

LABVIEW Real Time Control for Pneumatic Transfer System in TRIGA Research Reactor

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Abstract: K5088 board USB interface has been programmed using LABVIEW software to real time control the sample exchanger in Pneumatic transfer System PTS, for TRIGA nuclear research reactor with very short time response to facilitate the exchange of samples in pneumatic system optimizing the delay time. This is a replacement of the well-known PLC (programmable Logic Controller), to be compatible with the recent development of personal computers, USB hardware and, recent windows software. Development of control system with the reliability and robustness is a basic requirement of nuclear instrumentation and control in nuclear systems.

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Introduction

A Pneumatic device can be automated readily and the process may be implemented in stages, the sample exchanger is essential part in the pneumatic transfer system for the short time neutron activation analysis technique STNAA to irradiate samples in nuclear research reactors. Automatic control of the solenoid valves and time intervals can be based on the use of microprocessors, Programmable logic controllers PLC developed for process control applications to replace logic circuitry [1], A development of real time control is a challenge to replace the PLC system.[2]. The very short-lived nuclides (half lives<1 min) such as ^{110}Ag , $^{80\text{m}}\text{Br}$, $^{38\text{m}}\text{Cl}$, $^{116\text{m}}\text{In}$, ^{20}F , $^{179\text{m}}\text{Hf}$, $^{24\text{m}}\text{Na}$, $^{46\text{m}}\text{Sc}$, $^{77\text{m}}\text{Se}$ and $^{207\text{m}}\text{Pb}$ can be handled only by fully automatic pneumatic transfer system PTS, with moveable counting system to dynamically irradiate short-lived samples and count them in moveable counting chamber with a digital spectrometer.[3] The pneumatic system was constructed and installed in the TRIGA mark-II reactor of the technical university of Vienna.[4,5] The system is to irradiate small samples and it has been filled within a moveable thermal neutron absorber (Cd) to measure the irradiated samples by one of two detectors or with both of them. The transfer time to the first detector is 0.35 s while 2 seconds are needed to reach the second detector (HPGe, well type detector). The first detector is equipped with moveable counting chamber to change the sample detector distances between 3, 6, and, 12 cm within 2 seconds automatically. The two detectors are connected to digital spectrometer (DSPEC-plus) which allows a high throughput and zero dead time (ZDT) counting mode. An optimization process is to change the shaping parameters of the spectrometer according to the detectors specification or the counting rate. The

accuracy of the measurements depends on the optimization of the input count rate of each measured sample, regardless of sample size, matrices or irradiation and measuring technique. The sample exchanger of interest was constructed to facilitate the automatic analysis of about 30 samples in Atomic Institute, Vienna University of technology 2010. Programming Logic Control PLC; NAI5-FP0 control unit was implemented, and a group of interfaces and adapters, to facilitate the control of two valves islands (VM10, each 8 valves), the software used is a Delphi code, facilitating several functions through three interfaces.[3]

This work describes the replacement of this PLC control unit with other hardware and software. K8055 USB experiment interface board commercially from Velleman modules instead of PLC, and LABVIEW software has been used to program K8055 USB interface to have functioning of the control unit board instead of Delphi software. It is an advancement of automatic control which has been applied to the system with more reliable and robustness required for the Pneumatic transfer system.

Pneumatic system and sample exchanger

The pneumatic system components shown in Fig, comprise mainly from sample exchanger, sample magazine from polyamide tube with air compression tanks, pneumatic cylinder and, group of valves, regulators, optical sensors to monitor sample movement, assembled with appropriate complete detection system, and control unit with the software to manage the whole process[3]

K8055 USB experiment interface board

The K8055 interface board shown in Fig.2 is commercially designed by Velleman Corporation, for control. It has 5 digital input channels and 8 digital output channel, in addition, there are two analogue

inputs and two analogue outputs with 8 bit resolution. The number of inputs/outputs can be further expanded by connecting more (up to a maximum of four) cards to the PC's USB connectors. All

communication routines are contained in a Dynamic Link Library DLL, (K8055D.dll). [6]

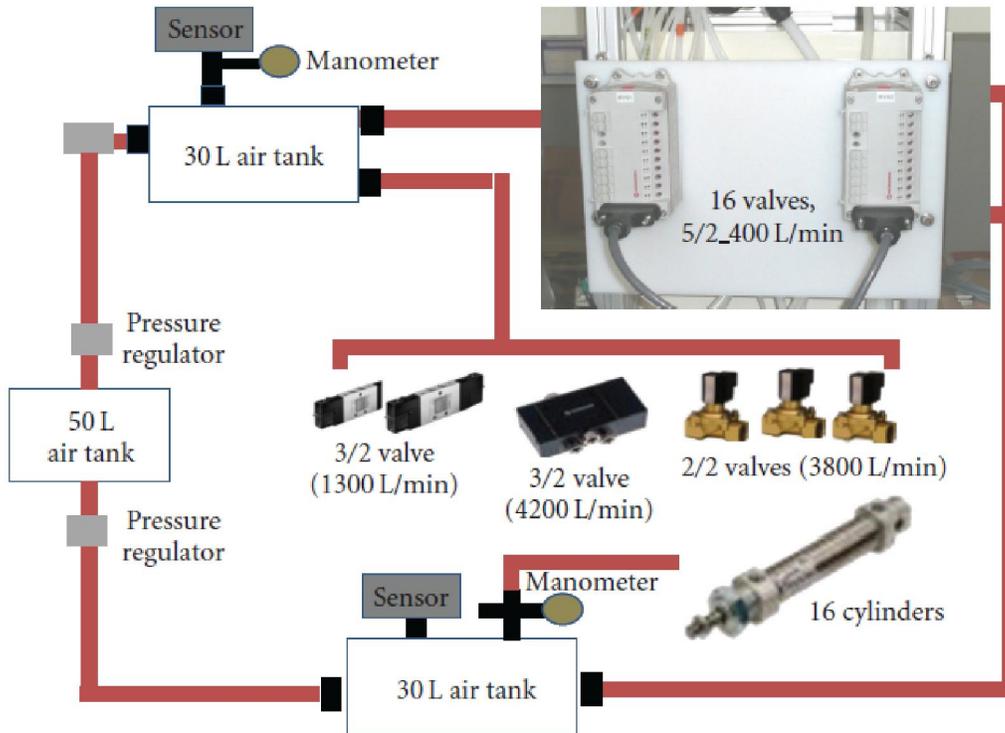


Fig. 1, Pneumatic system components

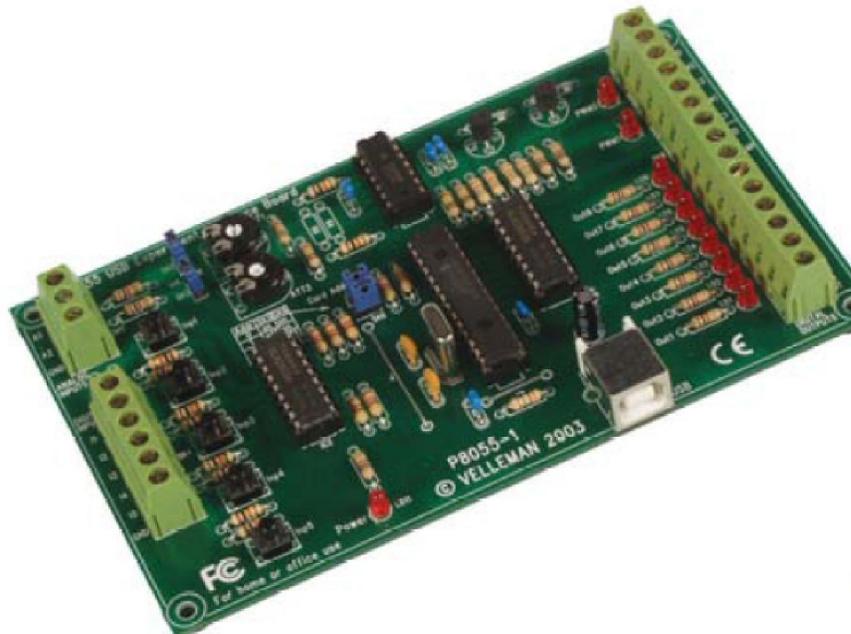


Fig. 2, K8055 USB board

LABVIEW

National Instrument NI developed LABVIEW software. The basic building block of a LABVIEW application is a VI (virtual instrument), which consists of a *front panel*, where you design a user interface, and a *block diagram*, where you create graphical code. The graphical code is highly intuitive for users familiar with block diagrams and flowcharts. The software includes math script, a textual math-oriented interface. It offers tools for signal processing, analysis, math and, generally compatible with the widely used m-file script syntax, the code help accessibility of thousands algorithms available on textbooks. LABVIEW VIs are modular in design, so you can run any VI by itself or include it as a module in your code. The code is compiled with execution speeds faster comparable to compiled C programs. This easily manages multiple targets, from real-time to embedded, through the project explorer. LABVIEW is an open environment with easy connectivity to your existing applications through .NET, ActiveX, DLLs, and a wide array of networking protocols. [8,9]

In this work, LABVIEW version 8.6 [9] is used to evaluate the problem assigned and compiled on both windows xp and, windows 7 environment, using the ArcPCI.dll file, of the velleman K8055 board.

Flowchart and logic control

The logic flowchart shown in Fig. 3, describes the logic control for samples movement in magazine M of sample exchanger, there are 3 magazines. For each magazine a delay time t_c to accomplish movement of all samples in that magazine before the introduction of samples from the next magazine. A check for the magazine signal $M=0$ means no samples, $M=1$ or, 2 or, 3 means handle the magazine no.1 or,2 or,3. Each magazine has 2 valves V_{ij} under control, the samples go to collector which has 2 valves V_{x1} , V_{x2} with the air pressure from pneumatic cylinder, and without air. So, for each magazine,

there are eight independent state values for signal control of the valves with delay time d_i . The state value used for control of valves, open ($T=true$) or close ($F=false$) signal. The input signal is coming from optical sensor before the assigned valve. The software controls the valves up to the logic in the flowchart, and the next Table 1, which describe the valves status for magazine no. 1 as an example.

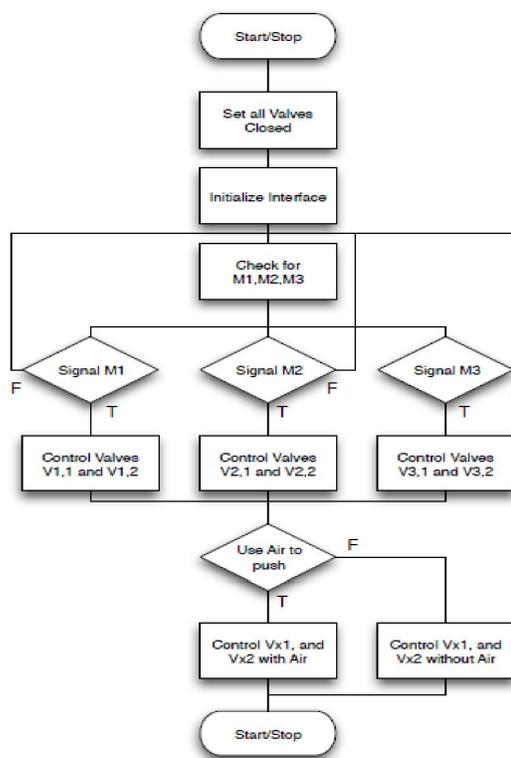


Fig. 3, Flow chart for the movement of samples in magazines of sample exchanger

Table 1, Control valves status for magazine no.1 in sample exchanger

Control valves $V_{i,1}$, $V_{i,2}$		Control valves V_{x1} , V_{x2} with Air		Control valves V_{x1} , V_{x2} without Air	
open $V_{i,1}$	delay d_1	open V_{x1}	delay d_5	open V_{x1}	delay d_5
open $V_{i,2}$	delay d_2	close V_{x1}	delay d_6	close V_{x1}	delay d_6
close $V_{i,2}$	delay d_3	open V_{x2}	delay d_7		
close $V_{i,1}$	delay d_4	close V_{x2}	delay d_8		

Results and Discussion

LABVIEW programming for the K8055 USB interface board is developed. The resulting example for control of different three magazines has been introduced, the control panel is shown in Fig 4 and the complete block diagram are shown in Fig 5,a-g

in sequence. The complete programming includes implementation of some basic virtual instrument sub VIs, linked but not shown here such as, open card, read card, write card, close card, enable outputs, and disable outputs and, read input cluster.

LABVIEW control panel shown in Fig. 4 indicates the control variable M for the specified magazine. M = 0 means no samples, when M=1 or 2 or 3, means handling of magazine no.1 or 2 or 3. There are eight state values for valves, each has a delay time d_i in seconds, as a control variable as assigned in Table 1. Each magazine has a total delay time t_c seconds. The Boolean icon V_{x2} used as true or false, the user can choose its value on or, off.

LABVIEW block diagrams shown in Fig. 5a,b,,g have been designed and tested, as an example to simulate and automatic control of samples movement in specified magazine, in the sample exchanger. It uses the main features of LABVIEW, such the stacked sequence structures, the case structures modules, and previously prepared sub modules, called sub VIs to open the K8055 card, close the card, read input cluster, write input cluster, and error handler modules, with the introduction of delay times as user assigned values.

The example has been tested repeatedly, and it has proven good agreement for the requirement of logic control, with good reliability, very fast response, real time control. This is to replace the PLC

controller in the sample exchanger of pneumatic system. An implementation for this controller is recommended in such many applications which could use sample exchanger, in automatic manner with a real time control of the process.

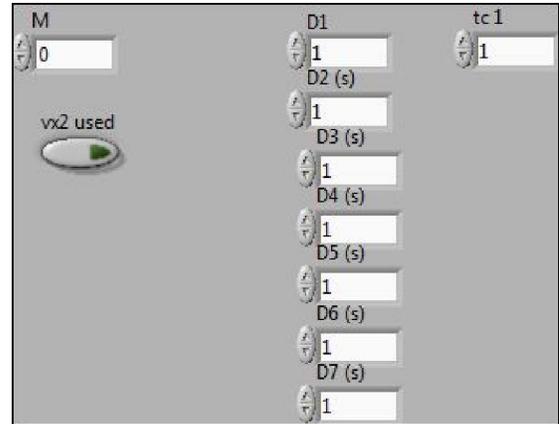


Fig. 4 LABVIEW control panel for sample exchanger

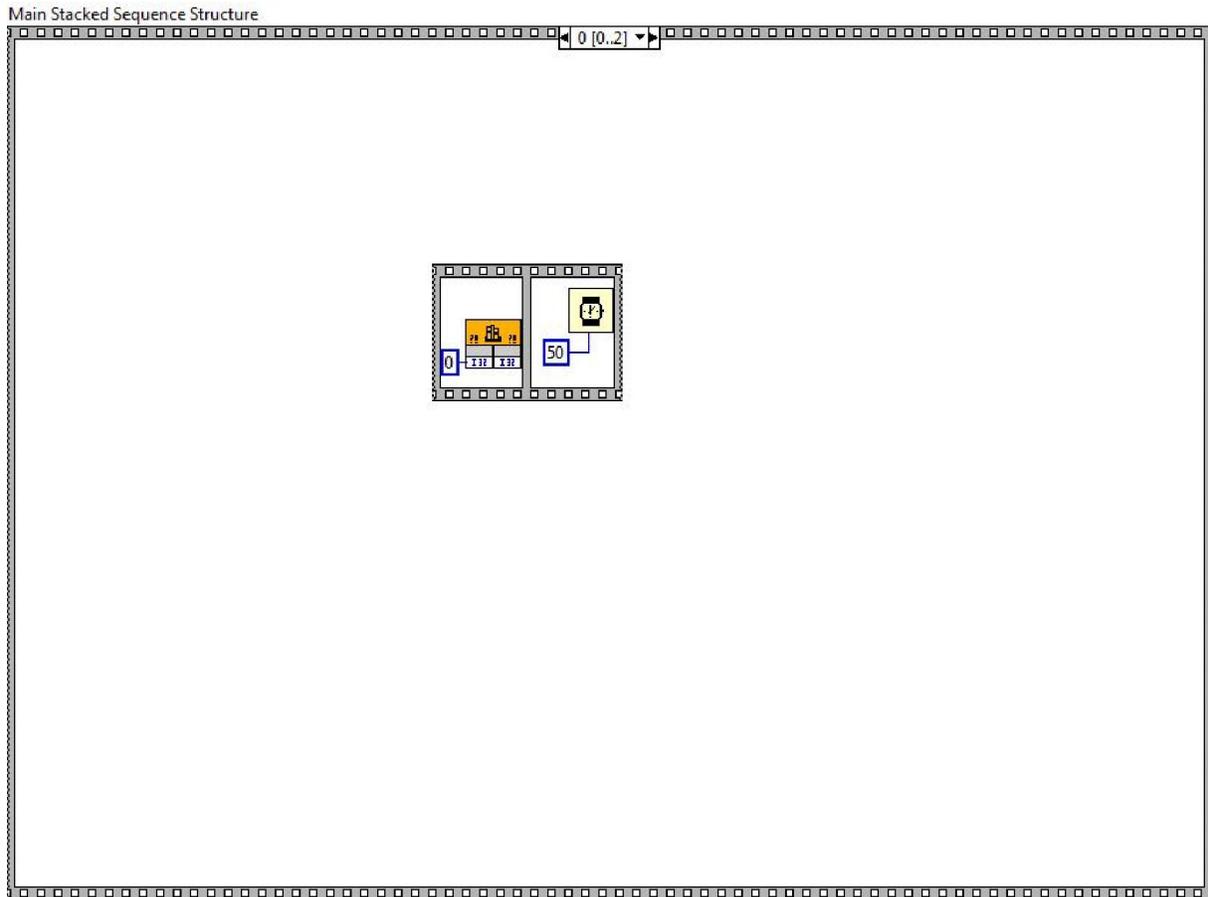


Fig. 5a, LABVIEW Block diagram, main stacked sequence structure, case=0

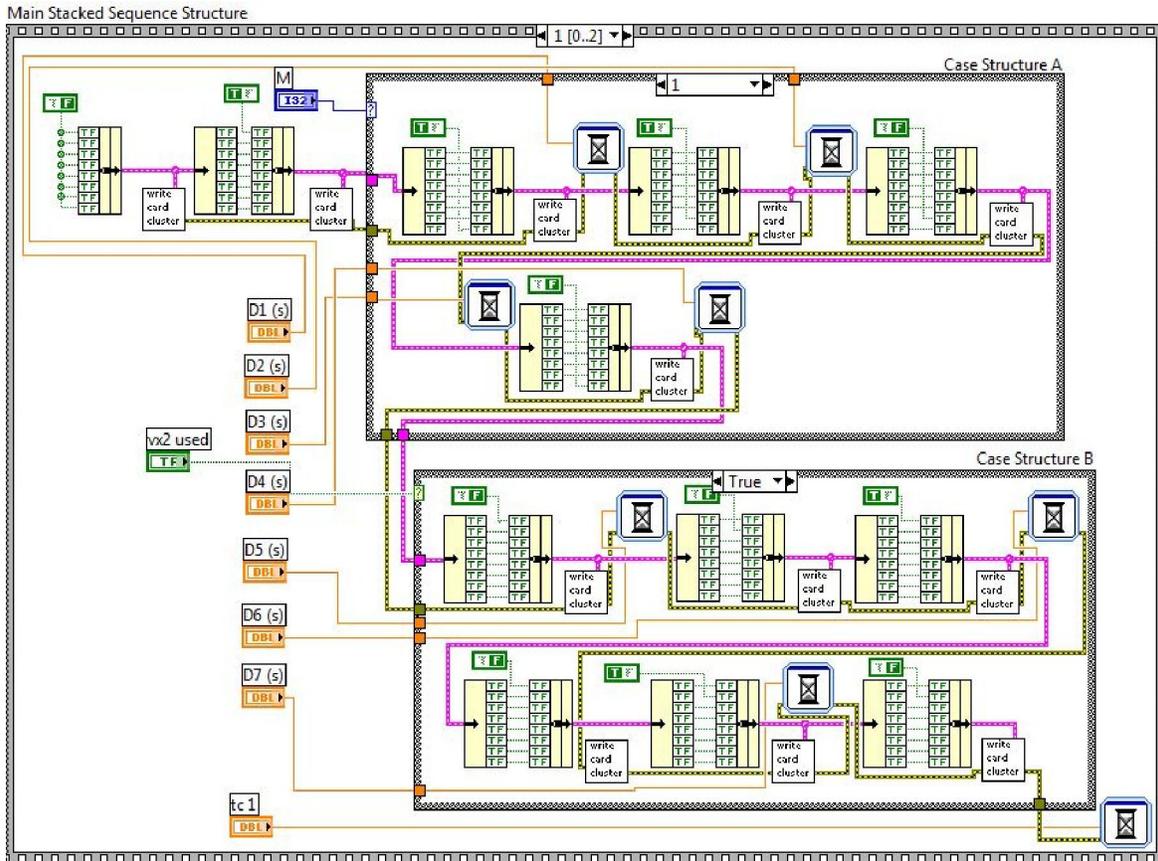


Fig. 5b, LABVIEW Block diagram, main stacked sequence structure, case=1

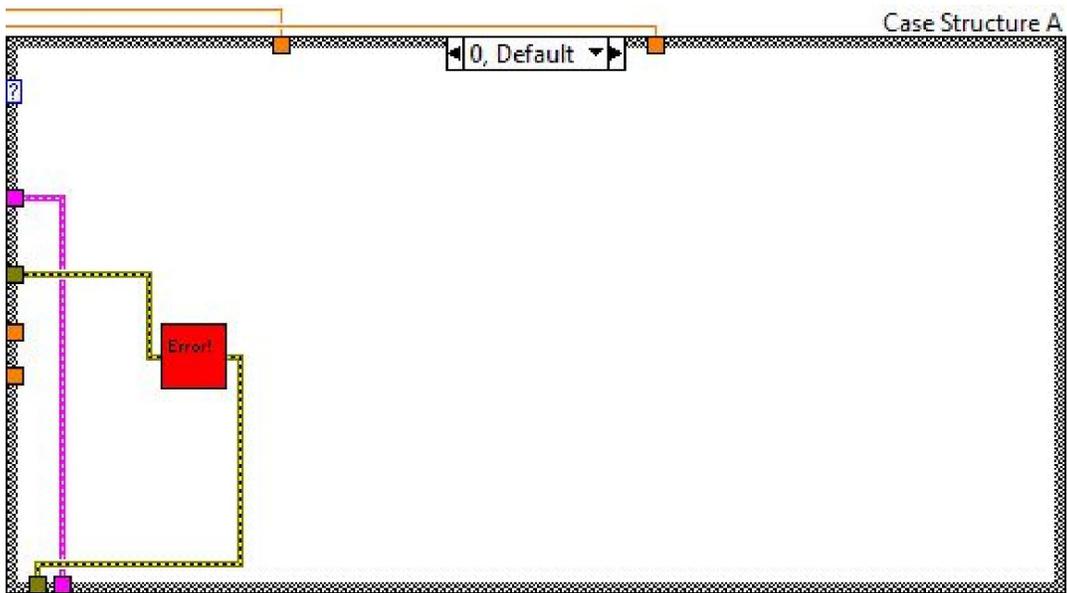


Fig. 5c, LABVIEW Block diagram, case structure A, case=0

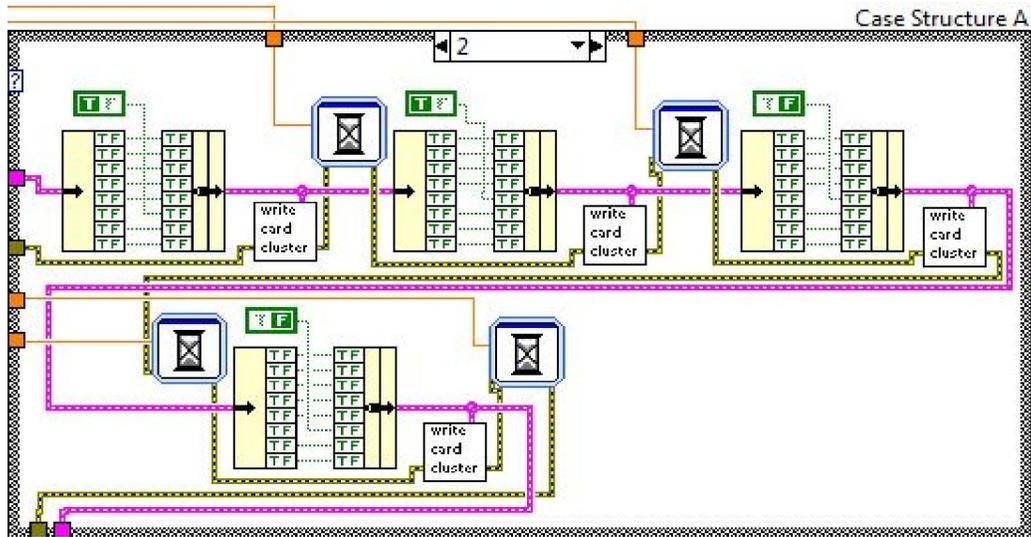


Fig. 5d, LABVIEW Block diagram, case structure A, case=2

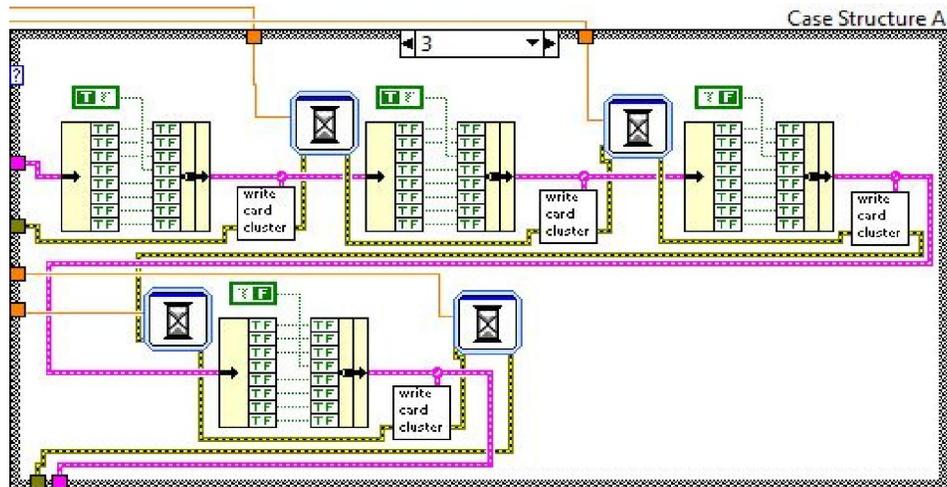


Fig. 5e, LABVIEW Block diagram, case structure A, case=3

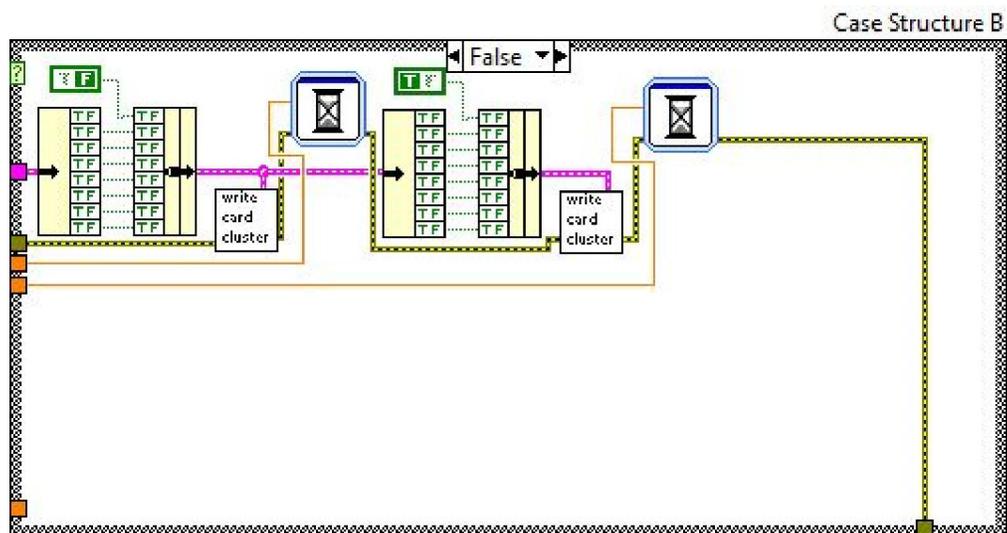


Fig. 5f, LABVIEW Block diagram, case structure B, case=false

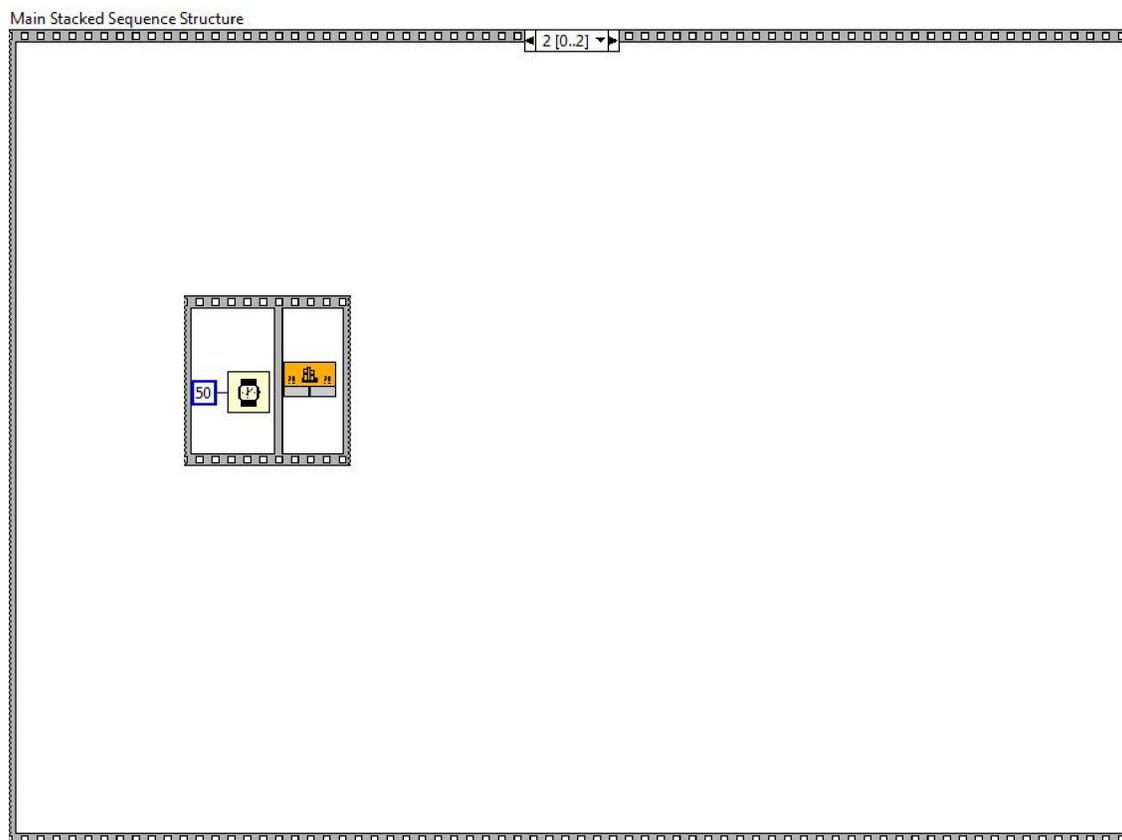


Fig. 5g, LABVIEW Block diagram, main stacked sequence structure, case=2

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