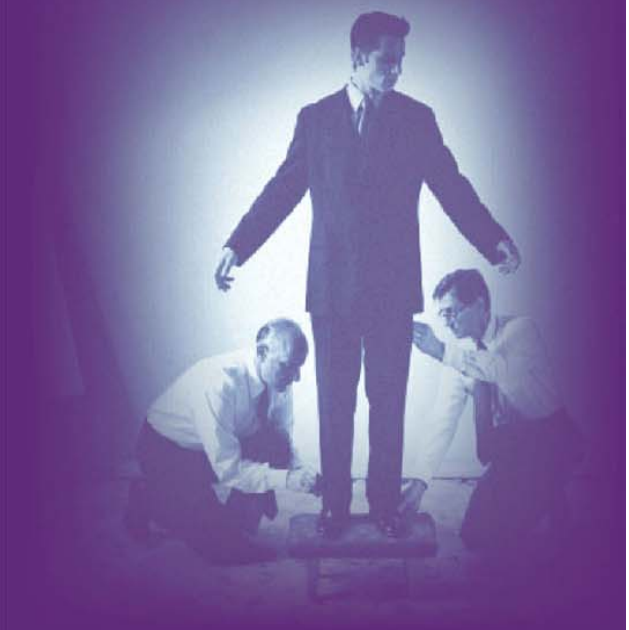
We Adapt
So You Don't Have To!



SMARTPEM

PEMFC single cell fuel cell test System

WonATech
Since 1991

Feature

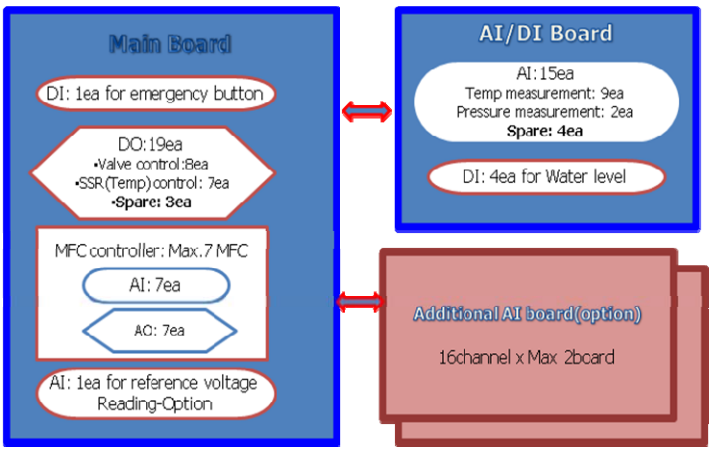
- Fully Integrated Compact Size
- Suitable for PEMFC single cell
- Automatic purge gas control
- Temperature measurement and control external anode & cathode line and cell
- Watch-dog function
- Full automatic by PC control
- Max 4channels control by one PC
- Accurate electronic load
- Stoichiometric control is available
- Nafion™ membrane type humidifiers for fuel and oxidant gas
- Various safety functions
- Powerful software with independent data analysis software

Description

The SMARTPEM™ is very compact, however, fully automated and integrated at a very attractive price. This system was designed to test Max. 100Watt PEMFC . SMARTPEM™ includes PC controlled electronic load, gas controller and humidifiers Our control and measurement software with powerful graphical user interface makes you easy to operate the SMARTPEM™. With the exceptional features of the SMARTPEM™, you can digitize your fuel cell economically and evaluate it easily.

100Watt SMARTPEM™ Uses SMART "B" controller. This controller is suitable for simple configuration for single cell test and compact designed.

➢ Smart B controller



100Watt SMARTPEM™ can be upgraded to SMART2 PEM/DMFC by adding Methanol pump by factory setting.

WonATech designed its own controllers to meet various requirement from users.
WonATech's controllers support the followings using AI(analog input), AO(Analog output),DI(Digital input) and DO(Digital output);

- MFCs and or liquid pumps control
- Heating and cooling control
- Valve control (gas flowing on/off, dry/wet gas selection etc)
- Electronic Load control
- Humidifier control
- Water supply control
- Back pressure regulator control(option)
- Measurement of temperature, voltage, pressure, humidity etc.

Many of fuel cell test system manufacturer use 3rd parties DAQ system for their fuel cell test system. This must have limitation of expansion of the system and/or cannot support specific requirement from users.

➢ Safety functions

100Watt SMARTPEM™ supports the following safety feature

1. Watch dog function: If there is no communication between control PC and system, System will be stopped automatically
2. Emergency button: Hardware and software emergency button provided
3. User can set safety limit value for each devices
4. Low voltage limit and high voltage limit setting: If the fuel cell(stack) is over high voltage limit or less than low voltage limit, Electronic load will not discharge the cell.

5. Water supply: Automatic water supply is done by level sensor(high & low)

➢ Humidification

Accurate and stable humidification is importable in fuel cell testing. WonATech's fuel cell test system use Nafion membrane humidifier and multiple line temperature control to control humidification more details.

➢ Accurate Electronic load

100Watt SMARTPEM™ use WonATech's fuel cell electronic load. This fuel cell electronic load is specially designed to meet fuel cell test including EIS measurement. This internal electronic load supports fast response time and EIS measurement.

WonATech supply Multichannel EIS monitor(model:Z#™) which is designed to measure EIS for stack. This multichannel EIS monitor is different from sequential type EIS measurement system. Z# has independent channel NOT sequential so this can provide simultaneously EIS measurement for multiple cells in stack. Electrochemical reaction is time domain; It means that sequential measurement is not accurate result. For single cell application, Zcon™(single channel) can support single cell EIS measurement with internal electronic load. 100Watt SMARTPEM™ equipped Z#/Zcon interface port for future usage of Z#/Zcon as option.

➢ Automation

WonATech's fuel cell test systems support stoichiometric operation. PC controls each devices with scheduled file also it supports batch operation which consists of several schedule files
For user who wants to operate the system manually not by schedule file, manual operation is supported.

Standard Configuration List

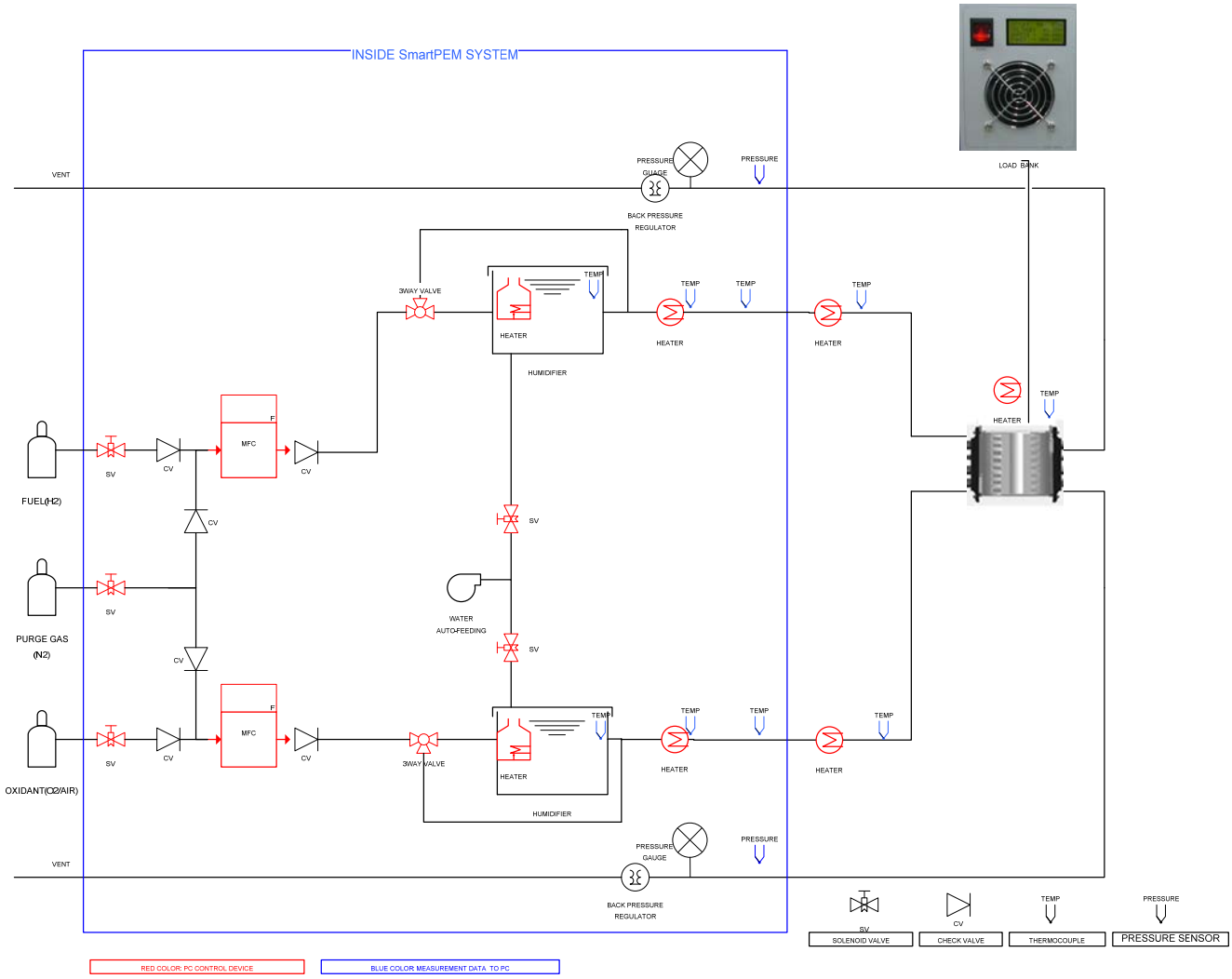
- Solenoid valve: 5ea
  (fuel gas, oxidant gas, purge gas, water refill control for humidifiers)
- MFC for Anode and Cathode (2set)
- Check valve: 6ea
  Each MFC has two check valve at in & out ; Purge gas out for anode & cathode
- 3 Way valve: 2ea
- Humidifier : 2set
- Automatic water feeding for humidifier: 2ea
- Back pressure regulator : 2ea
- Pressure sensor: 2ea
- Temperature controller(with line heater & thermocouples): 7set
  - ✓ Humidifier Temperature controller 2set,
  - ✓ Instrument inside gas line Temperature controller:2set,
  - ✓ Instrument outside gas line Temperature controller: 2set
  - ✓ Stack or cell Temperature controller: 1set
- Temperature monitoring only: 2 points with thermocouples
  Anode & cathode gas line inside
- Electronic load: 1set
- System controller including DAQ system with emergency switch
- Control PC(option) with WFTS Smart software
- Interface boards with cables

Optional Equipment List

- MFC(s) for Anode and/or Cathode for Reformate
- MFC for Nitrogen
- Pump for DMFC
- H2 Gas detectors (Fuel cell chamber is needed)
- Additional temperature controller with measurement
- Additional Temperature measurement
- Humidity measurement
- Additional Pressure measurement
- (Multichannel) Impedance Monitor
- External potentiostat/galvanostat
- Automatic back pressure regulator instead of manual type back pressure regulator (L type housing is needed)
- Zero voltage booster (External type)
- Fuel cell stack jig
- Stack multichannel temperature monitor(each cell)
- Stack multichannel voltage monitor(each cell)
- Differential pressure gauge
- Moisture trap (auto/ manual: External)
- DI water filter module (External)
- Conductivity measurement with DI water chamber (External)
- Fuel cell hardware fixture
- L type housing (with/without fuel cell chamber)

Block Diagram

SmartPEM™ Standard Configuration WITHOUT option devices



Hardware Specification

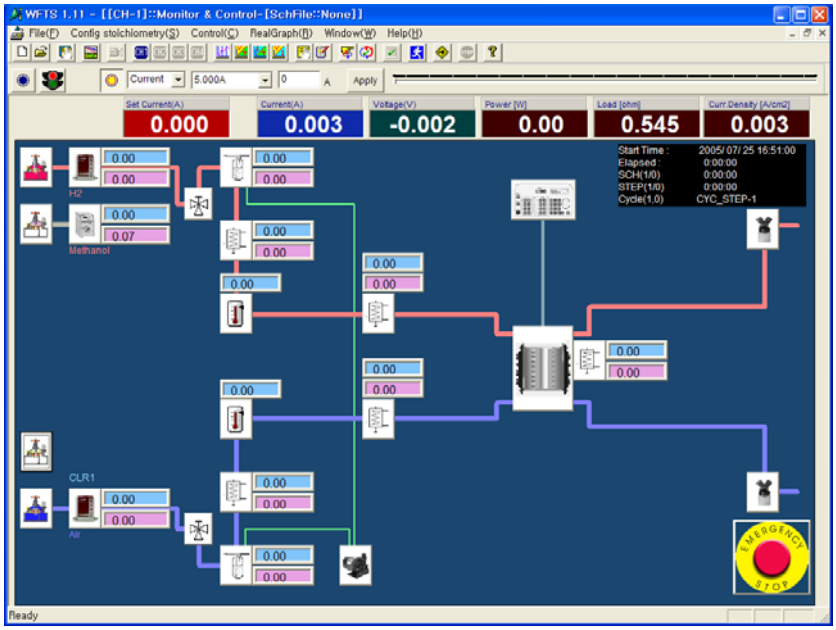
- MFC (Mass Flow Controller), 2 ea
  - Max. Flow rate : H2(2slpm), Air (5slpm)
  - Accuracy : 1% Full scale
- For 100W Single Cell Application
  - Anode gas flow rate : 0.04 – 2 slpm
  - Cathode gas flow rate : 0.1 – 5 slpm
- Humidifier, 2 set
  - membrane type(Nafion membrane tube length: 1meter)
  - Automatic Water feeding system(PC control)
- Built-in Precision Electronic Load
  - 4 ranges(voltage & current)
  - Max 200Watt (Max. 100Amp, Max 50V)
  - Standard: 10V(1,2,5,10V) 50A(5,10,50,100Amp) *1
    Other ranges available
  - Control: CC, CV, CP,STEPI,STEPV,STEPP
- Humidify or dry gas selectable
  - PC control 3 way valve
- Back Pressure regulator, 2ea
  - 0-50psi
- Temperature Control System
  - Control & measurement 7 points
    Humidifier(2), Gas line(inside, outside) 4, Cell Temp(1)
- Temperature measurement only
  - pipe line inside temperature : 2 points
- Pressure measurement
  - 2 points
- Compact size
  - 430W x 504H x 430D (mm)

***1: Voltage range and current range can be changed**

WFTS™ Software

FEATURES

- Quick and Easy Test Configuration
- Real-Time Graphic Data Output
- User Friendly Graphical User Interface
- Continuous Data Logging
- Background server program
- Independent Data Managing software
- Button click & play mode
- VOI (Value of Interest) Displaying selection
- Colorful display of each module status



DESCRIPTION

Dedicated WFTS™ software will be used to operate the testing system. This stable software consists of server program to communicate with system, main program to control & data acquisition and data managing program for analysis. Also this can support Max. 4 channels independently and simultaneously even if they have different configurations.

Automatic control and data acquisition is conducted through pre-programmed single or group schedules in the software.

Safety limit setting for each device can give safe operation with software emergency button.
Operator can do experiments easier by GUI based button click & play mode and monitor each status by color distinguishing icon button for each device and its setting value and reading value.

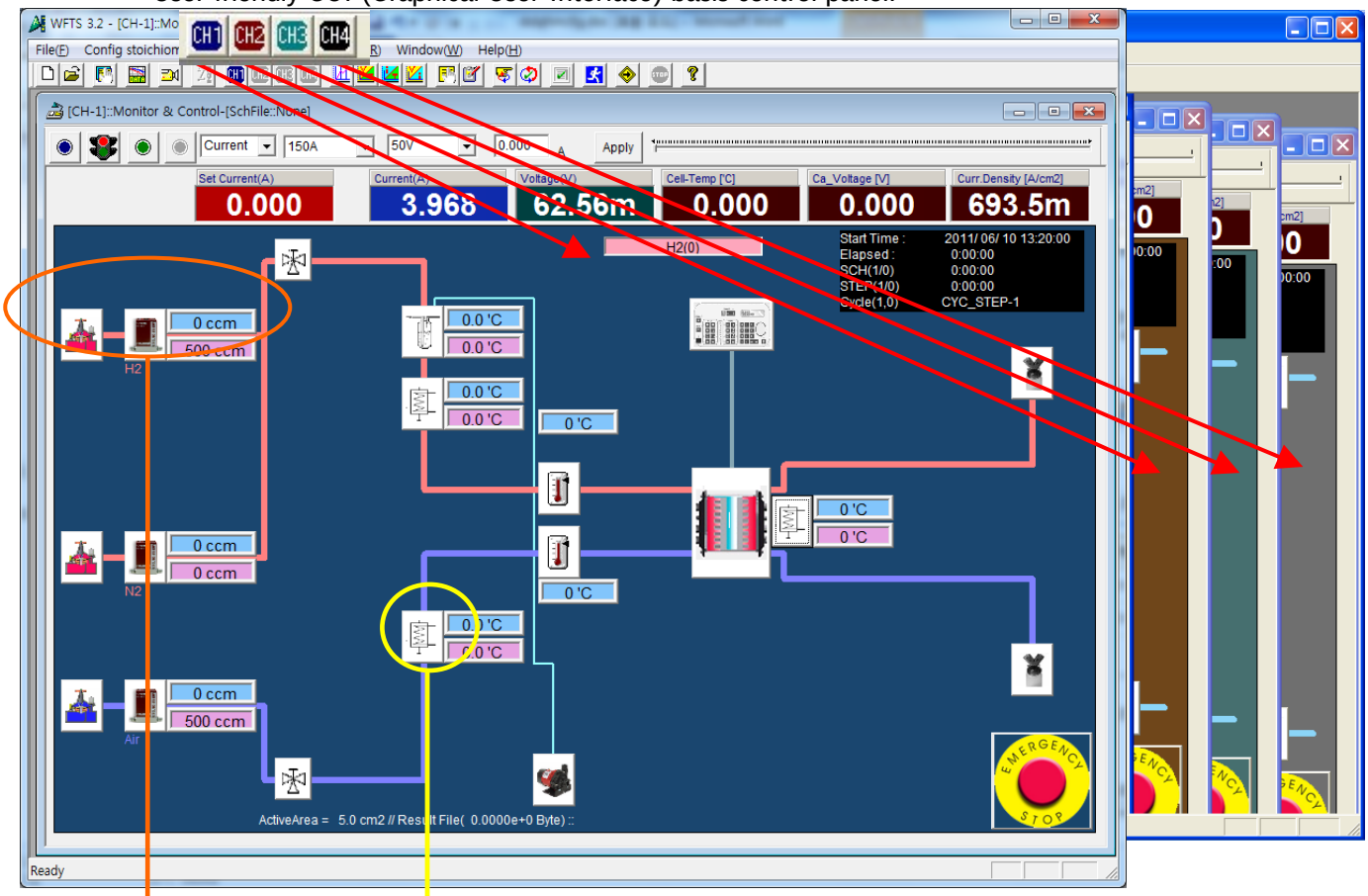
Value of Interest display makes operator monitor 3 of user selected reading values and 3 of fixed values (Load control value, reading current value and voltage value) as large digit.

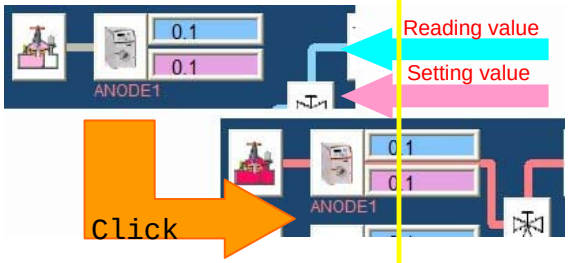
Based on Windows 2000/XP platform, the software emphasizes on friendly graphical user interface (GUI) and compatibility with Microsoft Excel and Access for data collection and presentation.

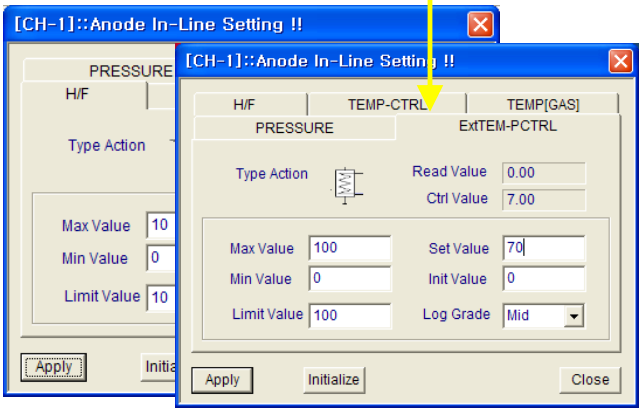
The real-time graphing portion of WFTS™ Software allows users to plot any number of variables versus any single variable or time. This feature is useful for developing real-time polarization curves or tracking cell performance across temperature ranges. Independent data managing software gives the various graphing, charting options and reporting.

Main Program

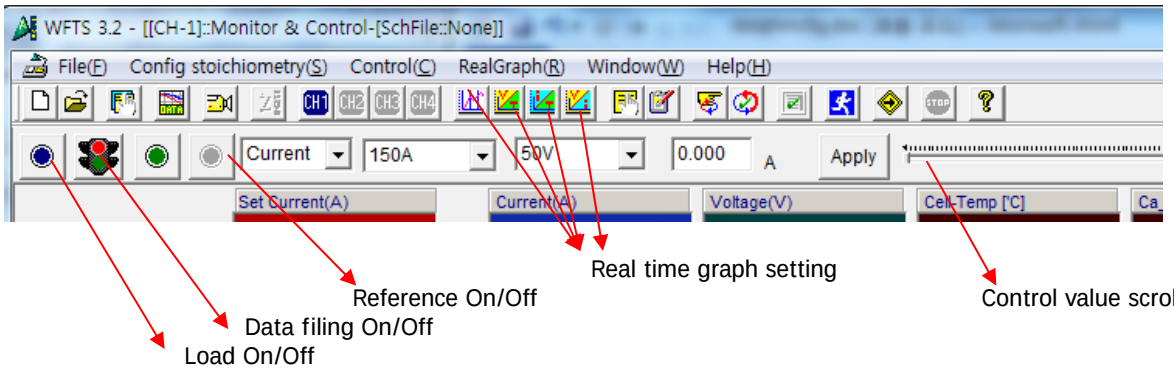
- Control panel (max. 4channel controllable)
  Each channel's control panel has different background color to prevent channel wrong-operation.
  User friendly GUI (Graphical User Interface) basis control panel.





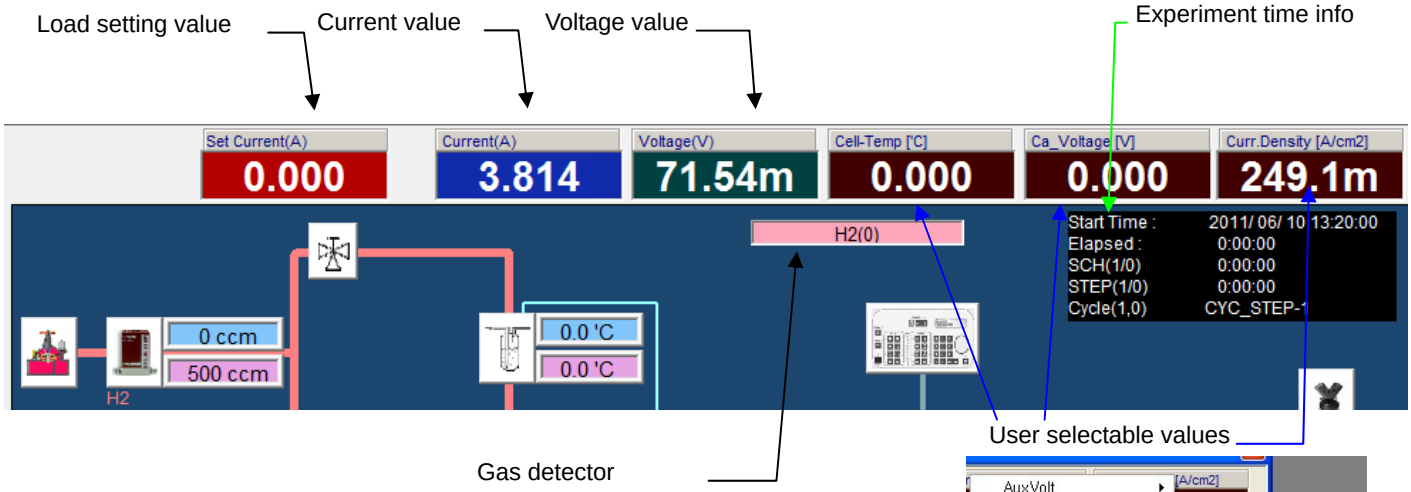


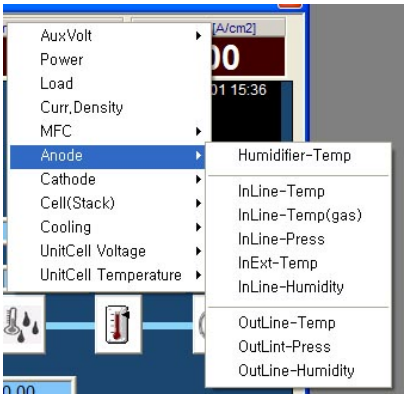
- Device value display
  Setting value & reading value or reading value only by each device's properties.
- Button click operation
  User can operate each device just by clicking each icon button.
  1) Direct control; solenoid valve, 3 way valve, heater power on/off, emergency stop
     e.g.) solenoid valve click → valve open (solenoid valve & MFC valve) → gas flow → color change (status display)
  2) Indirect control: Each devices to be controlled by setting parameters.(temperature controller, MFC, pump, electronic load, humidifier)
     e.g.) anode input line temperature controller click → parameter setting windows → apply
  3) Displaying related information: Stack's temperature monitor, pressure monitor etc. (safety limit setting available)
- Device icon button color change by status
  Each of device icon's color changes following running or idle status. (running → colorful, idle → grey). This feature makes operator able to monitor each device's status at a glance.



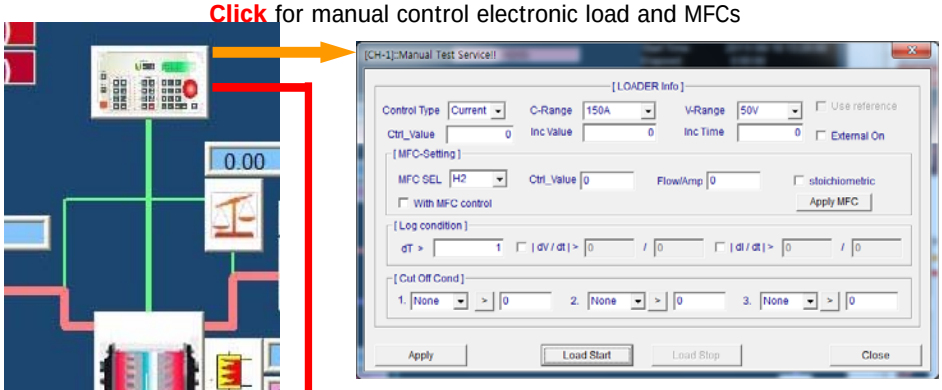
VOI (Value of Interest)

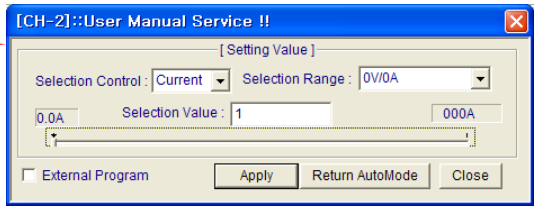
Fixed value (3), User's value (3)



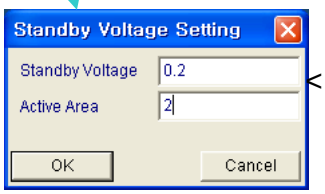


Click for manual control electronic load and MFCs



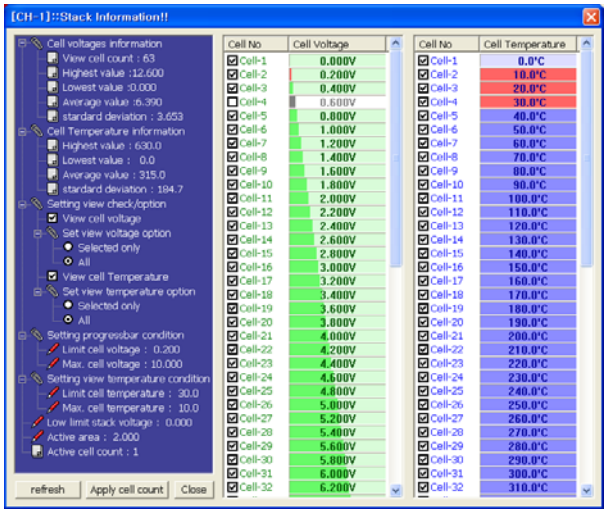


Click for manual control during
Pre-programmed schedule running



<= Cell standby voltage detection for safety operation

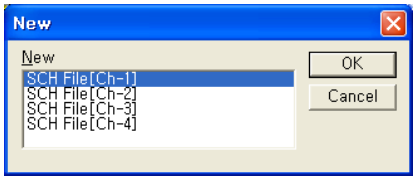
Cell or Stack information (option)



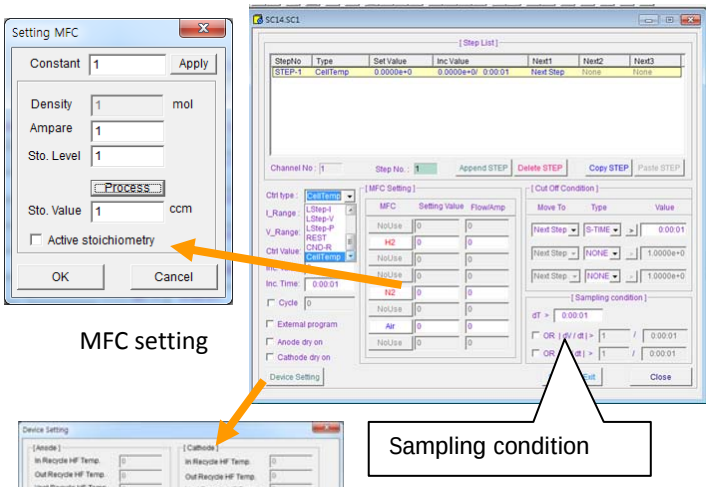
Stack voltage/temperature monitoring

- Stack Monitor
  - Safety Limit setting for voltage and/or temperature
  - Display Highest value/Lowest value during operation
  - Display average value, standard deviation
  - Stack standby voltage detection setting for safety operation
  - Back ground bar graph for each cell voltage & temperature with color.

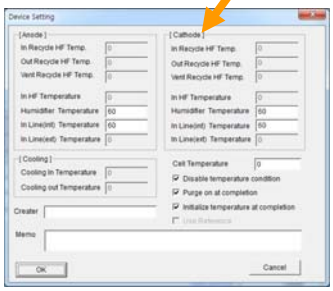
Schedule and batch file



Schedule file

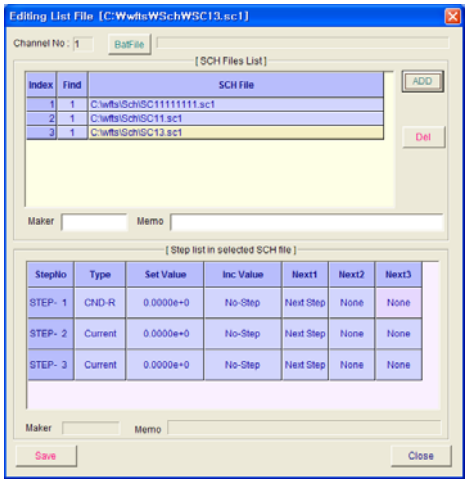


MFC setting



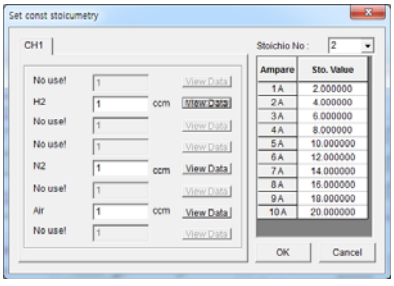
Device setting

Batch file



Batch file is a series of schedule files.

- Creating/modifying schedule file/batch file by channel ID for each channel configuration's difference.
- WFTS software detect channel ID for proper operation.



Stoichiometry setting

- Schedule file includes
  - Load control parameters
    - Constant current
    - Constant voltage
    - Constant power
    - Step current
    - Step voltage
    - Step power
    - Last StepI
    - Last StepV
    - Last StepP
    - CellTemp
    - Rest & conditioning rest
    - Current, voltage range setting
  - Data sampling time
  - MFC/pump control parameters
  - Each step's cut-off condition
    - Time
    - F-time
    - S-time
    - Current, voltage, power
    - Cell temperature
  - Temperature control
  - External program control for impedance monitor
  - Memo

During experiment using schedule file or batch file, operator can change each device's parameters and/or change load control by manually.

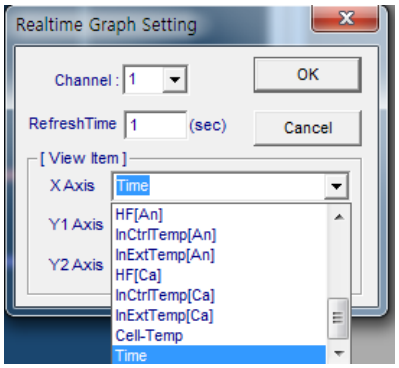
Operator can stop experiment by pressing stop button or emergency stop button or click purge gas' solenoid valve icon.

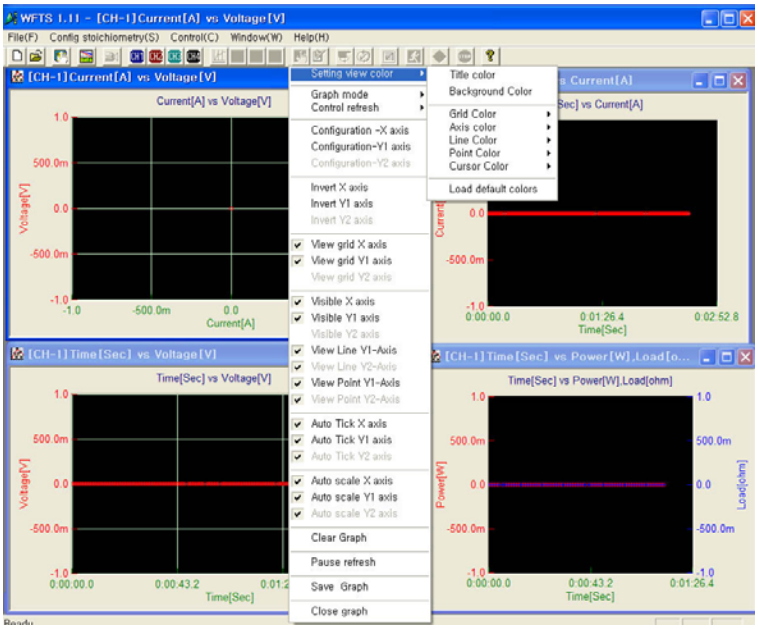
When he/she loads schedule file or batch file for each channel and apply experiment condition by apply icon clicking then WFTS software control each device following defined parameters on first schedule file except load control. Load control is only activated when experiment is started and gas flow makes cell/stack voltage up. WFTS continuously monitors cell/stack voltage and only if the voltage is higher than setting value (on view cond voltage), it makes load control enable.

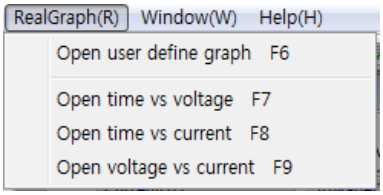
➢ Event Logging

WFTS software records each event for history reviewing. Each logging file can be view on Data manager software.

➢ Real Time Graphic Data Presentation
  - ➢ Predefined formats
    - Voltage vs. time
    - Current vs. time
    - Voltage vs. current
  - ➢ User defined X-Y-Y1 formats
    - User selects each axis parameters.



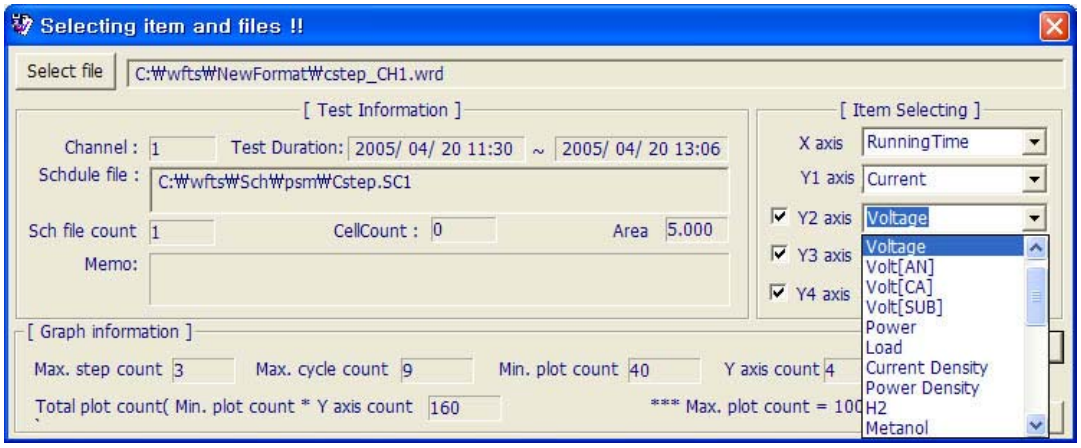




DATA MANAGER

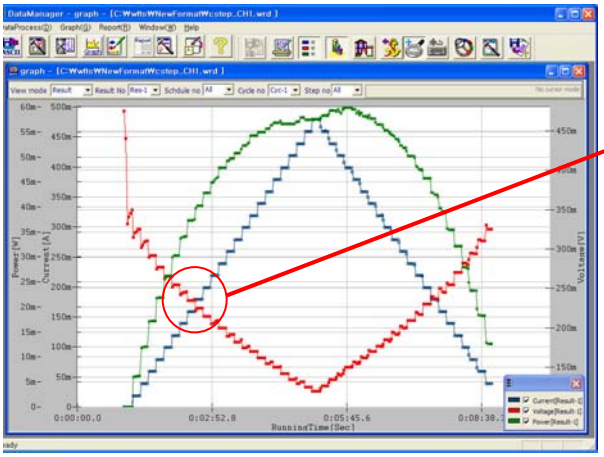
Independent data analysis program for Smart software .

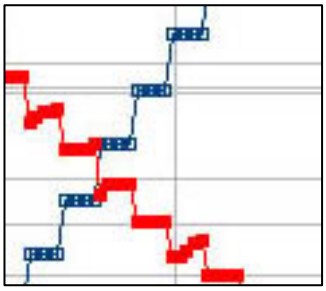
- Multi Y axis graph



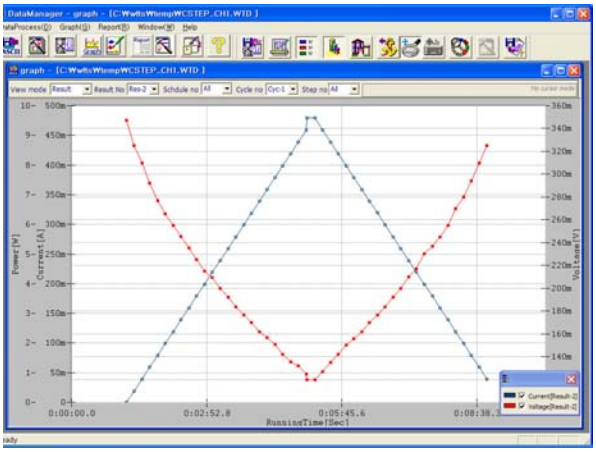
User selectable time base 4 Y axis graph

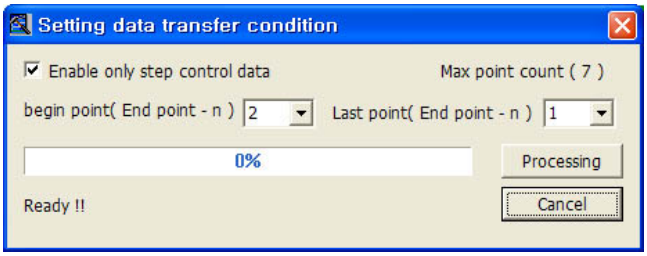
Any of measured parameters can be selected for each axis





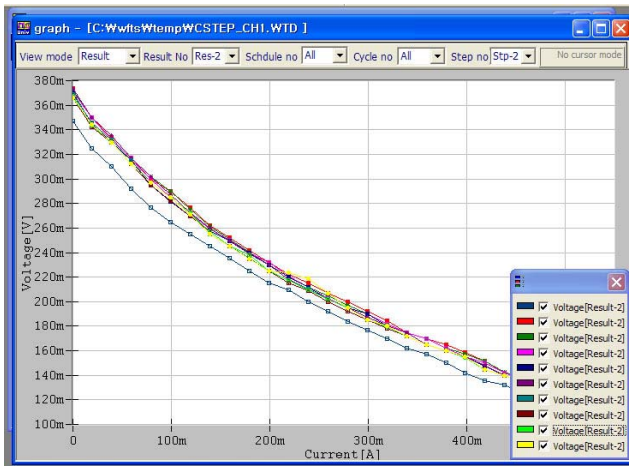
Step data sampling

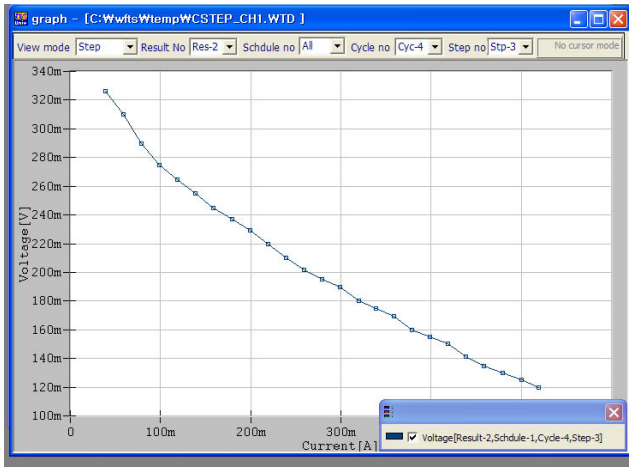




Graph parameter selection

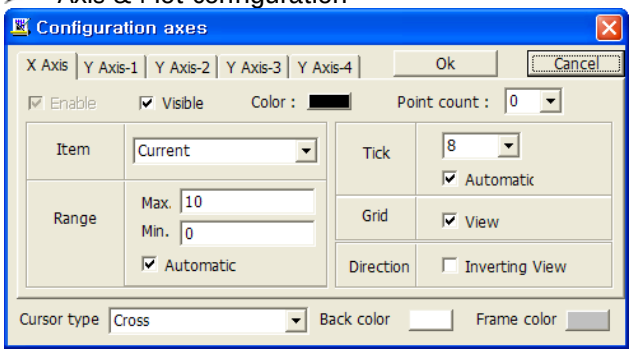
- View mode selection: Result/schedule/cycle/step
- Result Number selection
- Schedule Number selection
- Cycle number selection
- Step Number selection

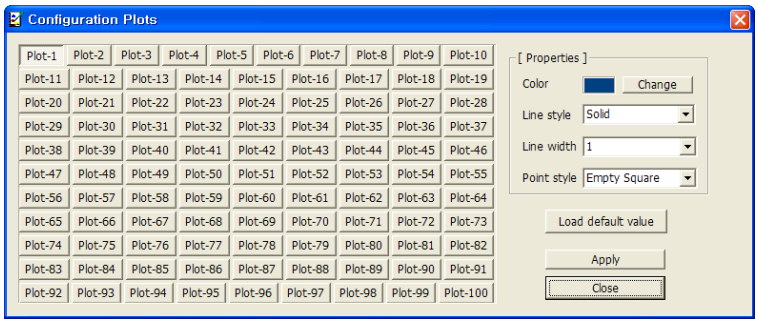




4th cycle, 3rd step selection

- Axis & Plot configuration





WonATech Fuel Cell related Products

- Fuel cell stack jig

- Conductivity Cell for fuel cell test

- External Electronic Load

- Multichannel(Single channel) Fuel cell stack impedance monitor

- Fuel cell hardware fixture

- SmartE: L-type cabinet fuel cell chamber type

- SmartE: L-type cabinet open type

- WFCTS: kW level test station

- SOFC Test System

- Zero volt booster

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