An Educational Data Acquisition Card

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ملخص البحث

نقوم في هذا البحث بتصميم و تصنيع لوحة حاسوب تعليمية تستخدم لإدخال و إخراج الإشارات الرقمية و التماثلية. تحتوي اللوحة على ستة عشر خطاً رقمياً يمكن برمجتهم للإدخال أو الإخراج و تحتوي على مدخل تماثلي و مخرج تماثلي بسعة ثمانية بت، لها تطبيقات كثيرة في مختبرات التحكم باستخدام الحاسوب و مختبر تهيئة المعالج الدقيق. هذا بالإضافة إلى أن اللوحة قليلة التكلفة نسبيا و لها تطبيقات واسعة في مجال الأتمتة الصناعية و يمكن تثبيت اللوحة مع أي حاسوب شخصي متوافق مع عائلة انتل من خلال ناقل ISA. لقد تم تصنيع هذه اللوحة في مختبر الأبحاث و المشاريع بالجامعة الإسلامية بغزة و تم فحصها و التحقق من كفاءتها في مختبر المعالج الدقيق حيث وضحت التجارب جودة اللوحة و استخداماتها الكثيرة في تطبيقات الإدخال و الإخراج الرقمي و التماثلي.

Abstract

In this work we provide a complete design for an educational data acquisition card. The card has an 8-bit analog input, 8-bit analog output and 16-bit programmable digital input/output (I/O). It has wide applications in computer controlled systems Lab, as well as microprocessor interface Lab. Moreover, the card is price competitive and has many applications in industry automation. It is interfaced to any Intel compatible PC through the standard ISA bus. The card is fabricated at the Projects and Research Lab of the Islamic University of Gaza, then tested for quality control in its microprocessors Lab. It proved to be robust and has a wide variety of digital and analog (I/O) applications.

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Motivation

Undergraduate programs in electrical engineering usually include courses related to computer controlled systems and microprocessors interface. Lab equipment for these courses is used to be expensive making severe stress on practical sessions related to these courses. Moreover, production of this equipment is monopolized by foreign big industries which have no service centers in our regions making the maintenance of these products either impossible or extremely expensive. In our work we aim to design and manufacture an educational data acquisition card, which is not only easy in usage and maintenance, but also cheep so that individuals can purchase or even implement it.

Digital I/O circuitry

The digital I/O circuitry has an 82C55A integrated circuit [1]. The 82C55A is a general purpose programmable peripheral interface (PPI) containing 24 programmable I/O pins. These pins represent the three 8-bit I/O ports (A, B, C) of the PPI. All three ports are capable of sinking 2.5 mA of current and sourcing 2.5 mA of current on each digital I/O line. The base address of the PPI may be 300h, 310h, or 320h depending on jumper setting (J1) shown in Figure 1. Port B is reserved for the analog output circuit while port A and port C are for digital I/O applications.

Analog output circuitry

The analog output channel contains a DAC0800 integrated circuit, which is an 8-bit digital to analog converter [2]. The converter generates a voltage proportional to the internal reference multiplied by the 8-bit digital code applied through port B of the PPI. Figure 2 shows the analog output circuitry.

Analog input circuitry

The analog input channel contains an ADC0804 integrated circuit [3]. It is an inexpensive commonly used analog to digital converter, which uses an 8-bit successive approximation register. After it is activated to start conversion, one has to wait a time interval longer than the conversion time (110 μs) before he is able to read data from the converter. The converter is addressed at 330h, 340h, or 350h depending on jumper setting (J2) shown in Figure 3.

As illustratesd in Figure 4, conversion is triggered by a dummy write operation to the converter and when conversion is terminated the output signal is activated. In our design, this output signal is directed ou either pooling or interrupt techniques depending on the user's application.

Card manufacturing process

Careful attention must always be exercised when beginning the layout phase. It is only through careful planning and the usage of good electrical design practices that long-term product reliability may be achieved. Combining the circuits shown in Figures 1, 2 and 3, the schematic of the complete design is sketched using OrCAD Capture [4] as shown in Figure 5. In this design, the card provides access to the ISA bus IRQ7 and IOCHRDY. It also includes connection to the power supplies. OrCAD Layout [5] is used to import the capture file and rout the circuit in two layers as shown in Figure 6. The I/O connector for the card is a standard 25-pin female type and is accessible at the rear of the computer chassis. Its pin assignment is summarized in Table 1.

Pin #	Function	Pin #	Function
D1	PORT C 3	D14	ANALOG OUTPUT
D2	PORT C 2	D15	PORT C 1
D3	PORT C 0	D16	PORT C 4
D4	PORT C 5	D17	+5V
D5	INTR	D18	ANALOG INPUT

D6	PORT C 6	D19	PORT C 7
D7	PORT A 0	D20	PORT A 1
D8	PORT A 2	D21	PORT A 3
D9	PORT A 4	D22	PORT A 5
D10	PORT A 6	D23	PORT A 7
D11	IRQ7	D24	GND
D12	+12V	D25	IOCHRDY
D13	-12V		

Table 1. D25 connector pin assignment

Finishing routing, the post processor setting is set and Extended Gerber files are generated. These files are imported to the CircuitCAM program, which is a combined Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) program [6]. It is used to import, check and edit circuit board production data in various CAM formats, and then output them again into a CAM format (LMD). CircuitCAM is particularly useful in calculating the isolation channels between the connector tracks in circuit board prototype production using LPKF circuit board plotter. This plotter is fully controlled through BoardMaster program [7]. This program is capable of importing production data generated by CircuitCAM in LMD format and production data generated by other programs in HP-GL format, of

and coated on both sides with solderable lacquer. The card after assembling the components is shown in Figure 7.

Software drivers

Using Visual C++ a Dynamic-Link Library (DLL) that allows the user to communicate with the card from thc familiar Visual Basic environment is developed. An input (InPort) and an output (OutPort) functions are defined in the DLL (dac.dll). They can be used in Visual Basic programs after adding the following lines in the declaration section:

```
Private Declare Function OutPort Lib "dac.dll"_
        (ByVal PortAddress As Integer, ByVal PortData As
Integer) As Integer
Private Declare Function InPort Lib "dac.dll"_
        (ByVal PortAddress As Integer) As Integer
```

To generate the DLL file, the following 2 files are added to a Win32 dynamic-link library Visual C++ project and then the dynamic-link library is built [9].

```
Library DAC
EXPORTS
      OutPort     @1
      InPort      @2
```

```
#include<stdio.h>
#include<conio.h>
short _stdcall OutPort(int PortAddress, int PortData)
{
   return (short)(_outp(PortAddress, PortData));
}
short _stdcall InPort(int PortAddress)
{
   return (short)(_inp(PortAddress));
}
```

The paper proposes a complete design for an educational data acquisition card. Although many other challenging designs have already been implemented, they are provided by big commercial industries, which used to hide most of the design and manufacturing secrets. Moreover, sophisticated commercial cards are extremely expensive and usually use special integrated circuits making the maintenance of these cards either expensive or impossible. These sophisticated cards provide more than needed in many undergraduate Labs. On the other hand our card is so clear and cheep that every student can purchase or implement it himself.

Many experiments such as stepper motor control, multiplexed display, keyboard and joystick interface are performed using this card [10,11]. Also a simple programmable function generator and a simple storage oscilloscope are implemented using its analog lines. These experiments and tests not only proved that the card is well designed and well fabricated but also demonstrated that it has a wide variety of applications.

Having succeeded in our design we are targeting to design a compact experimental tool for microprocessors lab in which the student is engineered to develop computer cards.

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References

[1] "82C55A CHMOS Programmable Peripheral Interface", http://developer.intel.com/design/periphrl/datashts/231256.htm, (current Dec. 2001).

[2] "DAC0800, 8-Bit D/A Converter", http://www.national.com/pf/DA/ DAC0800.html, (current Dec. 2001).

[3] "ADC0804, 8-Bit µP Compatible A/D Converters", http://www. national.com/pf/AD/ADC0804.html, (current Dec. 2001).

[4] OrCAD, Inc., "Orcad Capture User's Guide", 1998.

[5] OrCAD, Inc., "Orcad Layout User's Guide", 1998.

[6] LPKF Laser & Electronics AG,"CircuitCAM Manual", 1999.

[7] LPKF Laser & Electronics AG, "BoardMaster Manual", 1997.

[8] LPKF Laser & Electronics AG, "ProtoMat C60 Manual", 1999.

[9] "An Introduction to DLL Programming in C", http://libertybelle.0catch.com/dll1.htm,(current Dec. 2001).

[10] M. Abdelati et al., "Experiments for the microprocessor lab", IUG, 2001.

[11] J. Uffenbeck, "The 80x86 Family design, Programming, and Interfacing", 2nd edition, Prentice-Hall, 1998.

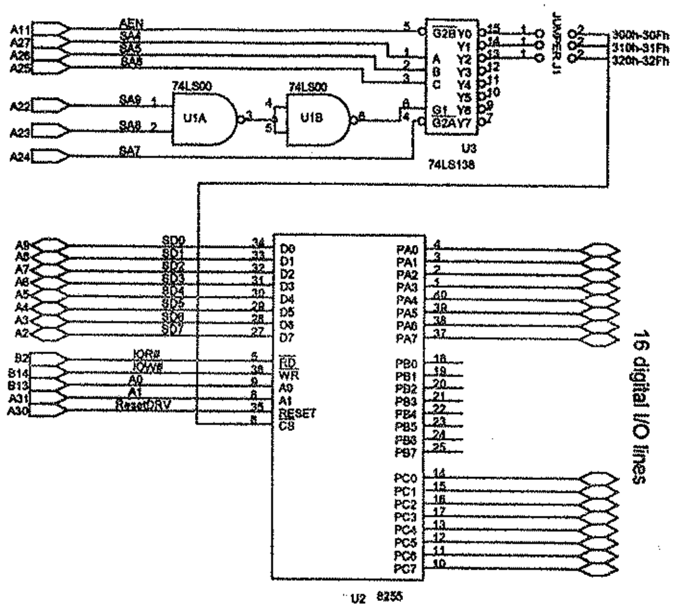


Figure 1. Digital I/O circuitry

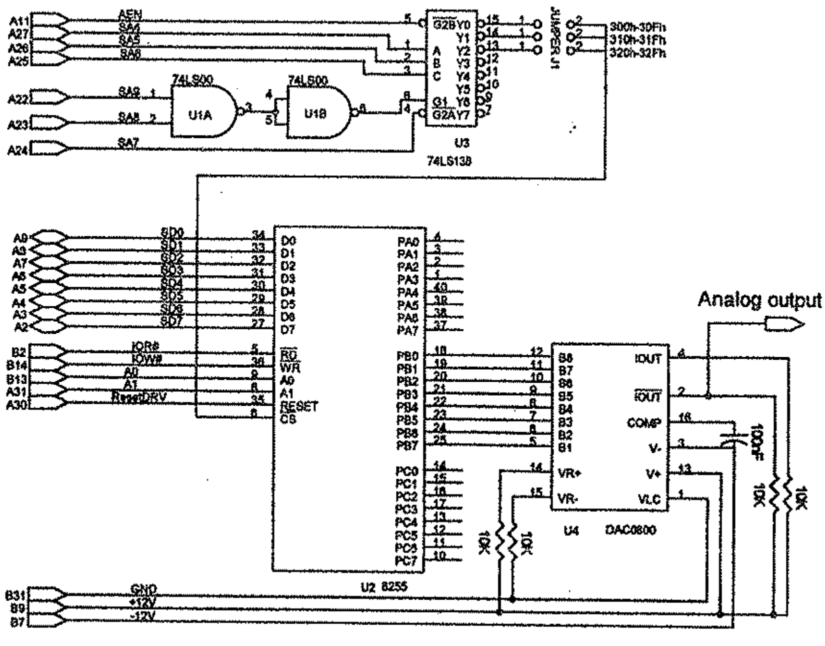


Figure 2. Analog output circuitry

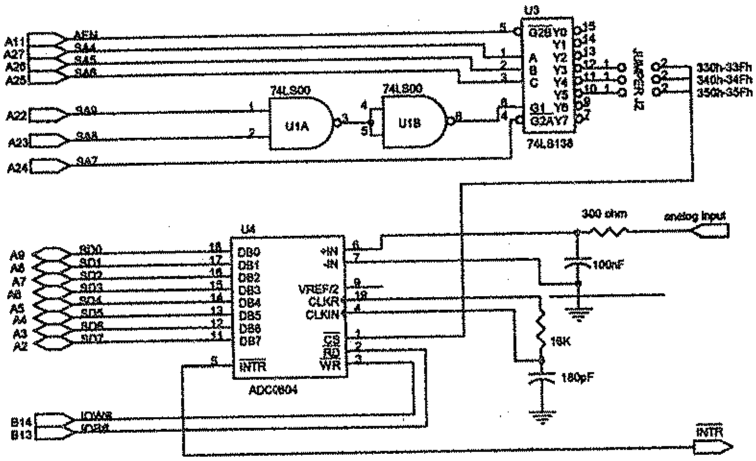


Figure 3. Analog input circuitry

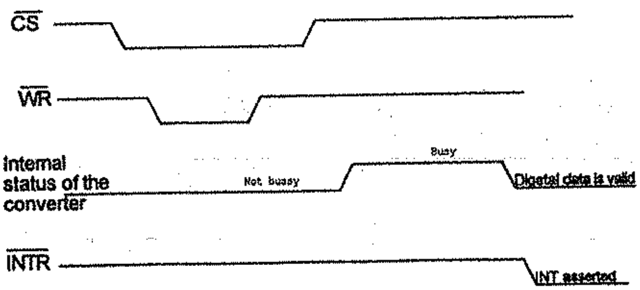


Figure 4. Timing of conversion

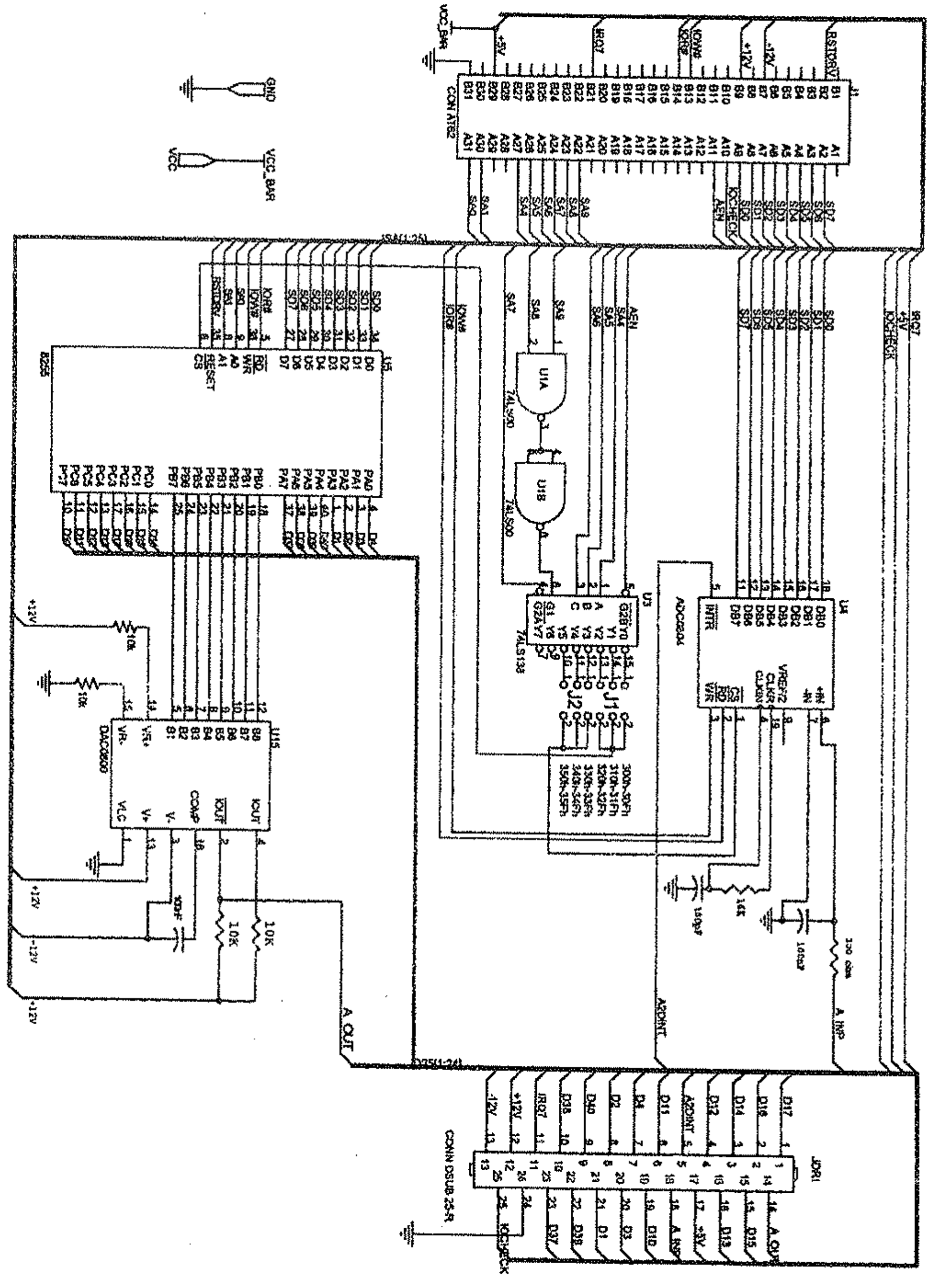


Figure 5. Designed card schematic

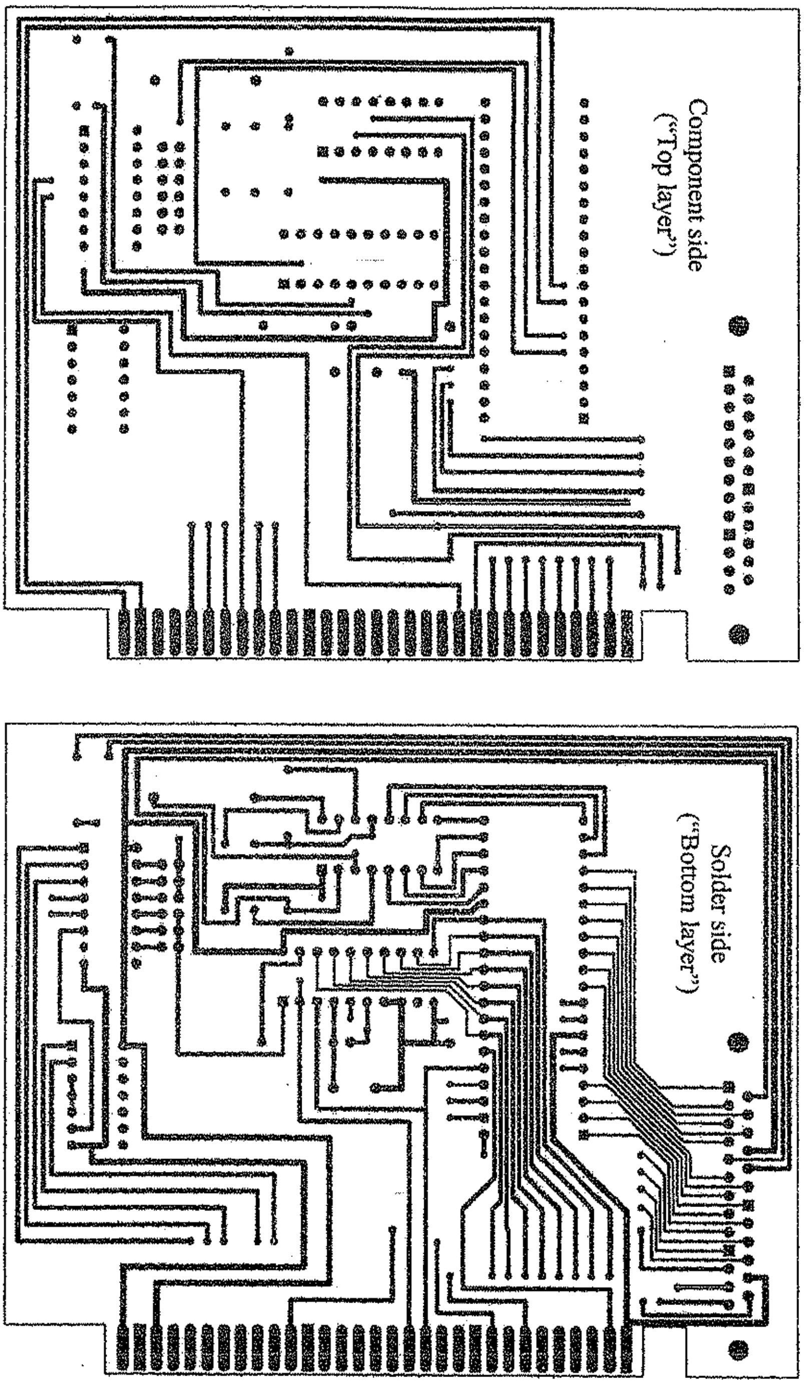
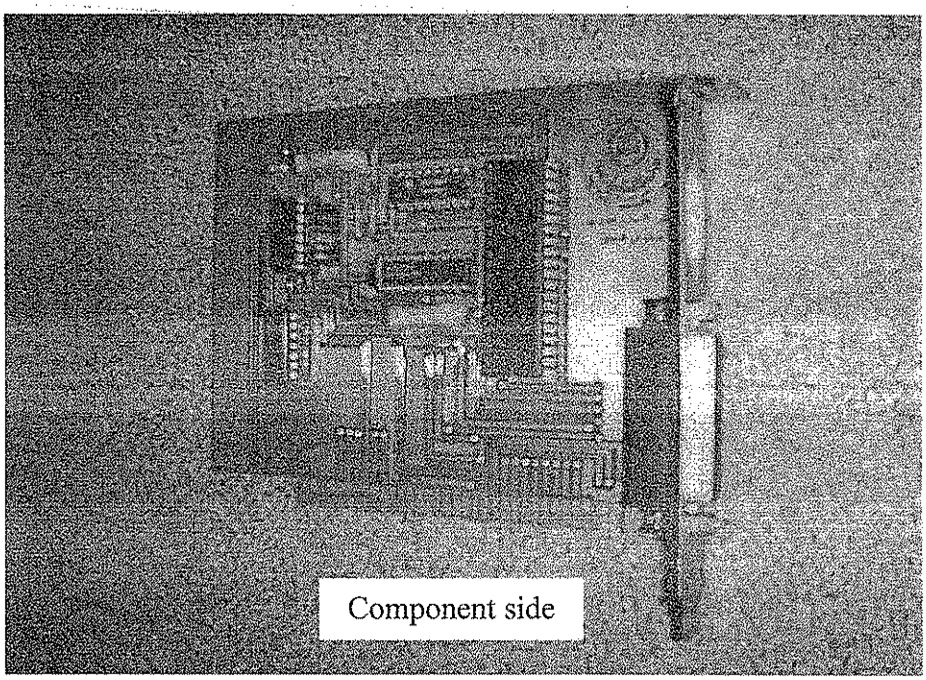


Figure 6. Designed card routing



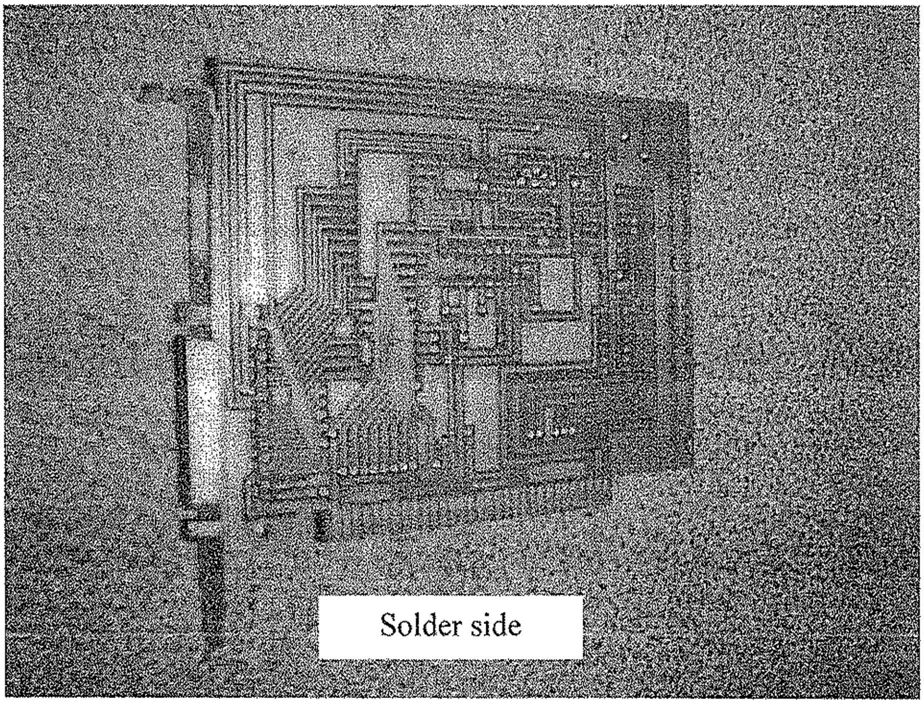


Figure 7. Manufactured card