



INTERSPEC BUS EXPANSION SYSTEM FOR THE SINCLAIR ZX SPECTRUM / ZX 81

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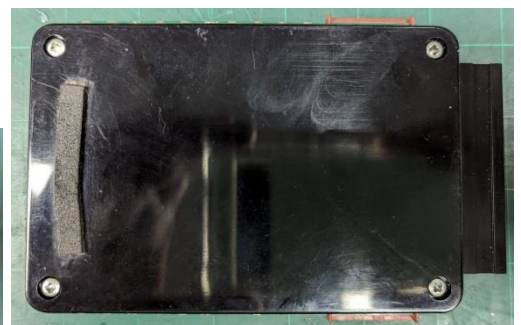
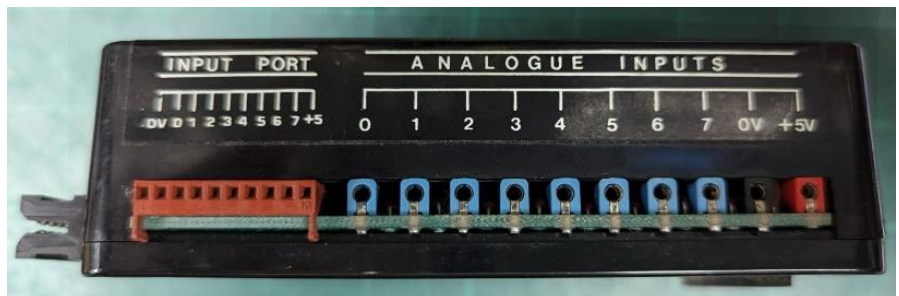
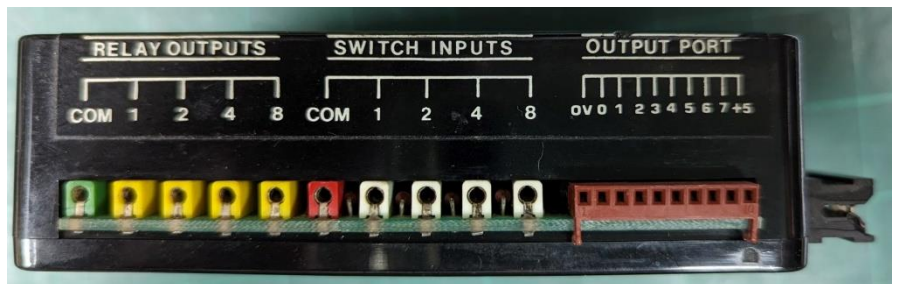
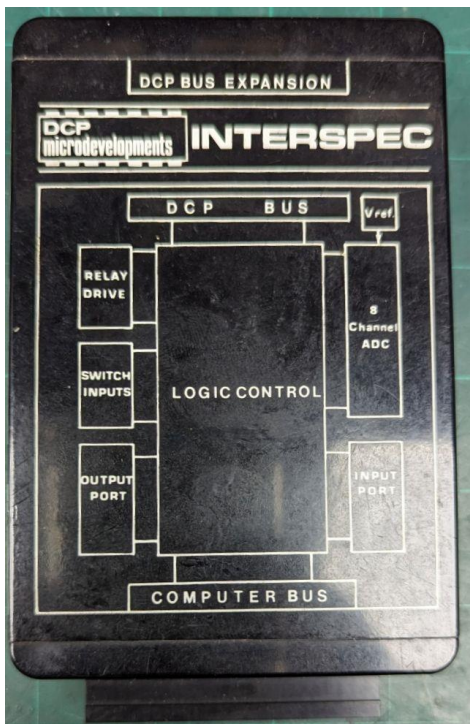
INTRODUCTION

The DCP INTERSPEC is a complete interface package for the Sinclair ZX Spectrum computer (or ZX81 with some short machine - code routines). The unit contains an 8 Bit TTL input port, 8 Bit TTL output port, 8 channel analogue to digital converter (ADC), 4 high current relay outputs and 4 switch inputs. Also, fitted on the rear of the unit is a DCP Bus connector which has all the necessary data, power and decoded address lines for easy expansion of the basic system. Using this Bus up to four more peripherals can be added directly or with a little extra simple electronics up to 255 additional items can be added using page-mode addressing. Interspec circuitry is mounted on a double-sided through-hole plated circuit board enclosed in a neat and tough plastic case.

External expansion is explained in this manual but it should be noted that any modifications or misuse of INTERSPEC in anyway will invalidate the guarantee — if unsure about connecting any equipment to the unit consult your supplier or a person qualified to advise you. It is important to ensure that the computers power plug is removed and that edge connectors are clean before plugging in INTERSPEC. The instructions and explanations to follow make extensive use of certain commands and functions of the computer, particularly IN and OUT. These are detailed in the computers handbook and on the back page of this manual is a quick reference guide as a fast aid to the user whilst programming and designing applications.

ZX81 Users note: This unit was primarily designed for use with the ZX Spectrum but will work with the ZX81 if short machine code routines are used. A book on using machine code on the ZX81 should be used - the IN and QUT commands as given in this manual will be needed. If a ZX81 RAM pack is needed you will need to make an adapter to parallel both INTERSPEC and the RAM pack electrically.

DCP INTERSPEC



INPUT PORT – ADDRESS: 95

The input port is an 8-bit TTL input port with 0Volts and +5Volts on a 10 way MOLEX 0.1" socket. It is standard LSTTL compatible and 'pull up' / 'pull down' resistors should be added as required. The connections are shown below (Fig. 1) together with an example for connecting up to 8 switches to the port (Fig. 2).

Fig. 1: Connections

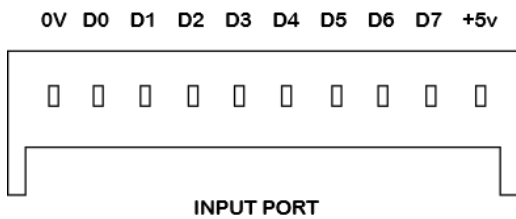
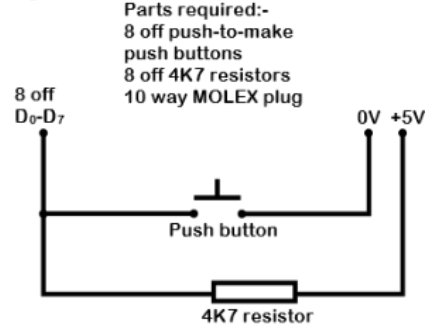


Fig. 2: Hardware example



The syntax for reading the input port is IN 95 with a function preceding IN; eg: PRINT IN 95. An example program for use with the hardware example in Fig. 2 is shown below.

ZX Spectrum Example

```
10 PRINT IN 95
20 PAUSE 50
30 RUN
```

You will need to enter BREAK to stop this program. When this program is RUN you will see the value of the input port displayed on the screen and updated once per second. Because the input ports are pulled up by the 4K7 resistors, the value of the port with no switches depressed is 255 – the total of all eight data lines D0 – D7 summed together. This binary representation applies to all of the ports on the INTERSPEC and is more fully explained in the ZX manuals. However, to aid the user a binary to decimal conversion table, is given in the quick reference guide on the back of this manual. Only logic levels of 0V and 5V must be used on this port otherwise damage will result.

OUTPUT PORT – ADDRESS: 95

The output port is an 8 bit LSTTL compatible port with buffer and latch and along with 0Volts and +5Volts is terminated in 10 way MOLEX 0.1" socket. The LSTTL outputs can sink up to 15mA per channel. The output connections are shown below. (Fig. 3) together with a hardware example for connecting up to 8 L.E.D.'s to its outputs (Fig. 4).

Fig. 3: Connections

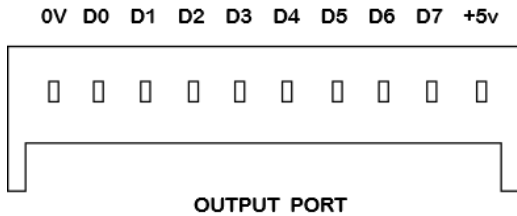
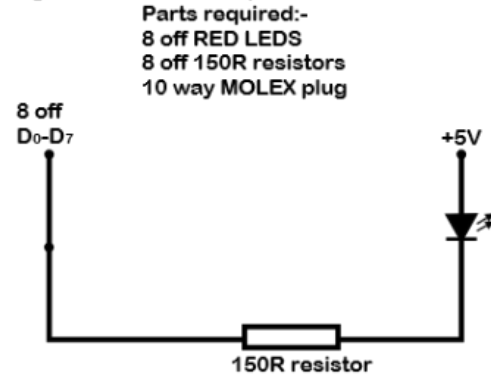


Fig. 4: Hardware example



The output port is Located at the same address as the input port but is selected by the command OUT 95. The syntax for outputting a value n (n = 0 to 255) is OUT 95, n.

ZX Spectrum example

```
05 95,255
10 FOR A = 255 to 0 STEP-1
20 OUT 95, A
30 NEXT A
40 PAUSE 20
50 95,255
```

This simple programming example will rapidly display all 256 combinations from 0 to 255 on the LEDs by using a simple decrementing FOR-NEXT loop. The LED on each channel is turned on by a logic 0 being outputted to its channel and turned off by a logic 1 So if you use OUT 95, 0, all LEDs will be on, OUT 95, 239 will light only D4 and so on. Any combinations of LEDs may be turned on or off depending upon the value sent to the port. Reference to the conversion table on the back page will aid decoding these outputs. Cables connected to this and other sections of INTERSPEC should be kept as short as possible to avoid interference on the TV/Monitor screen.

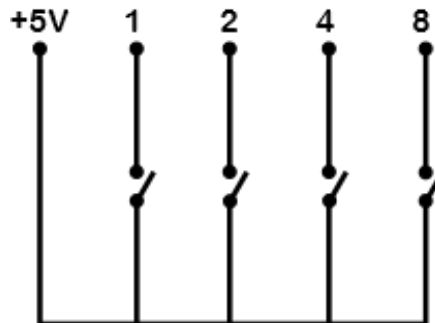
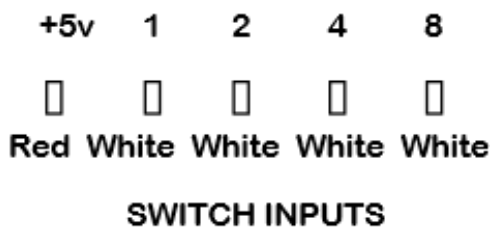
NOTE: Lines 05 and 50 turn all the LEDs OFF.

4 BIT SWITCH INPUTS – ADDRESS: 63

This section of INTERSPEC provides 4 switch inputs and a common line terminated in 2 mm sockets. All 4 Inputs are 'pulled down' to 0V by internal 2K2 resistors and so need to be switched to +5 Volts (common socket) to activate them. The socket layout is shown below (Fig. 5) together with connection details (Fig. 6) for switches of other similar transducers. These could include micro switches, light dependent resistors, pressure switches etc, depending on your application.

Fig. 6: Hardware example

Fig. 5: Connections



The syntax for reading these switch inputs is the same as for the INPUT port but with a different address value, ie: IN 63 with a function preceding IN, eg: LET X = IN 63.

The switch inputs 1 to 4 are equivalent to D0 to D3 respectively on the data bus and so to read the true states of these inputs, the value from IN 63 should have 240 subtracted from it (because the data bus presumes D4 to D7 are all at logic 1). The following program example can be used with the hardware in Fig. 6 and subtracts 240 from the input value.

ZX Spectrum example

```
10 PRINT (IN 63) – 240
20 PAUSE 50
30 RUN
```

You will need to enter BREAK to stop the program. It is important that only 0V and 5Volts are used on these inputs – they should not be connected to anything but the switch input common.

4 BIT RELAY OUTPUTS - ADDRESS: 63

The relay output section of INTERSPEC is located at the same address as the switch inputs but is operated using the OUT command. Its terminals are five 2mm sockets and the relay contacts and relay common are completely electrically isolated from the computers electronics. Each relay contact is rated 12Volts @ 1AMP. The socket layout and internal relay configuration is shown in Fig. 7 and connection examples for some different types of equipment are shown in Fig. 8.

Fig. 7: Connections

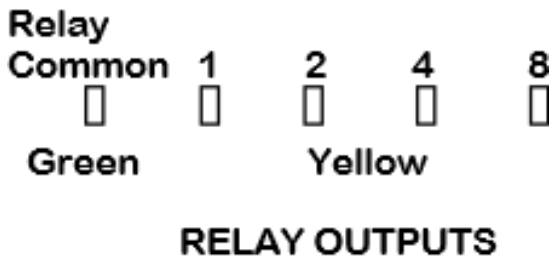
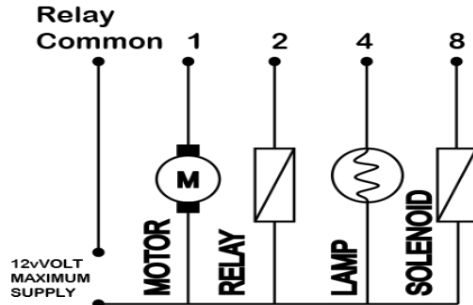


Fig. 8: Hardware example



The syntax for controlling the relay outputs, is OUT 63,n; where n is a decimal number between 0 and 15. With 0 switching all relays OFF and 15 switching them all ON. To switch individual relays, use the appropriate relay number for n, e.g., OUT 63,4 will switch relay 4 contacts ON. For combinations of relays on and off, use the sum of the relay numbers you require on, e.g., to switch on relays 1 and 8, use OUT 63,9.

NOTE: Switching a relay ON switches relays that are already ON, OFF! To keep an already ON relay, you need to add its value into n.

As you can see from Fig. 8, many different things can be controlled, and if higher current or voltage devices need to be controlled, you can use the INTERSPEC to drive a SECONDARY RELAY with a low voltage coil.

DO NOT EXCEED THE 12V 1AMP RATING OF THE RELAYS. DO NOT CONNECT ANY EXTERNAL POWER SOURCES TO ANY OTHER INTERSPEC INPUTS OR OUTPUTS.

ZX Example (By Chas to step through each relay combination)

```
10 FOR X = 0 TO 15
20 OUT 63,X
30 PAUSE 20
40 NEXT X
50 PAUSE 20
60 OUT 63,0
```

8 CHANNEL 8 bit analogue to digital converter – ADDRESS: 31

This section of INTERSPEC can convert any analogue voltage from approximately 0V to 2.7Volts into a decimal number which the computer can process or display. It can select one of eight analogue channels (input resistance 100k per channel) to read and these inputs along with 0V and +5Volt are terminated in 2mm sockets. The socket layout (Fig. 9) and example hardware (Fig. 10) is shown below: (The internal voltage reference for the ADC is a 2.7Volt zener diode, therefore V.ref accuracy is +/- 20%).

Fig. 9: Connections

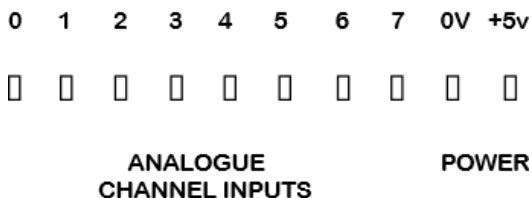
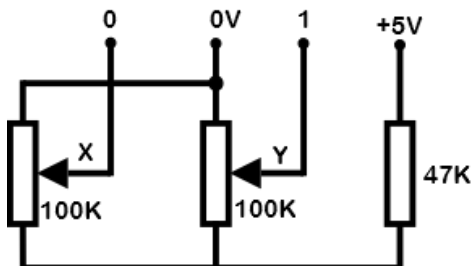


Fig. 10: Hardware example



The first command that is required is to tell the ADC which channel you wish to read. This is done by using OUT 31, n, where n is a number between 0 and 7 corresponding to the required channel. This write operation also starts the ADC conversion and in SPECTRUM basic the conversion is complete by the time the ADC is read, the syntax of which is: IN 31 with a function proceeding IN, eg: PRINT IN 31. Each time a channel is read it must be preceded by the channel select OUT command so as to re-initiate conversion. Conversion time is typically better than 1mS and this should be allowed for in the ZX81 or machine code programs. Using the hardware example in Fig. 10 a joystick can be made in the simple 'etchasketch'® type program below:-

ZX Spectrum example

```
10 OUT 31,0
20 LET Y = (IN 31/1.5)
30 OUT 31,1
40 PLOT IN 31,Y
50 GOTO 10
```

BREAK will be needed to escape from this program. Ensure that no more than +5Volts is applied to any channel input with respect to 0V.

DCP BUS Expansion Connector – ADDRESSES: 127, 159

To allow for easy expansion to add users own electronics or other DCP products the DCP BUS was developed. It uses a 15 way Molex 0.1" connector to supply power, data and decoded address lines and can directly control up to two input and two output devices using just a single OR gate per selection. With a little more straight-forward electronics up to 255 other devices can be 'page-selected'. We will only deal with the simple expansion approach here but should you wish to use the page decoding technique there are many good computer publications that adequately cover the subject which basically entails outputting a secondary address bus onto the data bus and using that 'address' to select further peripherals. The DCP BUS connector details are shown in Fig. 11 together with some examples for connecting hardware to the bus (Fig. 12-13). DCP AD1 is decoded to address 127, DCP AD2 to address 159). (Refer to manufacturers data for detailed specifications of the devices used below).

Fig. 11: Connections

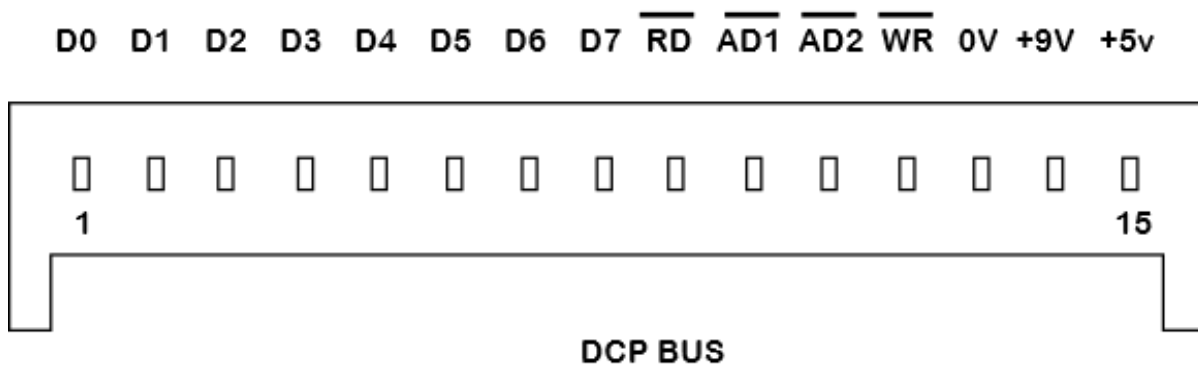


Fig. 12: INPUT PORT

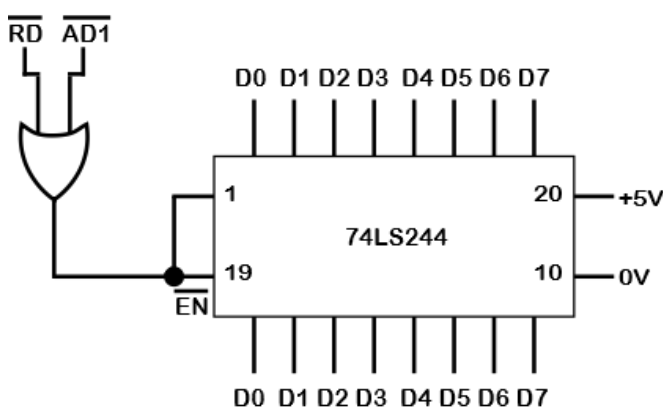
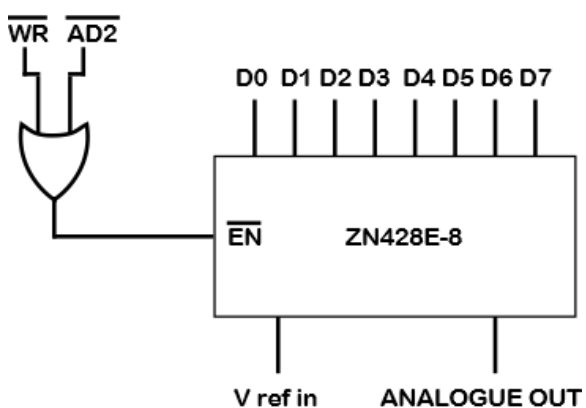


Fig. 13: DIGITAL TO ANALOGUE



The key to easy expansion is the two lines AD1 and AD2 which are fully decoded lines at address 127 and 159 and gated with the CPU's IORQ. With the addition of an OR gate to determine whether you are reading (RD) or writing (WR) to the data bus different I/O devices may be added. (Complete beginners in digital electronics are not advised to tackle this expansion). Once designated the extra I/O peripherals are controlled by the same technique as the other INTERSPEC facilities.

INTERSPEC - QUICK REFERENCE GUIDE

INTERSPEC - ADDRESSES AND CORRESPONDING FUNCTIONS

ADDRESS	SYNTAX	COMMAND/FUNCTIONS OPERATION
31	OUT 31.n	ADC - select channel n (n=0 to 7)
31	IN 31	Read ADC value-precede by function
63	OUT 63,n	Controls relay outputs, where n is sum of relays used
63	IN 63	Heads switch inputs (subtract 240)
95	OUT 95,n	Output n to output port
95	IN 95	Read input port-precede by a function
127	IN/OUT 127	Reads or writes to DCP BUS AD1-syntax as above
159	IN/OUT 159	Reads or writes to DCP BUS AD2-syntax as above
191	—	NOT USED ON INTERSPEC (DCP PRODUCT 1983)
223	—	NOT USED ON INTERSPEC (DCP SPEECH)
255	—	NOT USED ON INTERSPEC (DCP SPEECH)

(The above addresses were chosen after considering the Spectrum and printer hardware restraints.)

BINARY DATA LINE TO DECIMAL VALUE TABLE

DATA LINE	D ₀	D ₁	D ₂	D ₃	D ₄	D ₅	D ₆	D ₇
DECIMAL VALUE	1	2	4	8	16	32	64	128

GENERAL INFORMATION AND SERVICE

The DCP INTERSPEC should only be used in accordance with these instructions and no responsibility will be accepted for misuse of this unit.

If you suspect your INTERSPEC is not working correctly you should contact your supplier to arrange for the service - please retain the original packing and your proof of purchase. The INTERSPEC is guaranteed for 12 months from date of purchase providing it has been used in accordance with these instructions and has not been modified in any way. Connectors for available from most electronic shops or mail order firms such as MAPLIN, RS and Ambit. For further information on other DCP products contact your dealer or us; educational enquiries should be directed to Griffin and George Limited who supply and support our range. We reserve the right to make design changes to our products without notice

INTERSPEC — ADDITIONAL INFORMATION

This information is published in addition to the standard Interspec manual and provides extra useful details and hints including basic machine code examples for the ZX81.

There have been different versions of the Sinclair Spectrum Computer released, all externally similar but internally layout and circuitry changed. The difference between some Spectrums can give apparent errors in Interspec's performance resulting in occasional random data being read or sent. If you experience these problems a simple remedy is to enter a 'PAUSE 1' command before and/or after an IN or OUT command.

eg:-

10 PRINT IN 63	would become: -	10 PAUSE 1
20 GOTO 10		20 PRINT IN 63
		20 GOTO 10

When using Interspec or any other products on the Spectrum it is important that the edge connectors are clean and also make sure that your power supply can handle any extra circuitry you have added — be careful not to overload the Spectrum Power Supply.

As mentioned before the Interspec pack may be used with a ZX81 by using simple machine code routines. Two simple routines are shown together with an example Basic program that makes use of these routines. When using machine code remember to allow a delay time for the analogue to digital conversion.

Machine code routines:

	Address	Code	Z80 Assembler	Function
IN ROUTINE	16514	219,63	IN A,N	Load accumulator with INA accumulator
	16516	50,136,64		Load address NN with accumulator
	16519			Return to basic
	15420			Spare location tor IN data
OUT ROUTINE	16521			Load accumulator with data at address NN
	16524			Load OUT port with accumulator
	16526			Return to basic
	16527			Spare location tor OUT data

The routines start at address 16514 because this is the address in ZX81 memory taken up by the first byte in a REM statement at line 1 of a basic program. (The code can be relocated and used on a ZX Spectrum.)

Variables:- 16514 = IN Port address: 16520 = Data from IN Port: 16525 = OUT Port address: 16527 = DATA for OUT Port.

USING MACHINE CODE WITH INTERSPEC

Basic program:

```
1 REM XXXXXXXXXXXXXXXX
10 FOR A = 16514 to 16527
20 INPUT C
30 POKE A,C
40 NEXT A
50 PRINT "PORT ADDRESS?"
60 INPUT P
80 POKE 16515, P
90 POKE 16525, P
100 PRINT "OUTPUT DATA?"
110 INPUT O
120 POKE 16527,O
130 LET J = USR 16521
140 LET I = USR 16514
150 PRINT "INPUT DATA ="; PEEK 16520
160 PAUSE 50
170 CLS
180 GOTO 50
```

REM statement

BASIC routine to enter machine code Into REM statement addresses.

Enter port address 'P' and poke IN OUT ROUTINES address locations.

Enter OUT data 'O' into address 16527 the execute OUT routine.

Execute IN routine and print data from 16520

Pause for 1 second then repeat

When run this program will ask for the 14 bytes of machine code routine to be entered and then commence the Basic demonstration program. You can save the data on tape and after entering the code lines 10 to 40 can be removed. The routines are simple but effective in allowing the INTERSPEC to be used on a ZX81: without the need for the user to have an understanding of machine code.