Lab Assignment # 7

Applications of Data Translation Multi I/O Boards Using Agilent VEE

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Objective

- Generation and measurement of DC voltages
- Measurement of diode characteristics
- Acquisition and processing of time dependent signals

Equipment

- Computer with data translation multi I/O board (either DT21EZ or DT01EZ)
- Agilent VEE and Data Translation DT VPI software
- Agilent 34401A Digital Multimeter
- Agilent 33120A Function Generator
- Agilent 54622A Deep Memory Oscilloscope or Agilent 54600B Oscilloscope

Laboratory Experiments

1. Exercises

1.1. Characteristic of semiconducting diodes
Develop a virtual instrument measuring and displaying diode characteristics and determining the differential resistance at a definite operating point using a multi I/O board DT01EZ or DT21EZ and Agilent VEE.

1.2. Acquisition of time-dependent signals
Develop a virtual instrument for acquisition and processing time-dependent signals using a multi I/O board DT01EZ or DT21EZ and Agilent VEE.

2. Instructions to the Laboratory exercises
Use a computer equipped with either a DT01EZ or a DT21EZ board. These two multi I/O boards differ only with respect to the sampling rate; for exercise 1.1. you can use the DT01EZ as well as the DT21EZ, for exercise 1.2. you should use the DT21EZ. Both boards contain 2 analog outputs, either 16 single-ended or 8 differential analog inputs and 16 digital inputs/outputs. The engineering environment Agilent VEE is extended by DT VPI; all objects which are necessary for the programming of the board functions are located in the additional menu *DT DataAcq* (see appendix 1: Data Acquisition using the Multi I/O Board DT01EZ or DT21EZ).

Note: Some board functions are only hardware-controlled, i.e. controlled with jumpers positions on the board. If it is necessary to change such functions, ask the teacher. Other board functions are software-controlled using the configuration objects.

A special cable connects the multi I/O board with the screw terminal board STP-EZ; Fig. 1 illustrates the screw terminal locations on this board.

Fig.1: Screw terminal locations on the STP-EZ

(For further information see the user manuals **DataAcq-EZ** and **DT VPI**.)

The aim of this laboratory exercises is to learn about

- the application of multi I/O boards in the measurement technology, and
- the application of Agilent VEE for data acquisition and processing.

You should develop of a virtual instrument, which executes a concrete measurement having a comfortable graphical user interface, which guides the user through the program.

After finishing your work demonstrate that your program runs correctly, print out some characteristic results and document your program together with a description.

Exercise 1.1.
In this exercise a virtual instrument is to be developed, which

- measures the forward characteristic $I_F = f(U_F)$ of a semiconducting diode,
- displays the characteristic on the screen,
- supervises the diode current and stops the actual measurement if the current exceeds a definite limit,
- determines the differential resistance in a selected operating point of the characteristic.

Start with a very simple program, which only generates and measures a DC voltage, and test the result using a digital voltmeter. Then program a loop changing the voltage step by step, measuring each output, and save all measured data in an array.

Keep in mind, that only voltages can be measured with the ADC inputs. For current measurements a current-voltage converter must be used. Use a resistor R_{meas}, measure the voltage across it using a second ADC input and calculate the current. Display the current versus voltage curve.

Build the actual measurement circuit using a diode and a resistor and connect it with the screw terminal of the I/O board. For correct connection and measurement take note of the hardware characteristics of the ADC (single-ended or differential input)!

Note: The maximum output current of the DAC is 10mA.

Program a limit supervision of the diode current, which stops the measurement, if the current exceeds the limit I_{Fmax}, and program a correct reset to zero of the output voltage at the end of the measurement.

Finally, program the determination of the differential resistance $r_F = dU_F / dI_F$ of the diode in a definite operating point given by a bias current $I_{F,B}$.

Program user inputs of the following parameters:
- number of objects, which should be measured,
- measurement resistor R_{meas},
- start voltage U_{start},
- stop voltage U_{stop},
- voltage step ΔU,
- current limit I_{Fmax},
- bias current $I_{F,B}$.

Exercise 1.2.
In this exercise a virtual instrument is to be developed, which
- measures one or two time-dependent signals,
- displays the signals on the screen,
- employs different methods of signal processing on the measured data.

Start with a very simple program , which only measures an AC voltage; display the measured voltage on the screen and test the result using an oscilloscope. Observe the different possibilities of the configuration of the I/O board and change the different settings.
Note: For a correct acquisition of a time-dependent signal the criterion of the sampling theorem must be fulfilled (see also exercise *Sampling Theorem / Lab Assignment #3*).

In the next step change the shape of signal (i.e. sinusoid, triangular, square-wave, signals with DC offset), determine characteristic values of the measured data (i.e. mean value, peak value, period) and calculate the spectral function using FFT (see also exercise *FOURIER Transform / Lab Assignment #4*).

Program user inputs of the following parameters:
- sampling rate f_s,
- duration of measurement t_m,
- trigger mode.

Finally, use a first-order high-pass or low-pass and measure the response function of a square-wave input signal. Use two input channels to measure simultaneously the input and output signal of the circuit. Observe the possibility of an external trigger to start the data acquisition using the signal of the

SYNC output[1] of the function generator. Use the response function to determine the characteristic values time constant and cut-off frequency of the circuit.

Appendix 1:
Data Acquisition using the Multi I/O Boards DTEZ01 or DTEZ21

This quick reference describes only the simplest possibilities of generation and measurement of DC voltages using the two A/D converters and the 8 D/A converters (in differential mode).
For correct connection see the clamp scheme in the description of the laboratory experiments.

Before using the outputs and inputs, the I/O board must be configured. There are two possibilities for configuration:
- hardware configuration using jumpers directly on the I/0 board and
- software configuration using a special driver software.

The software configuration will be done by two special objects from the DataAcq menu: *D/A Config* and *A/D Config* (see Fig.1).
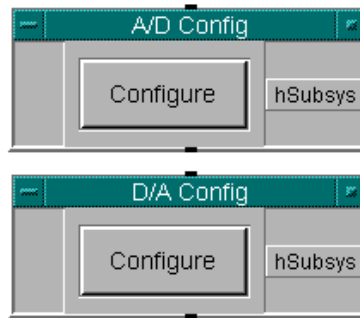
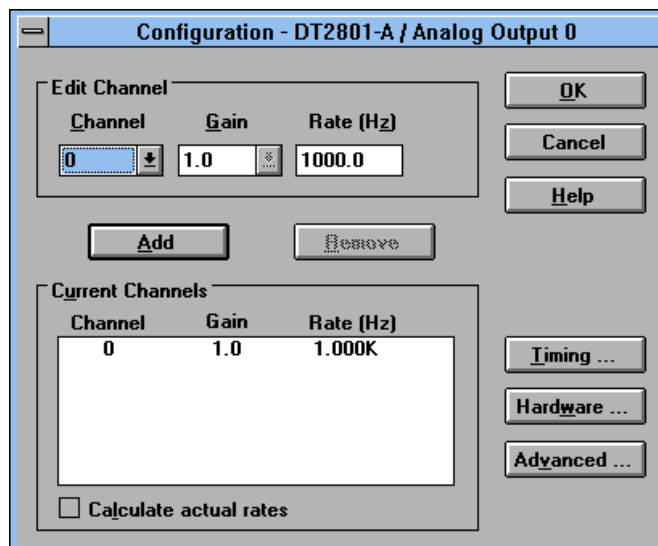**Fig.1: Objects for the configuration of the ADC and DAC**

Fig.2: Edit window for the basic D/A configuration

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[1] The generator must be used in the burst mode. To generate a correct trigger pulse a special pulse former must be used (see Appendix 2).

At first open the object *D/A Config*. With the switch the edit window of the configuration object will be opened (see Fig.2). In this window the number of active channels (using the switches *Add* or *Remove*) and the sampling rate can be chosen.
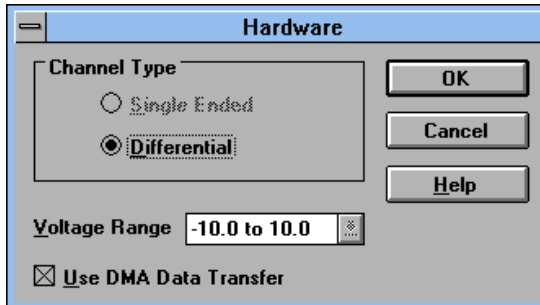

Fig.3: Hardware configuration window

With the switch *Hardware...* a further window will be opened giving information about the hardware configuration done by jumpers only (see Fig.3). In this window it is shown that, the I/O board is configured in the differential mode without direct connection to ground for all inputs and outputs.

Further possibilities for configuring the output are given in the window for advanced configuration opened with the switch *Advanced...* (see Fig.4).
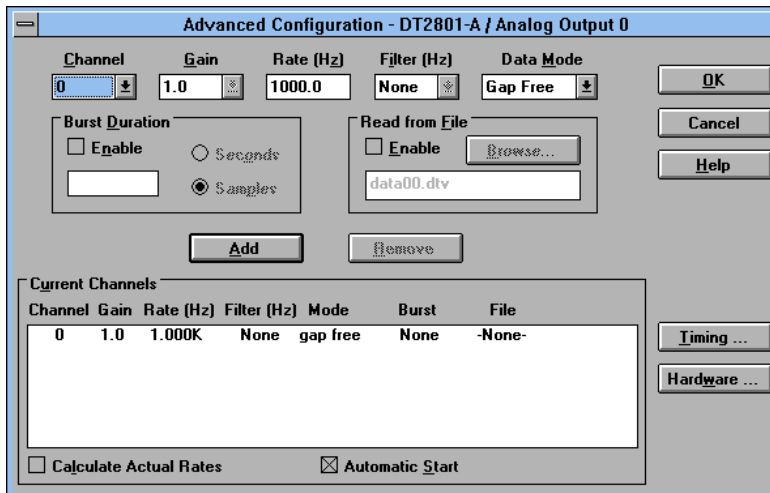

Fig.4: Window for advanced D/A configuration

Besides the basic properties of the I/O board this window gives the possibility to read the digital dates from a file and to generate a burst voltage of a definite duration or number of samples.

The object *A/D Config* gives nearly the same possibilities of software configuration with three quite similar windows.

Note: The objects *D/A Config* and *A/D Config* must operate before using some I/O operations, i.e. directly after the start of the program. This is especially important, if the program is running after a reset or a restart of the computer.
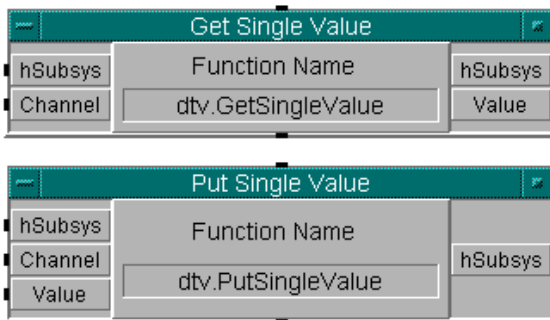

Fig.5: Objects for generation and measurement of a DC voltage

A DC voltage can be generated and measured after the correct configuration using the objects (functions) *Put Single Value* and *Get Single Value* (see Fig.5). The configuration will be done by a control word transmitted between the terminals *hSubsys*. One of the configured channels can be selected with the channel number at the input terminal *Channel* using an integer number. The terminal *Value* needs either an integer or a real number, which should be transformed in a voltage, or gives the measured voltage as a real number.

Note: If the measured voltage depends on the voltage generated by the I/O board, then it is necessary to trigger the object *Get Single Value* by the *ready* output of the object *Put Single Value*. In this case the measurement takes place, only if the DC voltage generation is ready.

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Appendix 2:

Instructions for using external trigger mode

For the external triggered signal acquisition the function generator 33120A must be used in the single triggered burst mode. Using this mode it is possible to generate a single positive square wave pulse with a well-defined duration and amplitude (see the user manual of the generator). You can select this mode and set all parameters using the front panel of the generator, but it is better to develop a short Agilent VEE program for remote control of the generator.

Before you start the signal acquisition using the I/O board, display the signals with the oscilloscope, and observe the possibilities for setting signal parameters.

Note: A data acquisition error happens if the external trigger mode of the I/O board is selected, and the duration time of measurement t_m is greater then the time difference between two trigger pulses.

The *SYNC* output of the 33120A generator delivers a TTL signal with a HL slope at the positive zero cross-over of the signal. Using the simple circuit shown in Fig. 1 a short L-level pulse will be generated from this HL slope, which is necessary to trigger the I/O board. Using CMOS technology this circuit works without an external power supply; the supplied voltage V_{CC} will be generated from the H potential of the *SYNC* output signal using a rectifier diode D and a charge capacity C_C.

Note: Using the square wave single burst mode the negative slope of the pulse is delayed approximately $12\mu s$ with respect to HL slope of the SYNC output signal. This is advantageous for external triggered measurements.
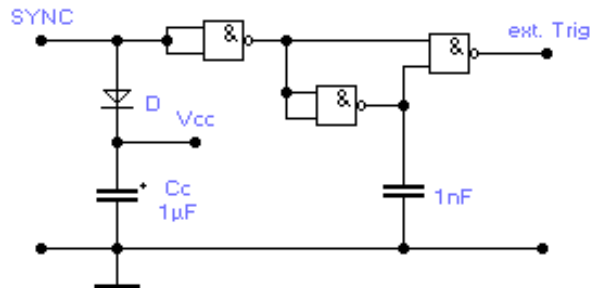
Fig. 1: Trigger pulse former circuit