PC Based Automation of Keithley 610 Electrometer
for Current-Voltage Measurements Using Lab-PC+

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Category:
Semiconductor

Products Used:
Lab-PC+
NI-DAQ™

The Challenge:
Conversation of reliable analogue systems to PC based measurement system. Speed up current-voltage measurement rate and increase research activity with minimum investment.

The Solution:
To develop a signal conditioner unit and a decoder unit for the functions of analogue instrument. Use of Lab-PC+ with NI-DAQ for data acquisition. Development of a software for measurement, analysis and storage using Q-Basic 4.5

Abstract
PC based instrumentation getting much attention with the advantage of speed up of measurements. Analogue systems, generally in use regarding to their reliability. Unfortunately the use of these systems, as a rule slow down researchers' productivity. This study presents adaptation of Keithley 610C electrometer to today's technology using a Lab-PC+. Range of 610C is 3 00 mA–10 fA and very useful for the characterisation of metal/semiconductor junctions. For that purpose some of the functions of 610C passed to home made decoder and signal conditioner unit. The co-ordination between Lab-PC+ and decoder, and buffers are organised with a software with NI-DAQ functions.

Introduction
One of the routine technique in solid state research is the Current/Voltage (I/V) measurement of metal-semiconductor junctions. That measurement provides information about current transport mechanism in junctions. I/V measurements using an analogue system, in general a time consuming process which slow down the information flow and analysis. Because of that, automation of I/V measurements are the essential need for researchers. Commercially available systems with digital interface exist although the analogue systems with their reliability, such as Keithley 610C Electrometer, may be available in research laboratories and its adaptation to today's technology may be more economical. The aim of that study is the automation of an 610C electrometer using a Lab-PC+ multifunction input-output (I/O) card via an optically isolated decoder, a relay group and a signal conditioner circuit.

Lab-PC+ and Interfacing with Keithley 610C

The control of the multiplier, range, fine zero adjustment, normal/fast mode selection and zero check in 610C Electrometer passed to a relay group controlled by a decoder unit as shown in Figure 1. Open circuit diagram of Figure 1 is given in Figure 2. The decoder unit inputs are all optically isolated from PA0-PA7 digital outputs of -PC+ for unexpected triggering and to breakdown the ground loops.

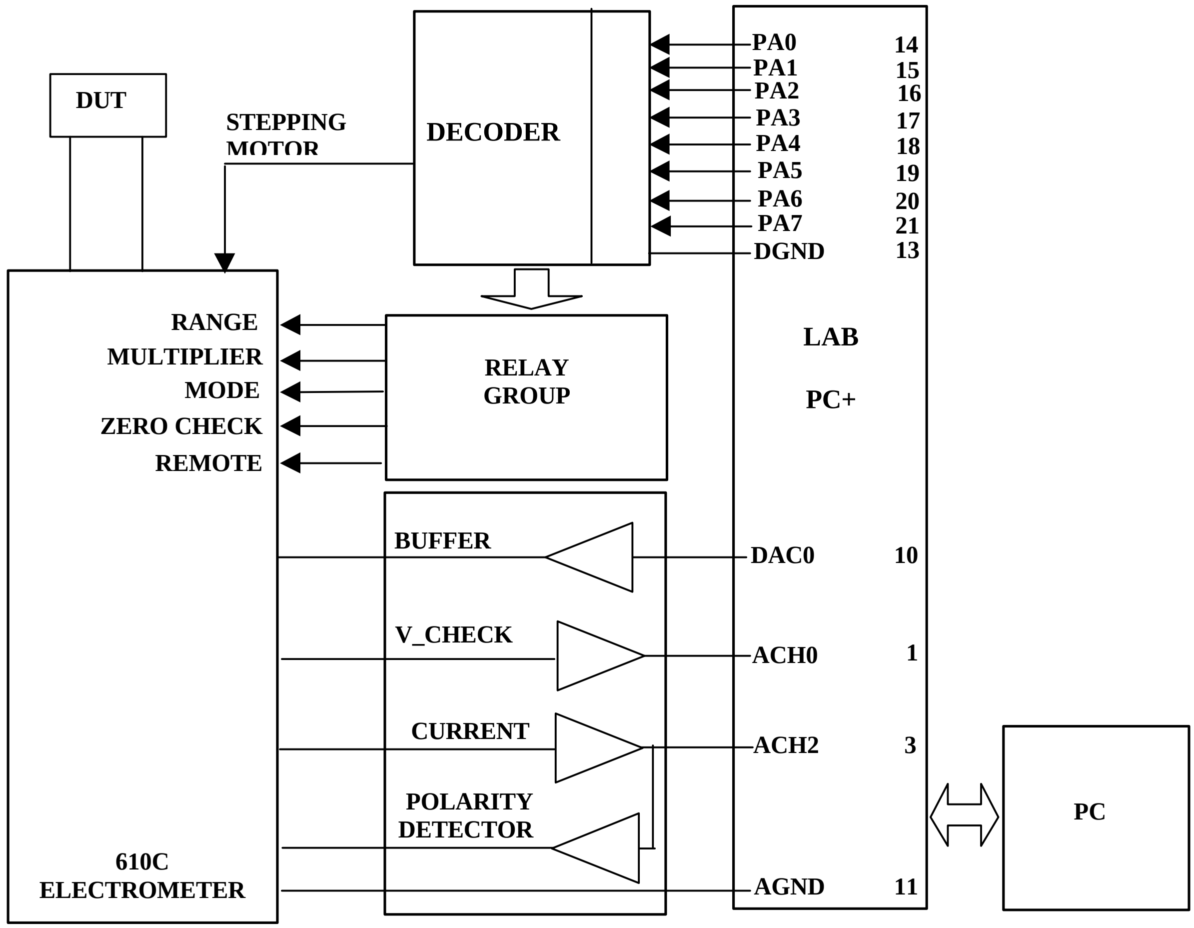
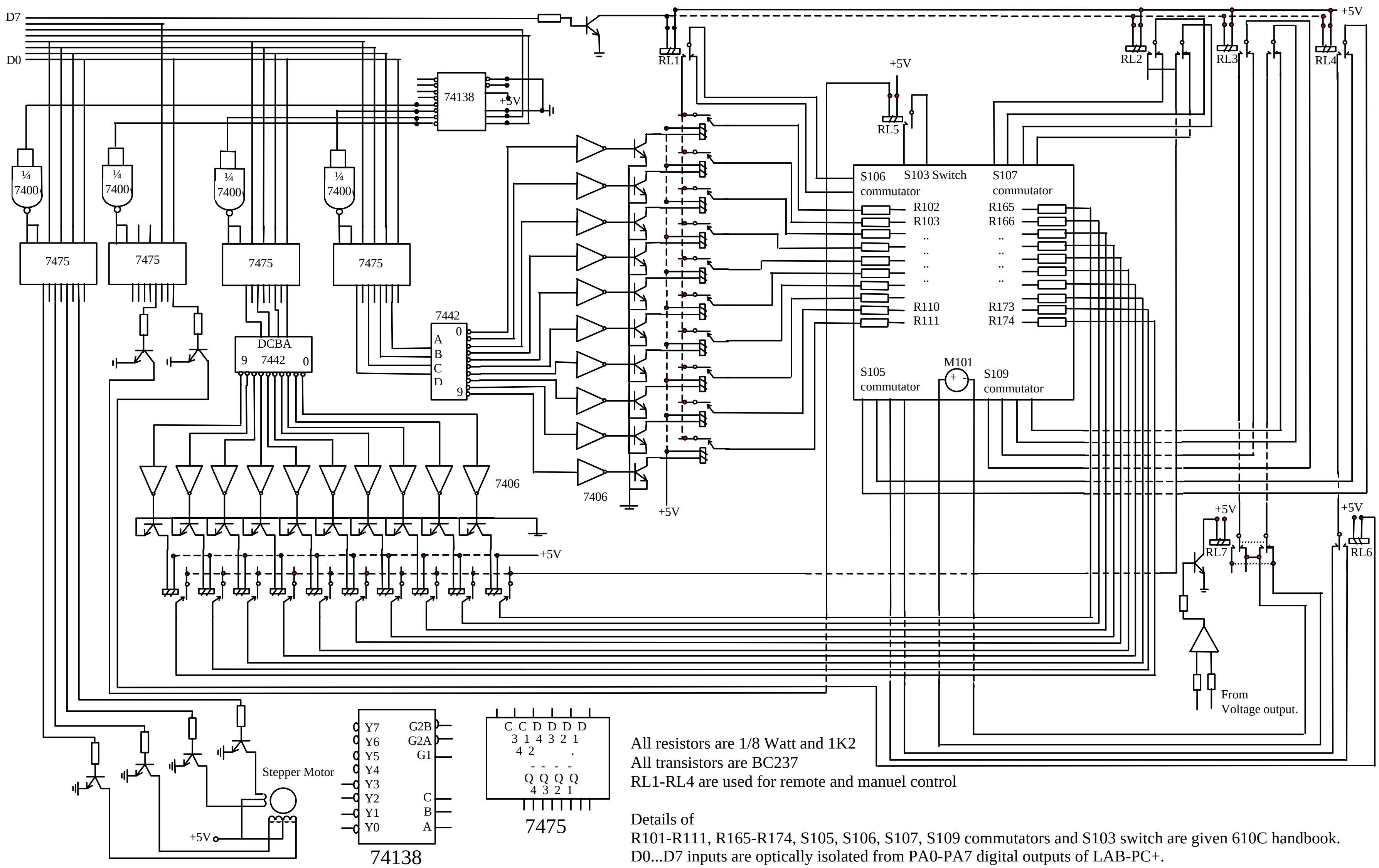


Figure 1. Block Diagram of Units Developed for Automation of 610C Electrometer Using Lab-PC+, I/O Card.



All resistors are 1/8 Watt and 1K2
All transistors are BC237
RL1-RL4 are used for remote and manuel control

Details of
R101-R111, R165-R174, S105, S106, S107, S109 commutators and S103 switch are given 610C handbook.
D0...D7 inputs are optically isolated from PA0-PA7 digital outputs of LAB-PC+.

Figure 2. Open Circuit Drawing of Decoder and Relays with Connection to 610CElectrometer.

To minimise the cables length used connection to 610C as given in Figure 2, decoder, relay groups and signal conditioner boards were located inside of 610C.

Control Word

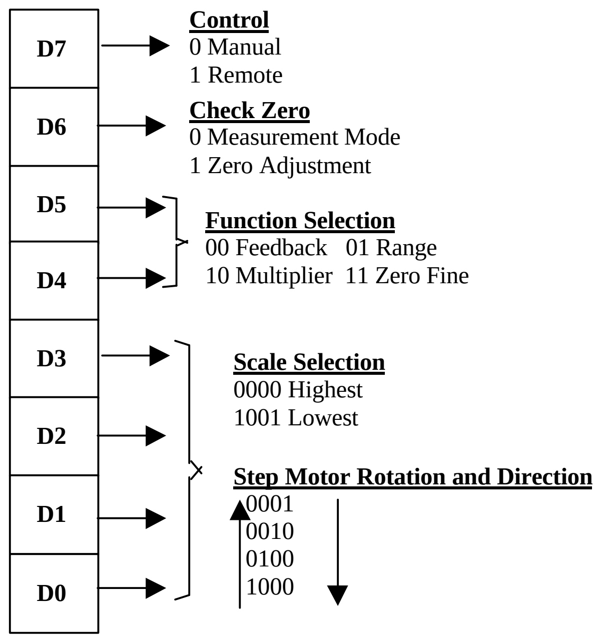


Figure 3. Control Word Structure for Communication.

PA0-PA7 digital input/output of Lab-PC+ are organised as output and used as a control word. The structure of that control word is given in Figure 3. PA0....PA7 digital input/output are named as D0...D7 after the optical isolation. The last bit, D7 was used as a remote control bit. After setting that bit to zero, 610C electrometer can be used manually using front panel. When D7 set to one the control of functions mentioned above passes to D0...D6 bits. D4-D5 bits were used for four function selection. A TTL74138 decoder from 3 to 8 used as address selection for desired function. After the setting of D4 and D5 bits as given in control word, Y0, Y1, Y2, Y3 output of 74138 selects; fast/normal mode operation, multiplier, range and stepper motor for zero fine adjustment, respectively. Prior to action of functions the related address code sent over 74138 and the bits of functions are memorised by the related 74LS75. With 00 address bit D0 and D6 are used for zero check and fast/normal mode operation selection. In same manner D0...D3 bits were used ten scale multiplier and range selection and to drive stepper motor coupled to zero fine ten turn potentiometer. The last selection always is memorised by the last used 74LS75 after switching to different address.

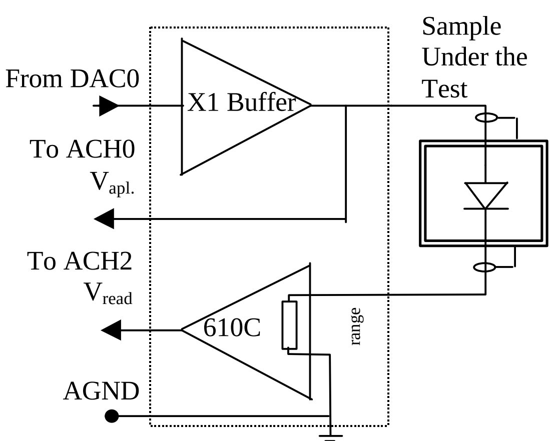


Figure 4. Voltage Application to Sample and Sampling Back Sample Voltage Corresponds to Current.

Current/Voltage Measurements

The voltage corresponding to current and sample voltage were read back by -PC+ at –5..+5V range with 12 bit resolution and software selectable gain. Voltage to the sample under the test was applied via a buffer unit as shown in Figure 4. The open circuit diagram of buffer units in Figure 1 and 4 are not given because of their simplicity. Applied voltage from DAC0 output of I/O card was read back from the closest point to minimise the errors.

Current flow through sample calculated from

$$I_{samp.} = V_{read} x R_{multiplier} /(R_{range} x 3)$$

equation, where 3 is the full scale output voltage of 610C. By taking into account the electrometer input impedance the real voltage across the sample calculated from equation given below.

$$V_{samp} = V_{apl.} - I_{samp.} x R_{range}$$

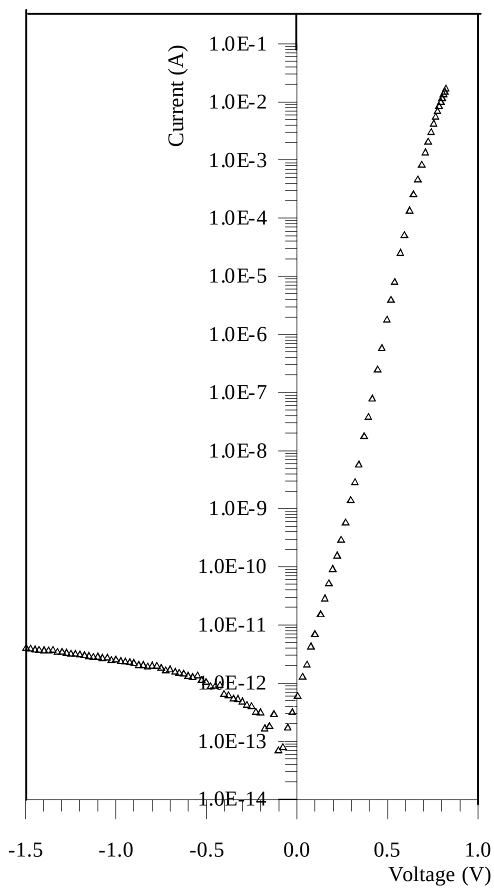


Figure 5. Base-Emitter Characteristic of BC108 Transistor as a Test Measuremenr. Voltage Increase os 25 mV and Measured Current spans from 20mA to About 100fA.

The software for I/V measurements uses NIDAQ functions with conjunction QBASIC library prepared by National Instruments. That program prepared in QB4.5 by us were used for communication with 610C over Lab-PC+, real time presentation of I/V measurements in Log-Lin scale and storing the measurement results for later analysis. As an example base-emitter current voltage characteristic of BC108 transistor is given in Figure 5. A comparison for higher currents than 10^{-12} A also was carried out with Keithley 487 picoammeter and any discrepancy did not detected.

Conclusion

This presented study showed that with an experience in hardware and knowledge of programming one can be update an existing highly reliable analogue measurement system to toady's technology. This adaptation process get much easier and acceptable for scientific research purposes when we used a high quality multifunction I/O card.

Acknowledgement

This work supported by Ataturk University Research Fund under project number 96/24.