

Simulation of Control System with Lab VIEW

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Abstract: *In this paper, the virtual instruments software LabVIEW and its Simulation Interface Toolkit are introduced at first. With visualization technology, LabVIEW can simulate an industry plant with better effect. The LabVIEW Simulation Interface Toolkit (SIT) provides a seamless integration between MATLAB/Simulink software and LabVIEW. A method is presented to implement real-time digital simulation with no hardware-in-the-loop and a pure software real-time digital simulation example of a lever process control system using LabVIEW Simulation Interface Toolkit is given. It can get better effect in teaching or training of industry process control system with minimal cost.*

Keywords: *LabVIEW Simulation Interface Toolkit, Real-time, Digital Simulation, MATLAB.*

I. INTRODUCTION

With the development of computer technology, the drawbacks of traditional control system simulation system become more and more apparent. Putting virtual instruments software into control system simulation system will result in not only the cost reduction of the hardware, but also the enhancement of the teaching or training effect.

NI LabVIEW is the graphical development environment for creating flexible and scalable test, measurement, and control applications rapidly and at minimal cost [4]. With LabVIEW, engineers and scientists interface with real-world signals, analyze data for meaningful information, and share results and applications. Regardless of experience, LabVIEW makes development fast and easy for all users. LabVIEW programs are called virtual instruments, because their appearance and operation imitate physical instruments, such as oscilloscopes and multimeters. Every VI uses functions that manipulate input from the user interface or other sources and display that information or move it to other files or other computers. MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Simulink can easily analyze model and simulate control systems [7]. Simulink can work with the MathWorks Real-Time Workshop. Real-Time Workshop generates and executes stand-alone C code for developing and testing algorithms modeled in Simulink. The resulting code can be used for many real-time and non-real-time applications, including simulation acceleration, rapid prototyping, and hardware-in-the-loop testing [5]. So Simulink is widely used in simulation of all kind of systems. But Simulink lack the imitation of physical instruments or equipment in appearance and operation. It is a good idea to combine LabVIEW and MATLAB in simulation of control system.

The LabVIEW Simulation Interface Toolkit [1] integrates LabVIEW with the software of The MathWorks, Inc. known as Simulink and Real-Time Workshop in a way that allows us to develop, prototype, and test control systems using models developed in the Simulink simulation environment. The Simulation Interface Toolkit automatically generates LabVIEW code to interface with a Simulink model resulting in a flexible and easy-to-use user interface. After configuring the Simulink model to communicate with LabVIEW, then we can create a LabVIEW host VI that automatically calls, runs, and interacts with the Simulink model [2]. Examples in [1, 3] teach us how to create LabVIEW user interfaces for Simulink models and run simulations on NI RT Series hardware. But our goal is to implement real-time digital simulation with no hardware-in-the-loop. It is a pure software real-time digital simulation, so the cost will be low.

II. CONFIGURING THE SIMULINK MODEL

To create a user interface in LabVIEW for a Simulink model, we first must have a Simulink model. Before using the Simulation Interface Toolkit, we must have the MathWorks MATLAB 6.0 or later, MathWorks Simulink 4.0 or later and National Instruments LabVIEW 7.0 or later installed on the host computer. We can complete the following steps to build a new lever control system model in Simulink.

2.1 Installing the Simulation Interface Toolkit configures MATLAB to launch the SIT Server when we launch MATLAB. The SIT Server transfers data between LabVIEW and MATLAB. Launch MATLAB on the host computer. The MATLAB command window displays the following message.

Starting the SIT Server on Port 6011

SIT Server started

This message indicates that the SIT Server is running.

2.2 Enter simulink in the MATLAB command window to launch the Simulink Library Browser window. In a new model, place a Transfer Fcn block, three Constant blocks a Sum block, a Scope block and other blocks in the model window. The NI Toolkit Sinks library contains two blocks—the NISink block and the NIXYGraph block. These two blocks export the output of the model to LabVIEW so LabVIEW can display the data. At each point we want to monitor in the simulation model, add a NISink to allow LabVIEW to read the data at that point in the simulation model. After wiring the sources, functions, and sinks, the model looks like the diagram in Fig. 1.

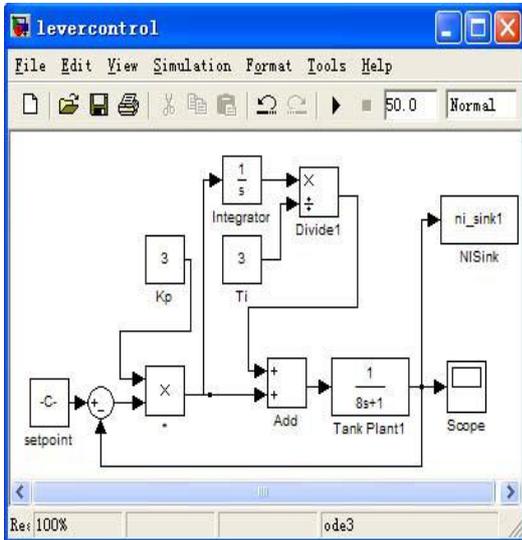


Fig.1 Levercontrol model

2.3 Select Simulation»Simulation Parameters to open the Simulation Parameters dialog box to set the simulation parameters. Reference [7] gives a guide how to choose a Fixed-Step Solver and step size. On the Solver tab, type 50 (which must at least be greater than the settling time of a control system, so we can see a full step response chart of a control system.) in the Stop time text box. By changing the Stop time to an infinite value, the simulation runs until we stop it. Set the Type option to Fixed-step in the Solver Options section and type 0.1 in the Fixed-step size (fundamental sample time) text box. The Configuration Parameters Dialog Box of Levercontrol model looks like Fig. 2.

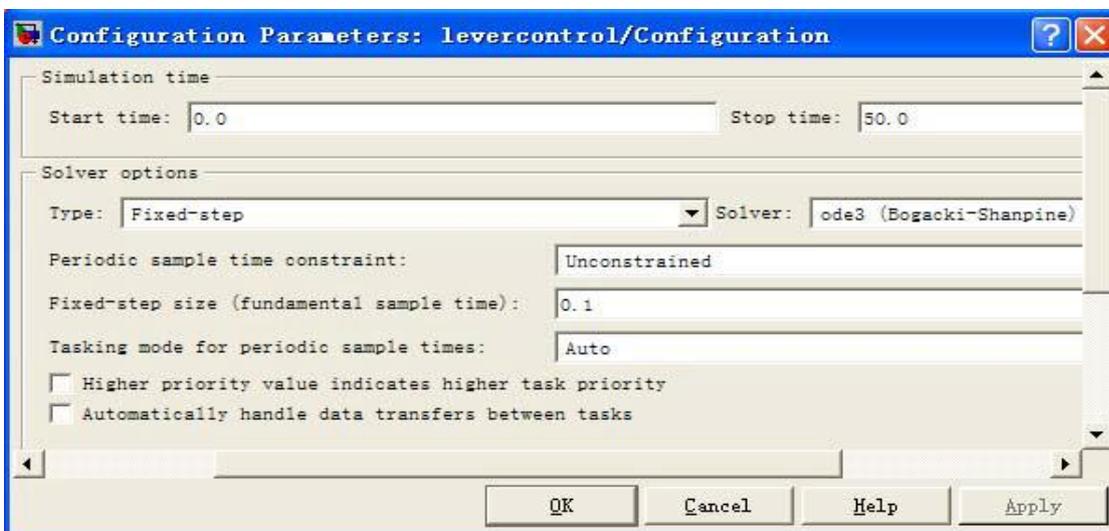


Fig.2 the Configuration Parameters Dialog Box of Lever control model

2.4 Save the model as Levercontrol.mdl. This Simulink model represents a lever control system with a PI controller. We can adjust the parameters (kp, Ti) of PI controller to achieve the desired performance. We now

can create a user interface in LabVIEW for the Simulink model. The model must remain fully-operational within the Simulink environment.

III. CREATING A LABVIEW USER INTERFACE

To interact with the Levercontrol model using a LabVIEW user interface, we need to create the user interface in LabVIEW. We need controls for manipulating parameters in the Levercontrol model and indicators to display the step response of the tank. We can complete the following steps to create the controls and indicators that reflect the parameters and sinks of the Levercontrol model.

- 3.1 Launch LabVIEW on the host computer and open a new VI. Select a tank control and place it on the front panel of the VI. Change the lever scale to 0 to 5.
- 3.2 Select one slider control and place it on the front panel. Label the slider control setpoint.
- 3.3 Select the waveform chart and place it on the front panel of the VI. Label the waveform chart lever of tank. This waveform chart displays lever of tank.
- 3.4 Select two sliders control and place them on the front panel. Label the sliders PI controller-kp and PI controller-Ti. Change the PI controller-kp and PI controller-Ti scales to 0 to 10.
- 3.5 Save the VI as Levercontrol.vi. The front panel of the VI looks like Fig.3.

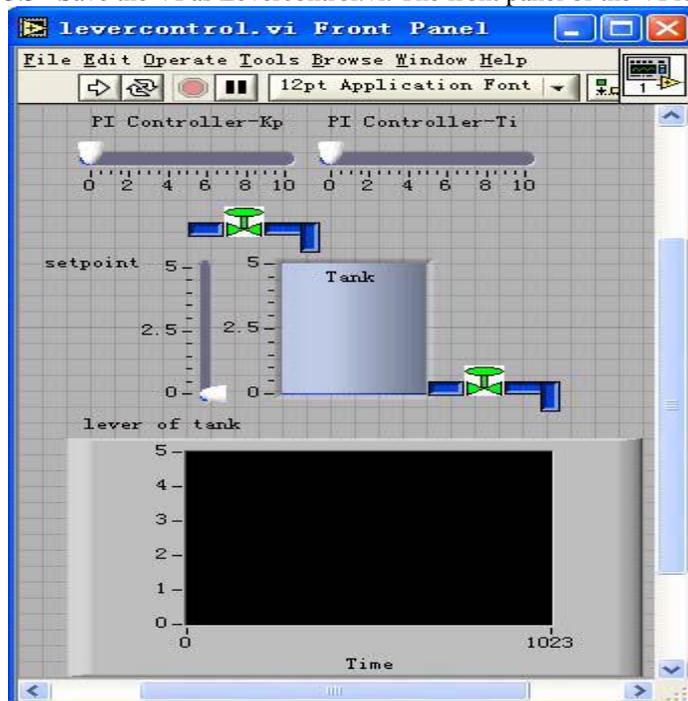


Fig.3 The front panel of Levercontrol.vi

IV. CREATING CONNECTIONS BETWEEN THE LABVIEW USER INTERFACE AND THE SIMULINK MODEL

After The Simulation Interface Toolkit enables LabVIEW to run and communicate with the Simulink model once we make the appropriate connections. MATLAB and Simulink must remain open to configure and run the simulation model.

On the front panel menu bar, select Tools»SIT Connection Manager to launch the SIT Connection Manager Dialog box. Now the Controls and indicators list box displays the controls and indicators we created on the front panel of the Levercontrol VI.

Click the Load Model button to display the Select Host dialog box. In the Select Host dialog box, make sure the Machine Name/IP is localhost. Click the OK button. By selecting localhost, LabVIEW connects to the SIT Server that MATLAB initially started. If we choose to start MATLAB on a separate computer with SIT 2.0 installed, we can connect to that computer by typing in the correct IP address.

In the Select Model dialog box, navigate to the folder where we saved the Levercontrol.mdl. Select the Levercontrol.mdl file and click the OK button. All the parameters and sinks associated with the Levercontrol

Model appear in the Model parameters and sinks listbox in the SIT Connection Manager dialog box. Now the parameters and controls have a  icon in front of them while sinks and indicators have a  icon in front of them. To create a connection between the Tank in LabVIEW and the NISink in the Simulink model, select Tank in the Controls and indicators listbox and select NISink» NISink in the Model parameters and sinks listbox. Click the Add to Connections button to add the connection to the Current connections table.

Similarly, create the setpoint, PI controller-kp and PI controller-Ti connections between the LabVIEW controls and indicators and the Simulink parameters and sinks. The SIT Connection Manager dialog box should look like the Fig.4. Click the OK button. The Simulation Interface Toolkit generates the block diagram code that governs the interaction between the LabVIEW front panel and the Levercontrol.mdl. The VI should look like Fig. 6 and block diagram code of Levercontrol.vi should look like Fig.5. The block diagram code consists of three main sections—the code to initialize the simulation, the code to set parameter values, and the code to receive indicator updates from the simulation model.

Notice that do not create the connections between the LabVIEW waveform chart (lever of tank) and the Simulink sink. Otherwise there will be a wrong effect of real-time digital simulation. So we must edit the block diagram code that the Simulation Interface Toolkit generates in Fig.5.

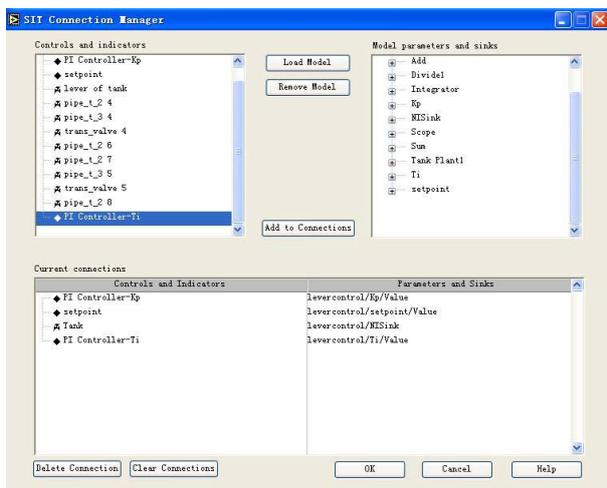


Fig.4 SIT Connection Manager Dialog Box

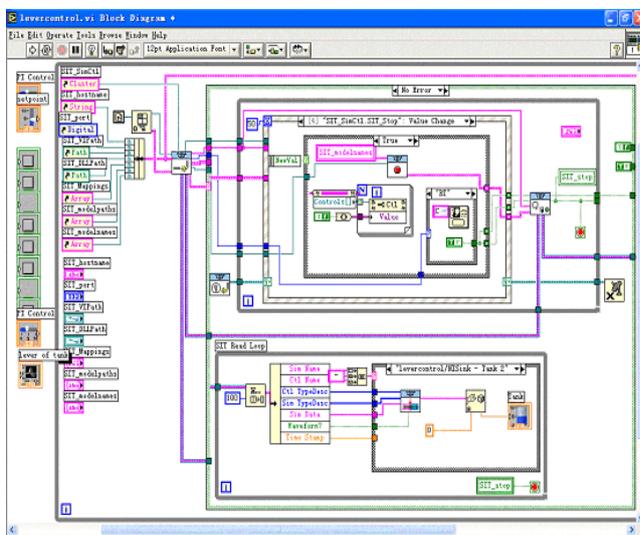


Fig.5 Block diagram code of Levercontrol.vi

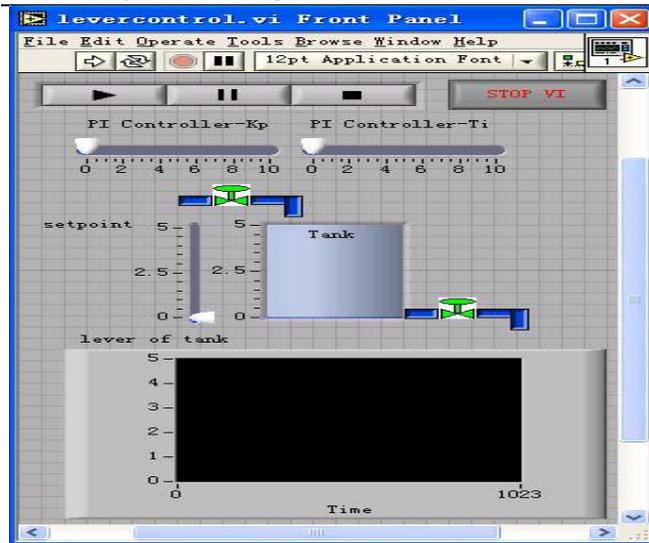


Fig.6 Front panel of Levercontrol.vi

Find the SIT Read Loop in the block diagram. Move the icon of lever of tank in the Case structure area. Wire it to the input line of the icon tank. So we can see the lever on tank and the waveform chart at the same time. The block diagram should appear similar to Fig.7. Save this VI.

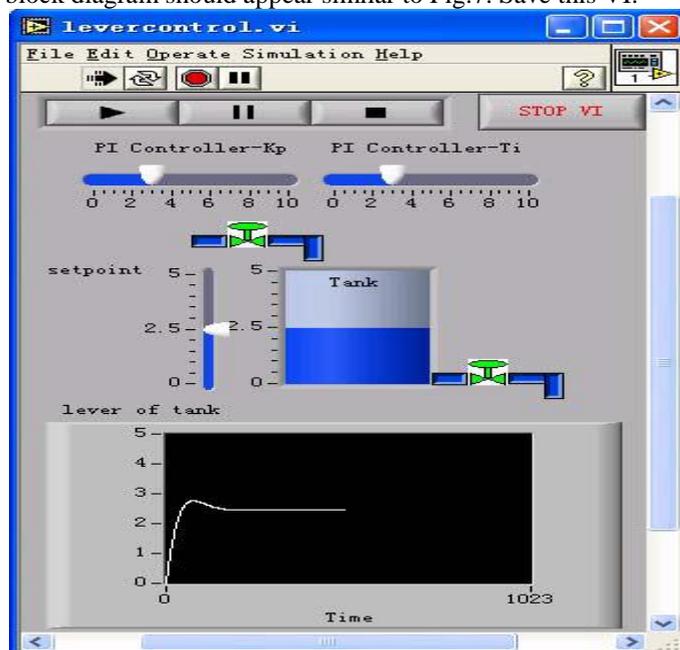


Fig.7 Front panel of lever control system simulation

Click the Run button  to run the VI. The Select Host dialog box appears. Verify that the host computer is localhost. Click the OK button. Although the VI starts do run, the Simulink model is not running yet. To run the Simulink model, Levercontrol.mdl, click the Run button , on the front panel. Adjust the values of setpoint, PI controller-kp and PI controller-Ti while the Simulink model is running until we get a good performance [6]. We can see the effect of step response of the tank. The front panel of the VI looks like Fig. 7.

V. CREATING A REAL-TIME DIGITAL SIMULATION

The simulation process described above does not require The MathWorks Real-Time Workshop. This uses Simulink to run the simulation. But the simulationprocess described above is not real-time simulation. In teaching or training of control system, real-time simulation can get better effect. One method to realized real-time simulation is described in[1,3]. This method use The MathWorks Real-Time Workshop with the

Simulation Interface Toolkit to generate a model DLL. Once generate the model DLL, and then we can run the model as a stand alone application in LabVIEW. Creating the model DLL enables us to run the model on an RT target for real-time, deterministic simulations. For example, we can use the model of a controller for prototyping or the model of the system for hardware-in-the-loop (HIL) testing. Both prototyping and HIL require I/O to read and generate signals. By combining the Model Interface VIs with DAQ I/O, we can implement real-time control systems or hardware-in-the-loop simulations. By using the DAQ functions in LabVIEW Real-Time Module applications, the VIs executes simulation models in real time with real I/O. For hardware-in-the-loop (HIL) and prototyping applications, we can run the model DLL in LabVIEW Real-Time to provide real-time inputs and outputs and to ensure determinism.

The second method is presented in this paper to implement real-time digital simulation with no hardware-in-the-loop. We only need the MathWorks MATLAB, Simulink and National Instruments LabVIEW installed on the host computer. So the cost is low.

Find the SIT Read Loop in the block diagram. The SIT Read Loop read data from Simulink and sends the data to the front panel of Levercontrol.vi. Place a Wait Until Next ms Multiple VI on the block diagram in the Case structure area. The Wait Until Next ms Multiple VI provides the timing for the loop. The loop time can be any number of whole milliseconds. This method is limited to a maximum of 1000 Hz (minimum of 1 ms wait). Millisecond multiple is the input that specifies how many milliseconds lapse when the VI runs. Right-click the millisecond multiple to create a constant, type 100 in the millisecond multiple text box which is equal to the Fixed-step size (fundamental sample time) set in Simulink. So the sample period of lever control system real-time digital simulation is 100 ms. The part block diagram should look like the Fig.8. Save this VI again with name Levercontrol.vi. Click the Run button to run the VI and click the Run button on the front panel to run the Simulink model Levercontrol.mdl. The real-time effect shows in the front panel. The lever of tank varies once per 100 ms.

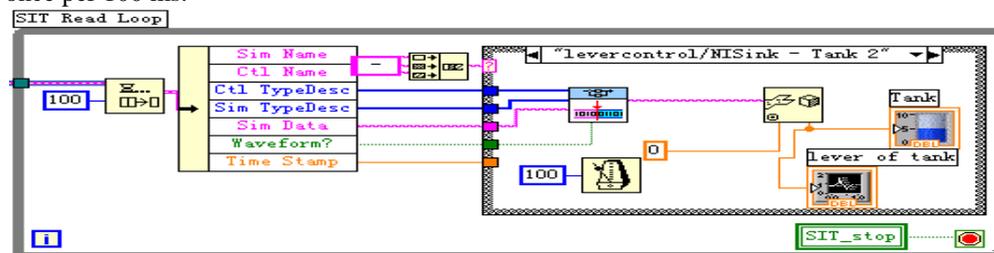


Fig.8 Part block diagram code of Levercontrol.vi

VI. CONCLUSION

Simulation Interface Toolkit provides a link between Simulink and Lab VIEW. The Simulation Interface Toolkit enables control design engineers to run Simulink models while using the power of a Lab VIEW user interface to display results and modify parameters as the model runs. The method presented in this paper can implement real-time digital simulation with no hardware-in-the-loop. The cost is low because we only need MATLAB, Simulink, Lab VIEW and Lab VIEW SIT installed on computer. Adjust the values of the setpoint slider or PI controller parameter sliders while the Simulink model is running. We can see the real-time response effect of the tank's lever. The VI described in this paper is just a simple example serving as a starting point. We can expand the VI to any other industry process control system. So the real-time digital simulation method presented in this paper is a good choice for engineers and teachers of control systems teaching or training.

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