editor

The Event Editor screen (Figure 2) allows for the creation of an event. Events can be one of three types: Simulated Discrete Input, Discrete Output, and 1553 Bus Event. This instance is a discrete output event. All events can be scheduled to occur at a specified absolute time, a relative/incremental time from the previous stage, or they can be triggered by the state of another discrete channel (Input or Output).

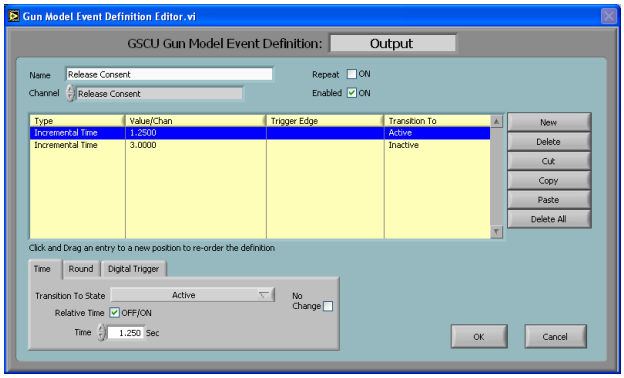


Figure 2 - Event Editor

Magazine Editor

The Magazine Editor screen (Figure 3) allows for the creation and manipulation of the ammunition magazine. The concept of the magazine is modeled by specifying how many rounds are loaded and what the state of the round is. By allowing the operator to configure individual round status, numerous possibilities can be tested. When the model executes and a live round passes by the firing pin while the gun is "armed", a modeled channel called "muzzle blast" is set to pulse to indicate a round was fired.

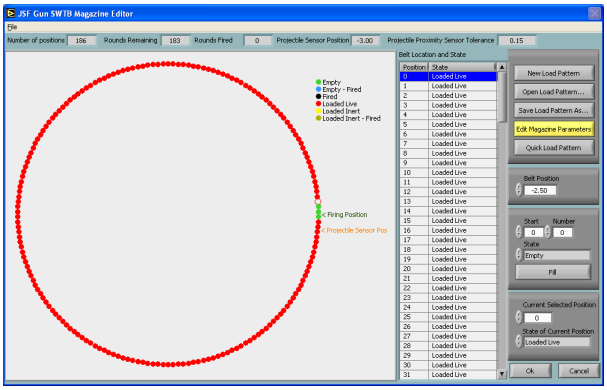


Figure 3 - Magazine Editor

Results

Through extensive testing and optimization, we were able to extract the required performance from the National Instruments PXI-RT Controller. The system was able to perform the complete modeling execution (I/O), event processing, and data transfer to the host via TCP/IP in 500usec. This rate was verified empirically using spare output bits from the digital I/O card in the RT system and collecting the timing information with a Viewpoint Systems DIO-64 digital time stamping board.

The resulting test system provides General Dynamics with capability that they never had before. The test system provides complete Gun System modeling capability, including the ability to inject faults into the model in order to characterize the controller behavior when the gun does not respond as expected. Numerous graphical and tabular views give the user numerous ways to view the captured data.

Previous modeling and simulation capability was limited to hardwired discrete simulators which did not offer true modeling and had no data capture and review capability. The following screen shots are a subset of the review capabilities.

Data Review

This screen (Figure 4) allows for post test review of the captured data. Another variation of this view allows the modeled analog and 1553 values to be graphed. As there are numerous channels of data collected, configurable lists are utilized to allow for quick viewing of the most commonly viewed channels. As any of the captured signals can be viewed on the same graph, relationships between specific signals can be determined.

The system allows for signals that are "missing" to be simulated which means that an execution can be a mixture of actual and simulated signals. All data is captured and the operator can select from the actual inputs, simulated input, or the net result of the two. This is important as the model cannot distinguish between an actual input and a simulated input. Typically the simulated inputs are only used for developing the model and are turned off when performing actual tests.

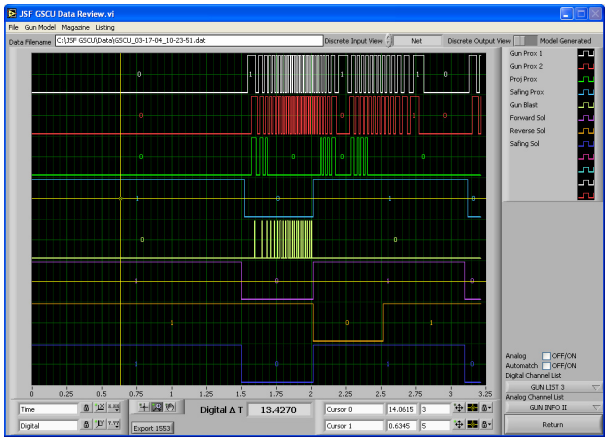


Figure 4 - Data Review

Event Log

Captured data can be viewed graphically, as shown above, or in a list view. This screen (Figure 5) allows for displaying data from an event centric view. Channels that are selected in the lists are filtered and displayed. When a transition occurs on a discrete channel of interest, the event is displayed along with any analog channels that have been selected for viewing. A tabular list is also available to view all channels based on a periodic rate.

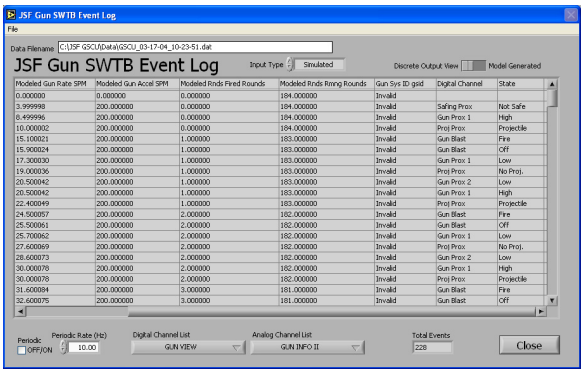


Figure 5 - Event Log