Thomson Scattering Scope Read/Write Software for the HIT-SI Lab

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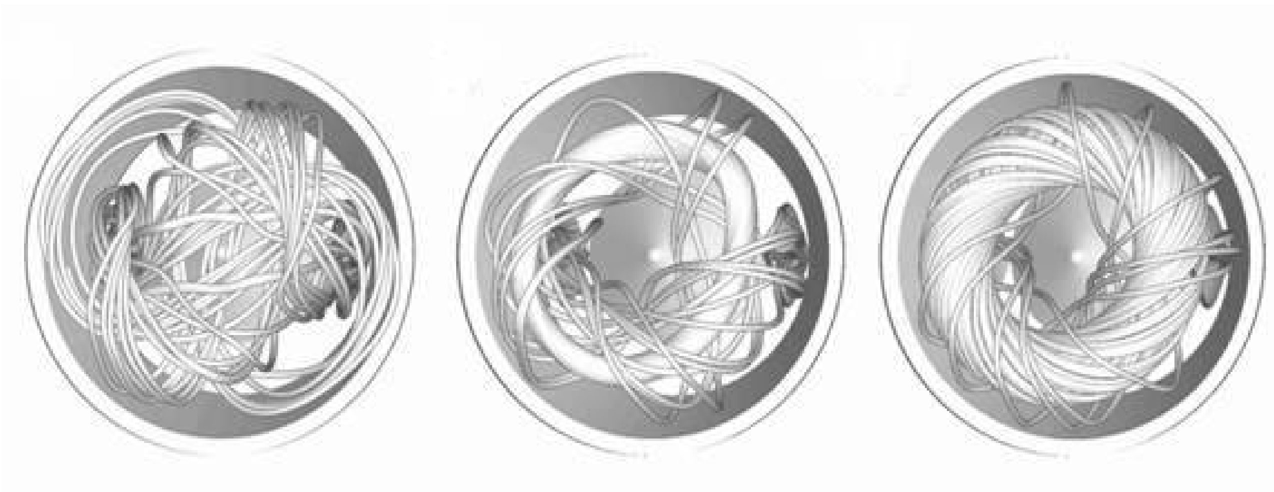


Contents:

1.Introduction

a. Purpose

The purpose of this report is to detail the functionality and features of the Thomson Scattering scope read/write software (TSReadWrite.VI) we have implemented for use by UW's HIT-SI fusion lab.

b. Definitions and Acronyms

HIT: UW's Steady Inductive Helicity Injected Torus fusion lab:

-http://www.aa.washington.edu/research/HITsi/index.html

VI: A LabVIEW Virtual Instrument

TSA: Thomson Scattering Apparatus

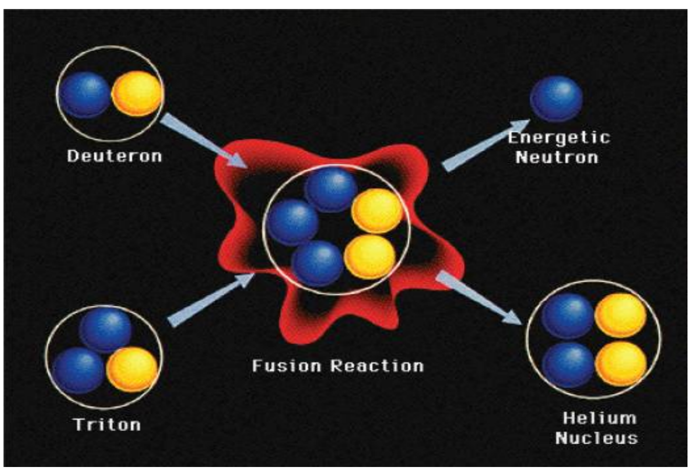
c. Scope

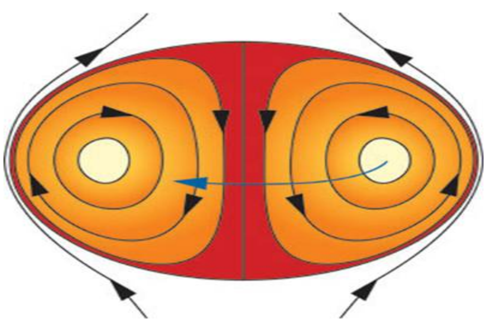
This software provides the ability for HIT scientists and technicians to view streaming data from the experiment's TSA, which includes several oscilloscopes. Because the reactor room is closed during reactor shots - when plasma is being created in the reactor - there currently is no way to view the waveforms of this key diagnostic in real time. TSReadWrite.VI provides this functionality, as well as the ability store the scope signal data to MDSplus HIT databases.

2.Physics & System Overview

a. Nuclear Fusion

Fusion is the process of combining two nuclei together and is the reaction that drives the sun. When two nuclei of elements with atomic numbers less than iron are fused, energy is released. The release of energy is due to a slight difference in mass between the reactions and products, governed by mass-energy equivalence. The fusion reaction requiring the lowest plasma temperature occurs between deuterium, a hydrogen atom with an extra nucleus, and tritium, a hydrogen atom with two extra nuclei. This reaction creates a helium atom and a neutron.





Spheromak Equilibrium Geometry

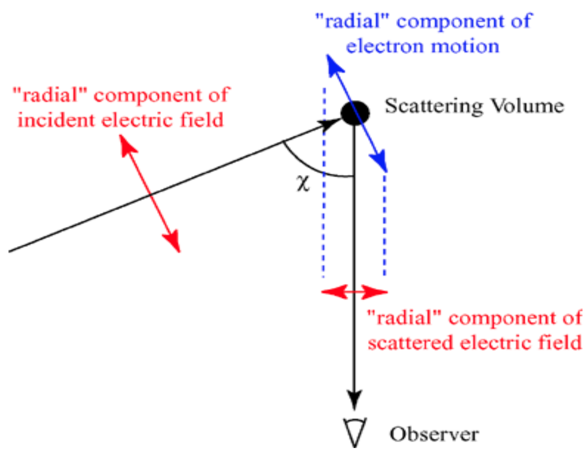
HIT uses a large electric charge supplied by a capacitor bank to ionize deuterium and tritium gas puffed into the reactor, creating the desired plasma. As described on HIT's webpage:

The Helicity Injected Torus (HIT) program investigates helicity injection current drive in magnetized toroidal plasmas of interest to controlled nuclear fusion. The HIT-SI experiment utilizes Steady Inductive (SI) helicity injection to form and sustain a spheromak equilibrium. Steady inductive helicity injection is an inductive current drive method that injects helicity at a *nearly constant rate, without open field lines, and without removing any helicity or magnetic energy from the plasma. The HIT-SI device includes the two non-axisymmetric injectors with a time varying toroidal flux and induced loop voltage. The injectors yield a constant rate of overall helicity injection with all applied power delivered into the plasma, rather than to the plasma facing surfaces. The lack of electrodes or other strong plasma-wall interactions make HIT-SI an ideal platform for clean studies of helicity injection current drive and current-profile relaxation.*

-http://www.aa.washington.edu/research/HITsi/index.html

b. Thomson Scattering

HIT uses a variety of diagnostics to measure signals for analysis from their fusion reactor and its plasma, including Thomson Scattering: The elastic scattering of electromagnetic radiation by a free charged particle, as described by classical electromagnetism.



As documented on Wikipedia:

> *In tokamaks and other experimental fusion devices, the electron temperatures and densities in the plasma can be measured with high accuracy by detecting the effect of Thomson scattering of a high-intensity laser beam.*

-http://en.wikipedia.org/wiki/Thomson_scattering

And as documented on HIT's website:

> *An eight spatial channel, seven frequency channel Thomson scattering system is capable of measuring radial profiles of the electron temperature and density. A 20 J, Q switched ruby laser system, with a 1 GW pulse, is used. The Thomson scattering diagnostic's range of operation is for electron temperatures of between 20 and 200 eV and electron densities greater than 1019 m-3.*

Currently, the TSA includes several dedicated Tektronix 3034B and 3014 oscilloscopes, whose location is shown below.

3.System Architecture

a. Architectural Design

The software, TSReadWrite.vi, currently consists of a free-standing LabVIEW interface to just one of the oscilloscopes described above, the TD3034b, with the ability to control its settings, read its waveforms derived from the TSA, and write its signal data to HIT's MDSplus database with the click of a button.

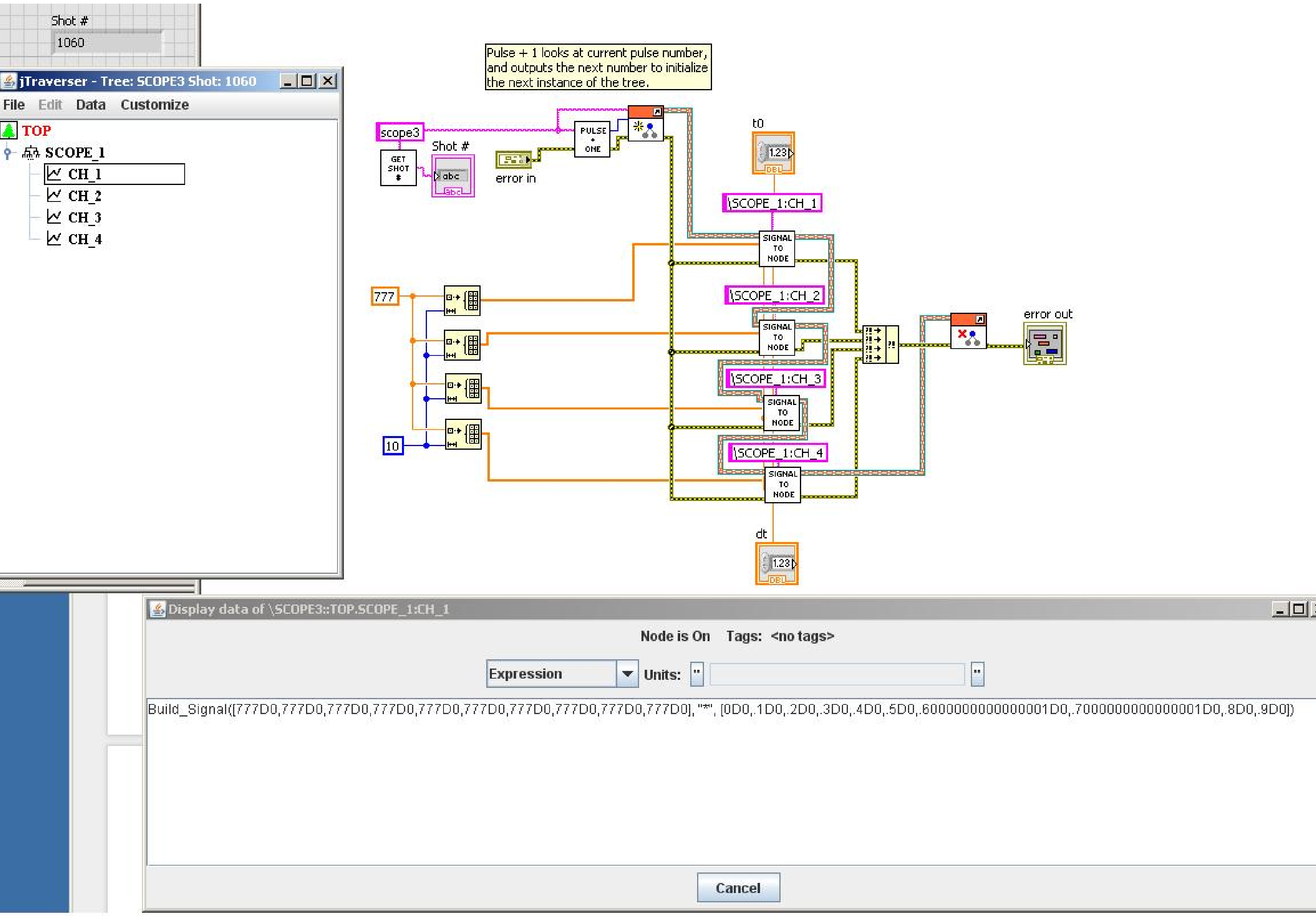
b. Oscilloscope Reading Capability

TSReadWrite.vi uses VISA (Virtual Instrument Software Architecture) to connect via IP address the desired TSA oscilloscope (TD3034b). Using a LabVIEW instrument driver for this specific scope conveniently provided us with custom sub-Vi's, which we used to construct scope waveform graph views and controls. The output of the waveform graph was then sent to our MDSplus writing functionality described below.

c. MDSplus Database Writing Capability

MDSplus is a set of software tools for storing data in a self-descriptive tree structure and is widely used in plasma physics experiments, where data is usually taken on a shot-by-shot basis (injection of plasma into the tokamak). Data can be stored and accessed in remote sites and can be read and written without transferring files. There exists a library of MDSplus VIs for Labview which can be used to access almost all of MDSplus functionality.

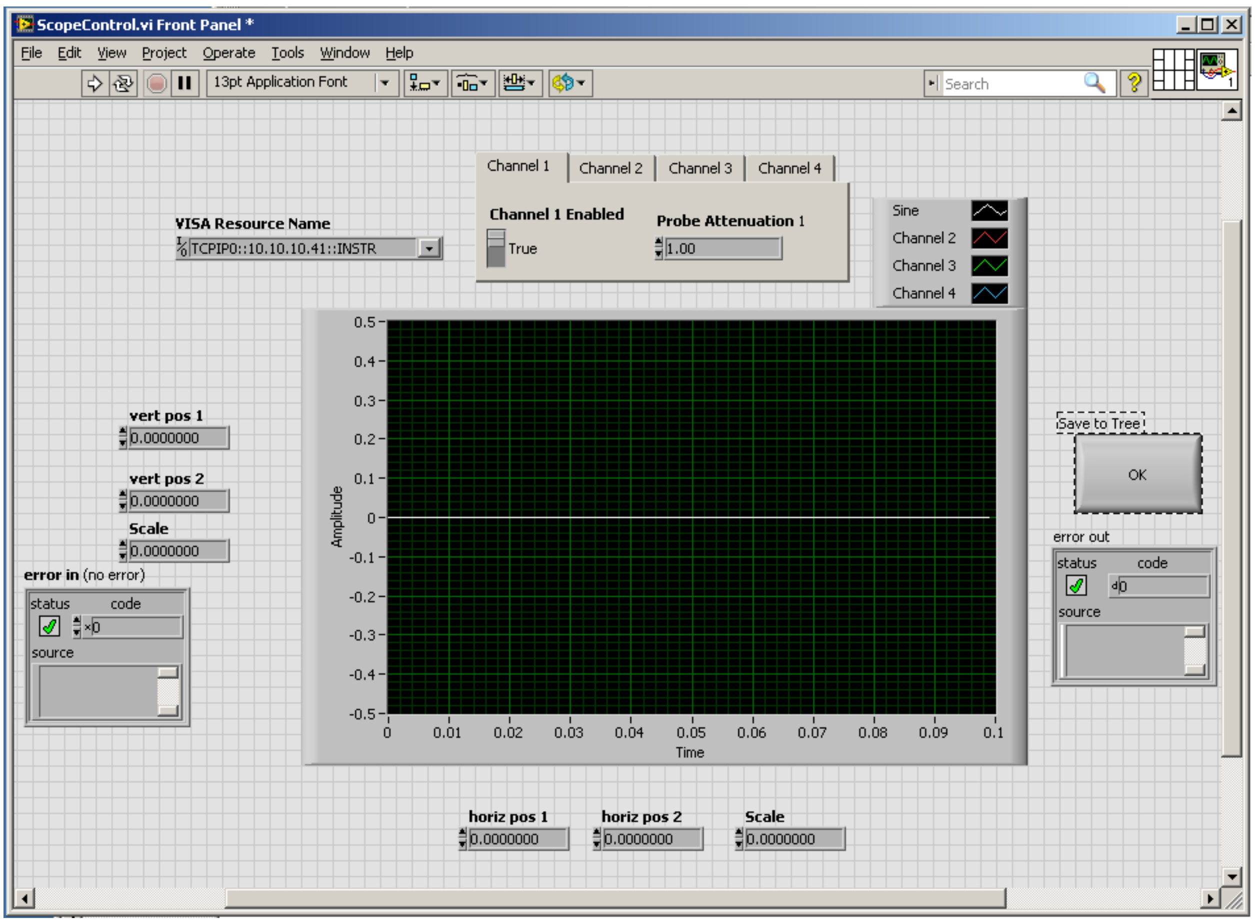
An MDSplus tree has a 'template' tree, which is cloned each shot by the To MDSplus sub-VI(pictured below). A pointer to this tree is created and used as a reference to put new data into the tree. The sub-VI Signal to Node is input the voltage readout from the oscilloscope, the starting time, and the time-resolution of the scope for the recorded shot (all provided for by the Tektronix Oscilloscope VIs). It then stores the signal data in the desired tree node, as specified by a tree node path name. Below is pictured the To MDSplus sub-VI being fed a dummy voltage array for each channel. The MDSplus graphic tree-traverser is open to the left of the block diagram, and the data in node \SCOPE_1:CH_1 is displayed below. As you can see the dummy array is successfully stored with the correct corresponding time array generated by the conditions to(initial time) and dt(time resolution).



4.Human Interface Design

a. Overview of User Interface

The user interface of this VI consists of a single view, containing a “remote control” cluster of scope parameter controls, a tabbed conditional control that allows for different channels of the TSA oscilloscope, and a single button which writes all scope data to the appropriate HIT database.



b. Outline of Future Work

Future work for this project will consist of making the software able to read and write the oscilloscope signal data of the various oscilloscopes contained within the TSA. This will most likely be implemented by linking pre-made Tektronix oscilloscope VI's to our database writing sub-VIs rather than further constructing our custom one.