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AUG 77 L M COLONNA-ROMANO

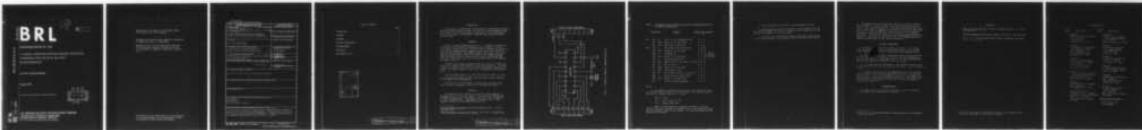
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A SIMPLE COMPUTER-DRIVEN ANALOG-TO-DIGITAL
CONVERTER FOR USE WITH AN 8-BIT
MICROCOMPUTER

Louis M. Colonna-Romano

August 1977

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INTRODUCTION

In the course of interfacing a microcomputer to experimental apparatus, analog-to-digital conversions were required since the microcomputer input ports accept only TTL-level signals. The purpose of this short report is to describe a simple and inexpensive computer-driven analog-to-digital converter (ADC).

HARDWARE

The ADC is shown schematically in Fig. 1. It consists of an 18-pin integrated circuit (National Semiconductor Corp. MM5357N),¹ a Zener diode, and a dropping resistor. This 8-bit device performs the conversion by a successive approximation technique, requiring 40 clock cycles to complete the conversion. The computer supplies the clock, start conversion, and output enable signals as described in the computer program shown in the next section. Characteristics such as differential non-linearity, quantization error, etc. are determined solely by the MM5357N and appear in Ref. 1.

The Zener diode, whose breakdown voltage was closest to 10.00V, was chosen from a batch of 1N961 diodes for use in the converter. If greater accuracy is required, the section on Possible Improvements should be consulted. The supply voltages, +5 and -12V, are supplied by the microcomputer.

The input analog signal (V_{in}) must fall within the range -5 to +5V. In the configuration shown, the ADC input and output signals connected to the computer are TTL-compatible.

The entire cost of the converter including the associated Zener diode, resistor, connectors, socket, etc., was under \$20 (1976).

SOFTWARE

As mentioned earlier, the ADC is driven by the microcomputer. A program to drive it is given in Table 1. The program was written for the 8080A microprocessor, first made by Intel Corp., but now supplied by numerous manufacturers. The reader is directed to Ref. 2 for a complete description of the 8080A instruction set.

¹Special Function Data Book, National Semiconductor Corp., p. 8-33, copyright 1976.

²8080 Microcomputer Systems User's Manual, Intel Corp., copyright 1976.

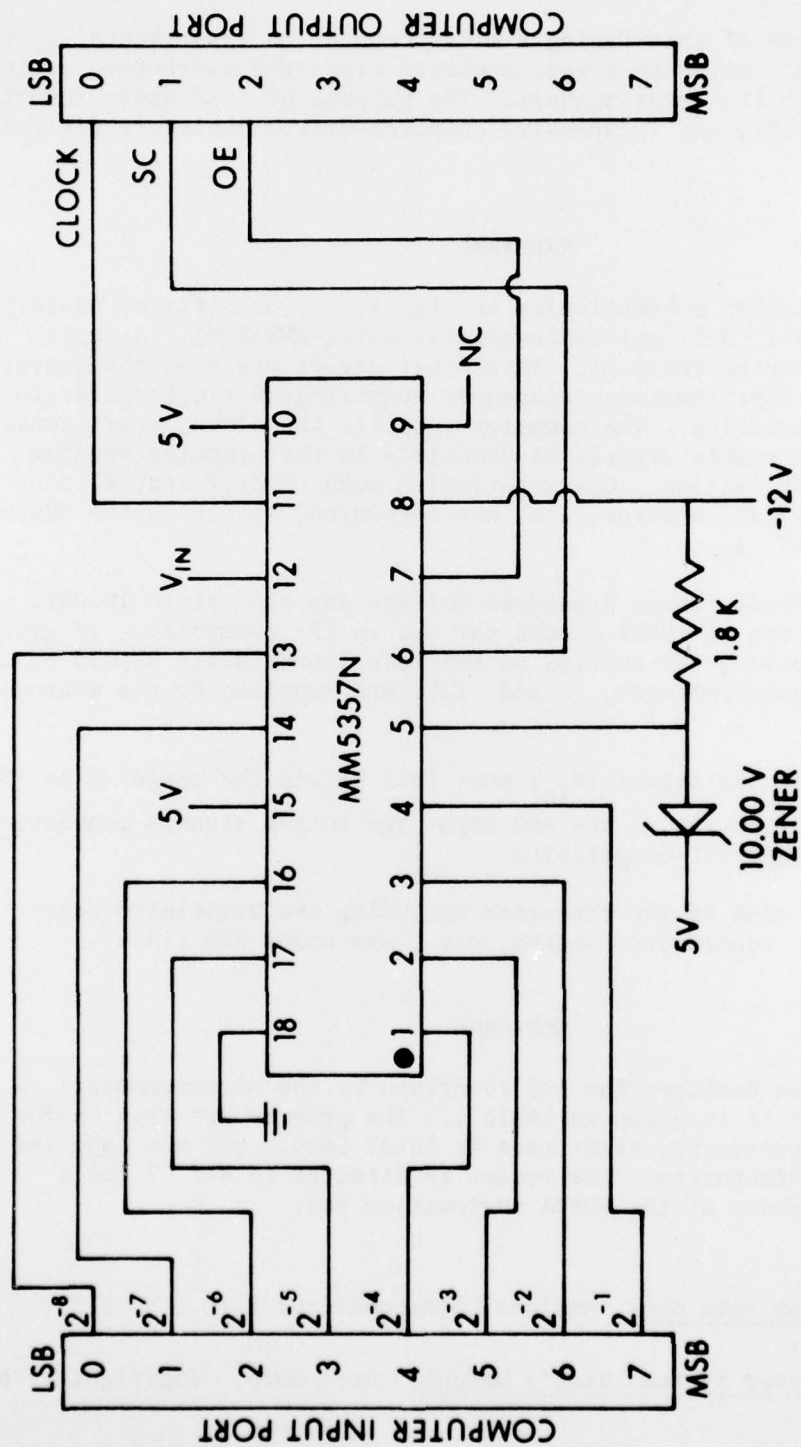


FIGURE 1. SCHEMATIC DIAGRAM OF COMPUTER-DRIVEN ADC.

TABLE 1. A PROGRAM TO DRIVE THE ANALOG-TO-DIGITAL CONVERTER WRITTEN FOR THE 8080A MICROPROCESSOR.

INSTRUCTION	REMARKS	OUTPUT PORT CONTENTS ¹		
		2	1	0
ADC: MVI A,2	Move 2 to the Accumulator (Acc)	0	0	0
OUT PADC	Output Acc to port PADC ²	0	1	0
MVI B,40	Move 40 ₁₀ to register B	0	1	0
ADC1: XRA A	Exclusive-or Acc with itself ³	0	1/0	0
OUT PADC	Output Acc to port PADC	0	0	0
INR A	Increment Acc	0	0	0
OUT PADC	Output Acc to port PADC	0	0	1
DCR B	Decrement register B ⁴	0	0	1
JNZ ADC1	Jump to ADC1 if zero flag is not set	0	0	1
MVI A,4	Move 4 to Acc	0	0	1
OUT PADC	Output Acc to port PADC	1	0	0
IN PADC	Input result to Acc	1	0	0
MOV B,A	Move contents of Acc to register B	1	0	0
XRA A	Exclusive-or Acc with itself	1	0	0
OUT PADC	Output Acc to port PADC	0	0	0
RET	Return to calling program ⁵	0	0	0

} Loop is executed 40 times

NOTES:

1. The contents of the three lowest bits of the output port, PADC, are displayed after execution of the instruction. The initial state of these bits is assumed to be low, i.e., zero.

Bit 0 - Clock

Bit 1 - Start conversion (SC)

Bit 2 - Output enable (OE)

2. PADC is a label assumed to be defined elsewhere as the port address of the port connected to the MM5357N chip. The input and output port are assumed to have the same address. All input and output are done through the accumulator.

3. This instruction sets all bits in the accumulator to zero.

4. During execution of this instruction, the zero flag will be set to 1 if the decrement of register B resulted in zero, otherwise, the zero flag will be cleared, i.e., reset to zero.

5. The result of the conversion remains in register B after return to the calling program. Only registers A and B are used by this routine.

The program causes the output port connected to the ADC (labelled PADC in Table 1) to supply the ADC with a start conversion pulse (SC) on bit 1, initiating the conversion. The program then pulses the clock (bit 0) forty times to complete the conversion. Raising the output enable (OE on bit 2) causes the MM5357N to make the result of the conversion available on its output pins where it can be read in by the computer input port. Finally, OE is returned to zero in preparation for the next conversion. The total time for a conversion with an 8080A-based micro-computer operating with a 2 MHz clock is about 950 μ s.

POSSIBLE IMPROVEMENTS

This ADC was designed to be as simple as possible. As a result, there are numerous improvements which could be made at a cost of additional components and complexity. Some of these are suggested below.

A. Multiplexing. Multiple analog inputs could be multiplexed into the ADC or multiple ADC's could be attached to the same computer input port with the addition of some enable logic.³ The latter configuration would be facilitated by the MM5357N's tri-state outputs.

B. Full-scale and zero adjustments. 500 Ω variable resistors could be used to adjust the conversion range more accurately. This is discussed in Ref. 1.

C. Direct connection to the microcomputer data bus. The I/O port could be eliminated by connecting the MM5357N directly to the microcomputer data bus. In this case an address would have to be assigned and logic provided to take over the function of the port. The computer clock could be used to clock the ADC (in this case, at 2 MHz) resulting in conversions in about 25 μ s.

ACKNOWLEDGEMENT

The author wishes to express his appreciation to Mr. D. McCoy for his assistance in the construction of the ADC.

³Kraul, D. R., "Designing Multichannel Analog Interfaces," Byte Magazine, p. 19, June 1977.

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1. Special Function Data Book, National Semiconductor Corp.,* p. 8-33, copyright 1976.
2. 8080 Microcomputer Systems User's Manual, Intel Corp., copyright 1976.
3. Kraul, D. R., "Designing Multichannel Analog Interfaces," Byte Magazine, p. 19, June 1977.

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