Miniature Imager for Neutral Ionospheric Atoms and Magnetospheric Electrons Engineering Data System Test

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What is MINI-ME?

The Miniature Imager for Neutral Ionospheric Atoms and Magnetospheric Electrons or "MINI-ME" is a low-energy neutral atom and electron imager that could reveal more about the global nature of the solar wind and its interaction with solar system planets. The ionosphere and the magnetosphere are outer layers of the Earth's atmosphere that interact with the solar wind.

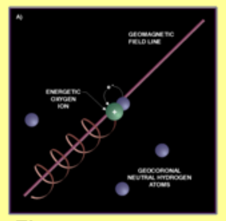

Figure 1.

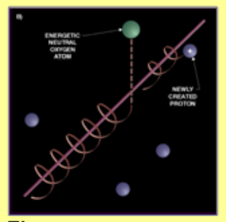

Figure 2.

Sensitivity:
▪MINI-ME will be sensitive enough to detect when a oxygen ion splits into a neutral oxygen atom and a proton (see Figures 1 and 2).

Implications:
▪Most solar system bodies are unshielded by their atmospheres and their surfaces are bombarded by solar wind and magnetospheric radiation. In this interaction, secondary products are ejected including neutral atoms which reflect the composition, habitability, and astrobiological characteristics of the body.

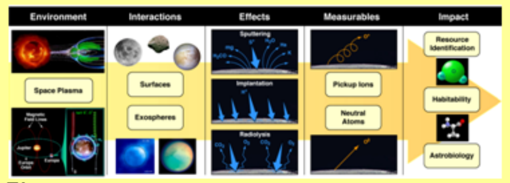

Figure 3.

Future Applications:
▪One day, MINI-ME could help explain why Venus lost its water and whether conditions at Europa, Jupiter's moon, can support life. If Europa harbors water, its convecting ice crust would likely bring evidence of life to the surface where it would be sputtered off by the radiation environment.

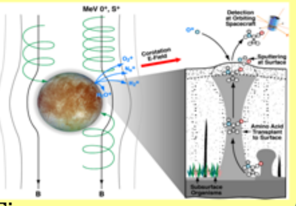

Figure 4.

MINI-ME Engineering Data System

The engineering data system uses fourteen probes to monitor conditions such as voltage, current, and temperature in the device and ensure that everything is working correctly.

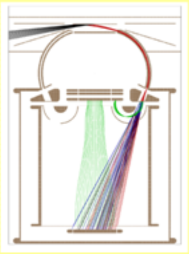

Figure 5.

High Voltage Source Control:
▪The system continuously adjusts three high voltage source outputs based on these conditions. For example, the engineering data system must supply the mass spectrometer's charged particle deflector (shown in Figure 5) with between +8 kV and –8 kV.

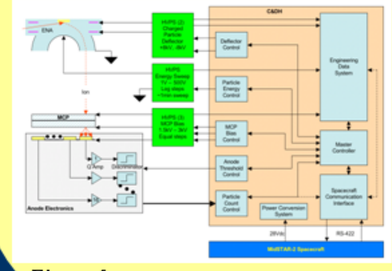

Figure 6.

Testing Methodology:
▪Over the summer, I created a LabVIEW test bench application that generates a series of analog and digital input stimuli and verifies that the engineering data system is working correctly. I also worked to define the circuit's interface with the rest of the satellite.

LabVIEW Graphical User Interface & Code

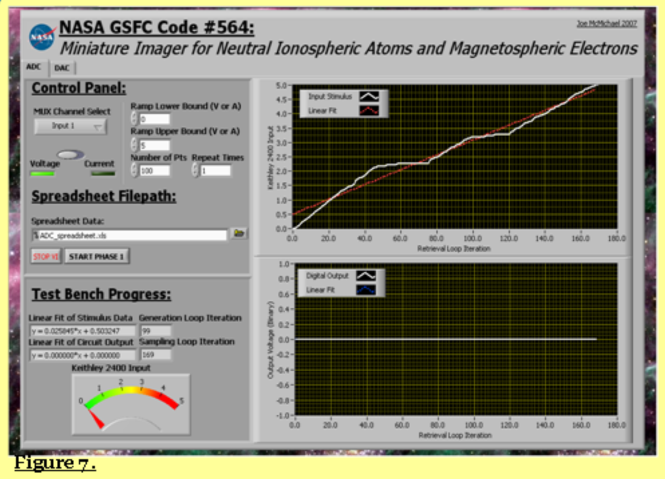

Figure 7.

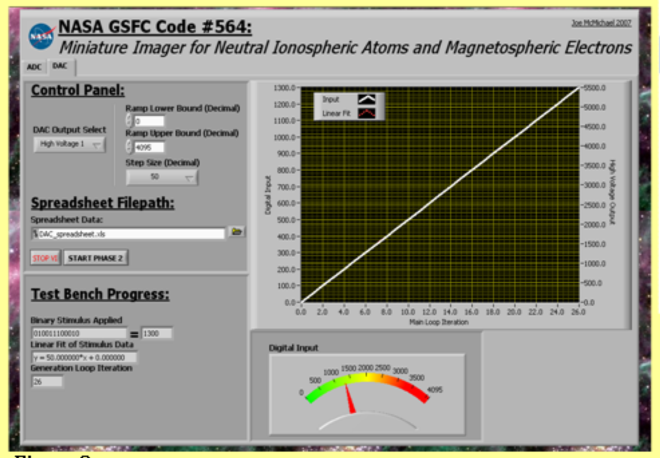

Figure 8.

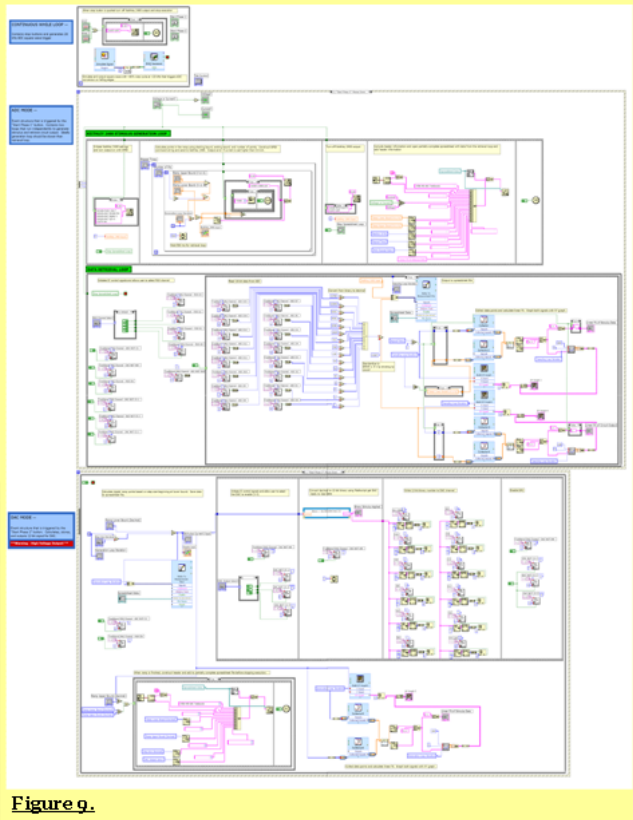

Figure 9.

This LabVIEW virtual instrument (VI) tests the MINI-ME engineering data system. The VI verifies proper operation by generating a series of analog/digital inputs, coordinating integrated circuit control signals to process these inputs, and retrieving output information using DAQ. The program has two modes of operation: "ADC" and "DAC."

ADC Mode:
In ADC mode, the VI uses GPIB communication to set the analog voltage or current output on a Keithley 2400 source. Also, one can control the lower bound and upper bound of a ramp with a finite number of points, and the number of times to repeat this ramp. Next, the user can specify the multiplexer input channel from the ADC using a ring (1-16).

DAC Mode:
In DAC mode, the VI generates a twelve-bit unsigned binary number using the PCI-DIO 32HS card. The user can specify a lower and upper bound for the ramp, as well as the step size. Possible outputs range from 0-4095 (000000000000-111111111111).

Conclusion

Although the MINI-ME engineering data system circuit board will not be fabricated until late 2007, this project offers an adaptable test application ready to be implemented. The virtual instrument allows a user to generate a digital or analog voltage/current ramp quickly, with the calibrated accuracy of a Keithley 2400 source. Data is automatically analyzed to determine a linear fit and archived to a spreadsheet. MINI-ME is expected to be finished by 2009 and will spend two years in orbit aboard the U.S. Naval Academy's MidSTAR-2 satellite.

Adaptability:
▪This VI is easily adaptable for testing other projects that require calibrated inputs. The handshaking sequence may need to be tweaked for different ADC, DAC, or multiplexer hardware components.

Pin Connections:
▪The bi-directional pin interface developed during this project requires 27 channels
▪Components use tri-state logic, and generate outputs of zero, one, or high impedance

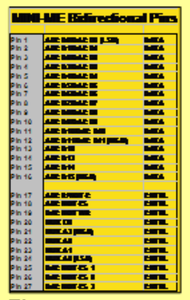

Figure 14.

Programming Methodology

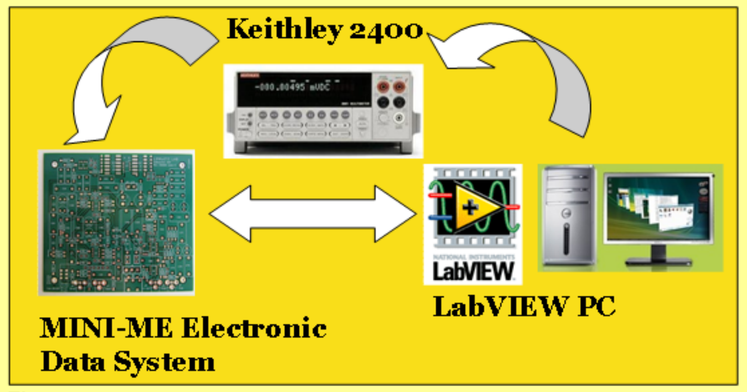

Figure 10.

A ramp of calibrated inputs is sent to the MINI-ME electronic data system to simulate voltage, current, or temperature readings.

Required Hardware:
✓LabVIEW PC
✓Keithley 2400 Source
✓PCI-GPIB card
✓Two PCI-DIO 32HS cards

Communication:
▪During operation, data is transferred through a 16-bit bi-directional bus. The bus uses tri-state logic (outputs are 0,1, or high impedance) to communicate with the single ADC and three DAC integrated circuits connected to it.

Sample GPIB Code (sets source to 5 v):

```
:SOUR:FUNC VOLT
:SOUR:VOLT:MODE FIX
:OUTP ON
:SOUR:VOLT:LEV 5
:OUTP OFF
```

Data Analysis:
▪Real-time data is displayed on two XY graphs.
▪The linear fit of a data set is calculated after each iteration and displayed in the lower left corner of the application.

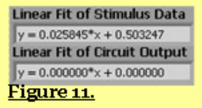

Figure 11.

Data Archiving:
▪All data is saved into a spreadsheet for future calculations.

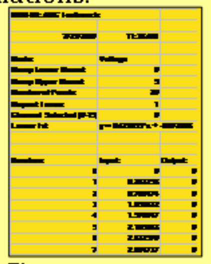

Figure 12.

Tri-State Logic:
▪Tri-State components generate outputs of low ('0') and high ('1'), but also include an unreadable high impedance state that allows other other elements to communicate.

Control Signals & Trigger Waveform:
▪The onboard analog-to-digital converter (ADC), digital-to-analog converter (DAC), and multiplexer require 11 control signals that trigger operations.
▪The ADC NOT CS line runs at about 20 kHz and triggers a conversion on every falling edge.

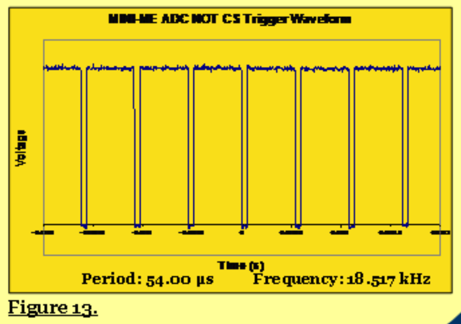

Figure 13.

Other Projects

GSFC TOF vo Test Setup Code Optimization:
▪I also optimized LabVIEW code for a cutting edge time-of-flight circuit. I rewrote a LabVIEW calibration function to be more easily manipulated using Matlab-based embedded code.

Figure 15.

Scilab "Bitshift" Function:
▪Worked with the open-source numerical computation program INRIA Scilab. Due to very limited bit manipulation support, I programmed a 16-bit "bitshift" function in Sci code. The syntax is *C = bitshift(A,k)*, which returns the value of A shifted by k bits.
▪For example, shifting 1100 (12, decimal) to the left two bits yields 110000 (48, decimal).

Acknowledgements

➤**Duane Armstrong** - NASA GSFC Code 564 *Mentor*
➤**George Suarez** - NASA GSFC Code 564 *Programming Advice*
➤**Jerry Karsh** - NASA GSFC Code 564 *MINI-ME EDS Designer*

*Figures 1-6 – Dr. Michael R. Collier, *MINI-ME Principal Investigator*

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