

PART II - HARDWARE REFERENCE

2.1 Specifications

<u>POWER:</u>	:	100-125 VAC, .25A
	:	200-250 VAC, .125A
	:	(50/60 Hertz)
<u>OPERATING ENVIRONMENT:</u>	:	
Temperature	:	0 - 50 deg C
Humidity	:	0 to 95% non-condensing
<u>SIZE:</u>	:	
Height, Width, Depth	:	14.80 by 2.60 by 7.60 in.
<u>WEIGHT:</u>	:	
Pounds (Kg)	:	Net 6.0 (2.7) Shipping
<u>I/O:</u>	:	
Optically Isolated I/O	:	
Input current	:	15mA min. 60mA max
max. voltage	:	7VDC (+ to -)
Output current	:	150mA min.
max. voltage	:	1.2VDC ON, 40VDC OFF
Differential Outputs	:	
Step	:	Frequency range=7hz to 23khz
	:	Accuracy = .02% of set rate
Pulse width resolution	:	1.085 usec
frequency resolution	:	.001% at 10 Hz, 1% at 10 kHz
Step and Direction	:	+25ma at 4VDC min.
	:	-25ma at 1VDC max.
Differential inputs	:	(Channel A,B and Z)
Signal high	:	2.6VDC min
Signal low	:	2.4VDC max
Max. Input Freq.	:	125 kHz from encoder
	:	200 kHz CH B alone
	:	(min. pulse width 2 usec)
Analog Output	:	+/-10 Volt at +/-10mA
resolution:	:	78mV
Analog Inputs	:	+/-10 Volt (factory range)
resolution:	:	78mV
Impedance	:	47.7 kohm
Parallel Inputs	:	0.75VDC max low, 1.5mA sink
	:	2.5VDC min high, 10k pullup
Parallel Outputs	:	0.5VDC max at -24 mA sink
	:	3.5VDC min at +15 mA source
	:	Max. Volts any pin, +5.5VDC
RS-232 all ports	:	+/-12VDC limited to +/-10mA
Baud rates	:	110 to 19200 BAUD
* Bits	:	7 or 8 Data, 1 or 2 Stop
Parity	:	Odd, Even, or None
Handshake protocol	:	None
* (PRINTER port is 8 Data and 2 Stop bits with no Parity)	:	

2.2 Screw Terminal Connections

2.1.1 ISOLATED INPUTS - *IN A* through *IN D*

The top eight *ISOLATED* screw terminals are connected to the four optically isolated inputs, two terminals each. Each isolator requires DC current to turn it on. This calls for an external power supply. Input drive current must flow from the "+" terminal to the "-".

The input circuits have 100 ohm current limiting resistors and are designed to be driven by a +5 VDC voltage source. Figure 2.1 below shows the circuit configuration.

The easy way to check the state of an input is to use the BASIC DIO (discrete I/O) instruction.

Otherwise, these inputs are read by the 8052 from an internal register at address FA08 hex. This "input port" register is an 8 "bit" register. The 8052 reads the state of the 8 bits in this register as a number. Discrete inputs must be logically separated for individual processing in a program. The four most significant register bits are driven by these inputs. Input register bits are normally high (1), and are driven low (0) when their optical isolator is turned on.

The most significant bit (bit 7) of the port register corresponds to "*IN D*", and bit 4 corresponds to "*IN A*". Bits 0 through 3 have no connection.

Typical I/O Connections:

- Switches and relays
- Programmable Controller DC outputs
- Integrated circuit drivers
- Transistors, open collectors

The *IN D* input may also be configured as an edge triggered (latched) hardware interrupt.

References:

Accessing Inputs:	Section 4.2.2: DIO Instruction
Optical isolators:	Section 2.1: I/O Specifications
I/O Connections:	Appendix C: Sample I/O
<i>IN D</i> interrupt:	Section 4.3: Interrupts

Figure 2.1 Optical Input Circuit

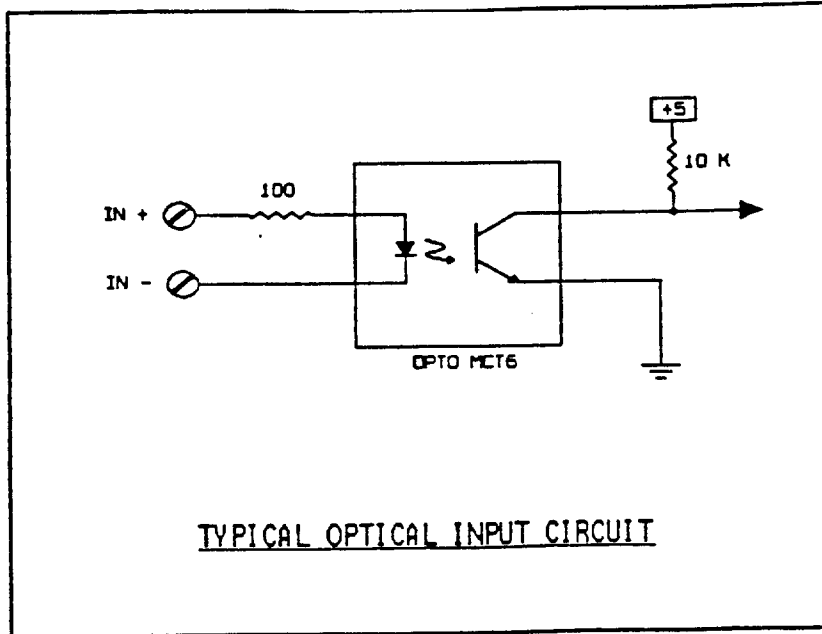
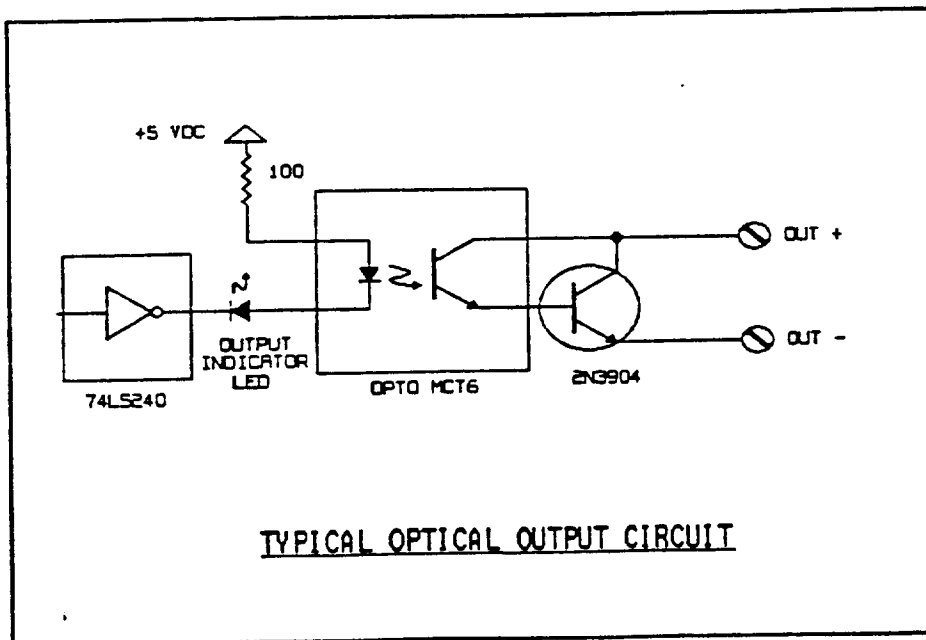


Figure 2.2 Optical Output Circuit



2.1.2 ISOLATED OUTPUTS: "OUT A" through "OUT D"

The second eight *ISOLATED* screw terminals are connected to the four optically isolated outputs, two terminals each.

Each output consists of an opto-driven "Darlington" transistor with the collector and emitter brought out to the terminals. Transistors are normally "off" but will conduct at least 50 milliamperes from the "+" to the "-" terminal when the output is turned on. These outputs are normally used as a small signal DC "switch".

A series current limiting resistor is required to prevent transistor damage, a resistance of 20 ohms or more per volt is suitable. The voltage between the two terminals must not exceed 40 volts. Figure 2.2 above shows the circuit configuration.

The easy way to turn on an output is to use the BASIC DIO (discrete I/O) instruction.

Otherwise, these outputs are controlled by the 8052 as the most significant 4 bits of an output port (address FC09h). The four bits are normally written to the port as a number. The lower four bits are unused. Discrete output bits must be logically isolated for individual access. The most significant bit (bit 7) of the port register corresponds to "OUT D", and bit 4 corresponds to "OUT A". An output is off when its associated bit in the output port register is zero.

Typical I/O Connections:

- Relays
- Programmable Controller/Computer inputs
- Power Transistors

References:

Accessing outputs:	Section 4.2.2: DIO Instruction
Optical isolators:	Section 2.1: I/O Specifications
I/O Connections:	Appendix C: Sample I/O

2.2.3 ISOLATED RESET INPUT: "RST+" and "RST-"

When the Reset input is energized, it resets the 8052 processor, turns off all outputs (except the *ANALOG* and *DIR* outputs) and restores the B52 to its power up state. This input may serve as a Panic Stop input, but all program data in volatile memory will be lost when the 8052 is reset.

Reset input ON current is 20 to 40 mA.

2.2.4 ENCODER INPUTS: "CH A+" through "CH Z-"

These terminals are designed to allow connection of a two phase linear or rotary incremental encoder with index channel. Encoder feedback is used to monitor position or speed.

Channels A and B are connected through a quadrature detector circuit to 16 bit counters with interrupt capability. Channel B also goes to a separate counter. Pulse counting operations are normally done with this Channel B counter.

The *ENCODER* inputs may be programmed for alternate functions as follows:

quadrature detection	(CH A and B)
pulse counting	(CH A and B)
interrupt input	(CH Z)
counter/timer retrigger	(CH Z)
level detection	(CH A, B, and Z)
general purpose input	(CH A, B, and Z)

The easy way to manage quadrature counting is with the BASIC *QUAD* instruction. Pulse counting operations use the *CTR* instruction.

The encoder outputs should be TTL compatible, with or without complementary outputs. The encoder must be externally powered with a +5 VDC power supply. B52 encoder inputs are compatible with line driver, or TTL encoder outputs and are "pulled up" internally to accommodate open collector encoder outputs. Figure 2.3 below shows the circuit configuration.

The complementary inputs (*CH A-*, *B-*, and *Z-*) are not required. They should be left unconnected if unused. If so, the "+" input drives comparators which will switch at a nominal 2.5VDC input voltage with 100 mV hysteresis. Forcing a reference voltage onto any "-" input allows changing the threshold switching voltage for that channel.

Encoder input signals are referenced to the GROUND terminals, so the external supply Common must be connected to GROUND. See Section 2.5 on GROUNDING below.

Typical uses:

- Positioning feedback
- Rate measurement feedback
- Parts counting
- Sensor threshold detection

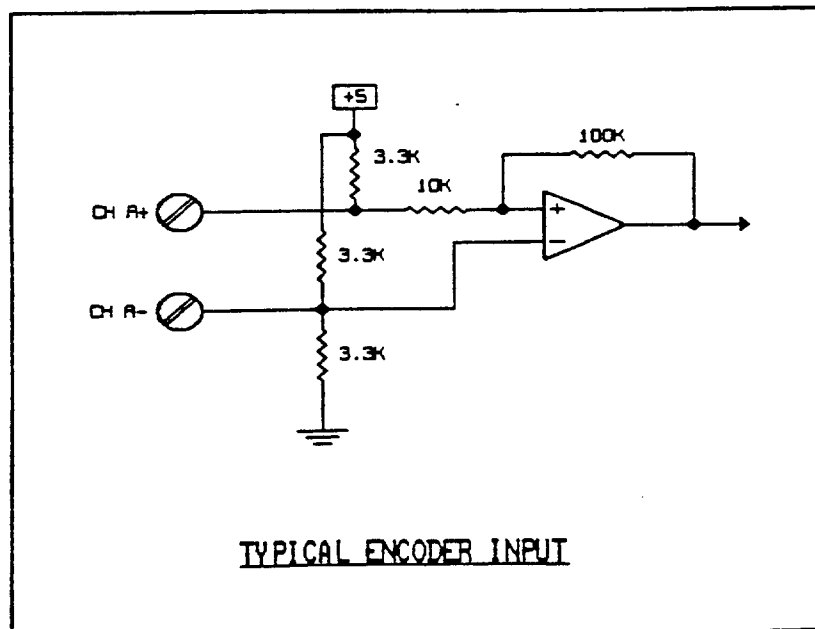
Typical I/O Connections:

- Incremental encoders
- Proximity sensor (timing, interrupt)
- Transducers (level sensing, interrupt)

References:

- | | |
|----------------------|---------------------------------|
| Accessing inputs: | Section 4.2.2: DIO Instruction |
| Quadrature counting: | Section 4.2.5: QUAD Instruction |
| Pulse counting: | Section 4.2.4: CTR Instruction |
| Interrupts | Section 4.4 |
| I/O Connections: | Appendix C: Sample I/O |

Figure 2.3 CH A, CH B, and CH Z input circuits



2.2.5 MOTOR OUTPUTS: "STEP+" through "DIR-"

These two pairs of terminals have TTL level outputs which will both sink and source in excess of 25 milliamperes. One output pair is a pulse output, controlled by the PWM output of the 8052 microprocessor. The other is a level output which may be set high or low by the programmer. For either pair, the "-" output state will be opposite that of the "+" output.

These outputs are compatible with Compumotor motor drives. They mate with the optically isolated Step and Direction inputs typical of these drives. In practice, they may be used for any practical purpose requiring frequency control, timed pulse width, or just a single on/off control output.

The Step output frequency range is approximately 7 Hz to 23 kHz. Pulse widths are controllable in increments of 1 microsecond from 21.7 usec to 17.1 msec. Frequency resolution is much better at the lower frequencies.

The pulse output may also drive an on board counter if independent pulse counting is desired.

Typical uses:

- Motor Positioning control (jog)
- Audible signal generation
- Pulse width modulation

Typical I/O Connections:

- Stepping Motor and Regenerative drives
- Speakers or other Audible devices
- Solid state relays

References:

Level output:	Section 4.2.2: DIO Instruction
Signal generation:	Appendix C: Sample I/O
Pulse generation:	BASIC Manual: Chapter 4.2.7
Motor control:	Section 4.1.6: Motor Control

2.2.6 ANALOG OUTPUT and GND

The analog output is driven by an eight bit digital to analog converter (DAC). The device used is the Analog Devices AD7524. The output voltage is referenced to ground (*GND*), and some care must be taken when making remote connections. See Section 2.5 on GROUNDING below.

This output signal has a voltage range of +10 to -10 volts, suitable for controlling a servo amplifier or other voltage controlled device. The BASIC **ANLG** instruction sets the output voltage.

The output voltage range is divided into a total of 256 increments of 78 mV. An external attenuator (voltage divider) may be added to reduce the range and increase the resolution.

This is not a power output, and must be amplified for any power application. Maximum output current is 10 mA. The output device is an operational amplifier, LM324.

Typical uses:

- Motor Speed control
- Power level control

Typical I/O Connections:

- Servo amplifier
- Power amplifier

References:

Setting output value: Section 4.2.1: **ANLG** Instruction

2.2.7 ANALOG INPUTS: "IN#1" through "IN#4"

The analog inputs feed a multichannel eight bit analog to digital converter (ADC). This device is the National Semiconductor ADC0809. The inputs are is referenced to ground (*GND*), and some care must be taken when making remote connections. See Section 2.5 on GROUNDING below.

Input voltage can be read using the BASIC **ANLG** instruction.

In the factory configuration, these inputs have a nominal input voltage range of +10 to -10 volts, for monitoring devices with variable output signal voltages.

With this input range, an input channel voltage is resolved in 256 increments of 78 mV. Internal components may be removed or altered to reduce the input range and increase the resolution. Socketed resistor networks can be removed or reinstalled to set the nominal input range to one of the following:

- 0 to 1 volt
- 0 to 10 volts
- 1 to +1 volt
- 10 to +10 volt

The input amplifier circuit consists of three sections. These include an input attenuator, the amplifier, and an output attenuator.

The input attenuator reduces the input signal amplitude by a factor of 10. The amplifier has a gain of 10. The output attenuator attenuates the signal by a factor of 2 while adding a 2.5 volt offset to convert a bipolar input signal to the ADC's required 0 to 5 volt range. The input attenuator and the output offset may be eliminated by unplugging components.

Typical uses:

- Temperature measurement
- Pressure measurement
- Position measurement

Typical I/O Connections:

- Temperature transducer
- Pressure transducer
- LVDT

References:

- Input range: Section 2.6.1: Configuring inputs
- Monitoring inputs: Section 4.2.1: ANLG Instruction

2.3 PARALLEL I/O Connections

In the standard configuration, the B52 has 24 outputs accessible on the *PARALLEL OUTPUTS* connector, and 24 inputs accessible on the *PARALLEL INPUTS* connector. These connectors are configured to be plug compatible with standard signal conditioning equipment.

2.3.1 PARALLEL OUTPUTS

The output drivers are TTL "bus" drivers (74LS244 and 74LS245) which can be used to drive whatever falls within their specifications. Outputs can be individually set high or low, or they can be used eight at a time for byte output functions. All 24 outputs (and the *ISOLATED* outputs) can be disabled (high impedance).

These outputs are assigned numbers (0 through 24) for reference, numbers which correspond to their associated module numbers on an I/O rack. This numbering convention is used when controlling outputs with the *DIO* and *SCAN* instructions. (These output numbers are also arranged in the logical order in which they would be addressed in software.)

PARALLEL OUTPUT drivers DO NOT invert the output signal. Write a "0" to a given output port bit to switch that output at the connector will switch from a high to low voltage. A "1" will set the output high again.

NOTE: Outputs 0 through 7 are driven by the 74LS245. This is a bi-directional device. When configured for input, these eight are assigned input numbers 100 through 107.

Typical uses:

- Solid state relay power outputs
- Discrete TTL signal outputs
- Binary or BCD byte or word output

Typical I/O Connections:

- I/O racks
- Remote device control signals
- Data bus

References:

Output control: Section 4.1.3: DIO Instruction
Connector pin numbers: Appendix A

2.3.2 PARALLEL INPUT

These inputs are assigned numbers (0 through 24) for reference, numbers which correspond to their associated module numbers on an I/O rack. This numbering convention is used when reading inputs with the DIO and SCAN instructions. (These input numbers are also arranged in the logical order in which they would be addressed in software.)

Inputs can be read individually as high or low (1 or 0), or they can be read eight at a time for byte input functions.

Typical uses:

- Solid state relay power inputs
- Discrete TTL signal inputs
- Binary or BCD byte or word input

Typical I/O Connections:

- I/O racks
- Remote device signal monitoring
- Data bus
- Absolute encoder

References:

Input read: Section 4.1.3: DIO Instruction
Connector pin numbers: Appendix A

2.4 RS-232 CONNECTIONS

The B52 comes equipped with four RS-232C communication ports. Two of the ports are intended for remote device control (for Compumotor CX series indexer/drives for instance). The other two are for the use of the programmer or operator. One is dedicated to the operator's console, the other is dedicated to be a printer output port.

All RS-232C ports are three wire implementation. Handshaking protocol is not supported by the Model 52. Communication devices having this feature must be configured to match, or may have to be "tricked" into accepting their own signals as the required handshake. To implement this, it is necessary to connect pin 4 to pin 5 and pin 6 to pin 20 on the standard 25 pin connector.

The B52 does support XON/XOFF protocol on the Console and the two auxiliary RS-232 ports to control transmission rates.

This function cannot work on the Printer port, however because it has no receiver input. All four ports are configured as Data Communications Equipment (DCE) as opposed to Data Terminal Equipment (DTE). This means the ports transmit from pin 3 and receive on pin 2 of the standard 25 connector. This makes them compatible with terminal devices, and most personal computers using a standard pin to pin RS-232 cable.

NOTE: There is no cable shield connection in the B52. RS-232 cable shields should be tied to Earth at the other end. Cable length should be limited to 50 feet.

2.4.1 *PRINTER* PORT

This output, labelled *PRINTER* is a minimal RS232 implementation. There is no facility for halting printer output to wait for the printer to catch up. As such, the printer port should be set for a low Baud rate.

This output may be best suited to driving remote RS-232 display devices.

The **BAUD** instruction must be issued to set this Baud rate prior to printing anything.

This output is accessed by the **PRINT#** and **LIST#** instructions.

Typical uses:

- Remote device control
- Text display
- Printer

Typical I/O Connections:

- Compumotor indexers
- Display terminal

References:

Printer: BASIC-52 USERS MANUAL: Chapter 4.1

2.4.2 RS-232 USER PORTS

These two ports, labelled *RS232#0* and *RS232#1*, may only be accessed from within a program. The programmer has full control of these ports for input and output using supplied custom instructions. The COM instruction sets up port protocol, XMT and RCV are used to transmit and receive characters.

Typical uses:

- Remote device control
- Text display
- Printer
- System communications

Typical I/O Connections:

- Compumotor indexers
- Display terminal
- Master computer

References:

RS-232: Section 4.2.6: COM Instruction
 Section 4.2.7: XMT Instruction
 Section 4.2.8: RCV Instruction

2.5 GROUNDING

There are two terminals labeled *GND* available. These are the zero volt reference point for all terminal connections not marked *ISOLATED*. They also happen to be the ground reference point for the 8052 microprocessor itself. Consequently, connections at these terminals that are brought out into the environment have the potential to pick up enough electrical interference (noise) to knock out the processor. When remote wiring is called for, using the *STEP* and *DIR* outputs, the *ANALOG* I/O, or the *ENCODER* inputs, steps should be taken to protect the B52 from environmental electrical fields.

A terminal is provided marked *SHIELD*. Cables attached to the terminals mentioned should be shielded from electrical interference, and the shield should be connected to its own terminal. This *SHIELD* terminal has a direct connection to power line *EARTH* and the chassis of the B52. There should not be any connection between the above *GND*, and the *SHIELD* terminal.

The Earth-to-Ground connection will often be made on some other piece of associated equipment. Multiple earth to ground connections can result in a "ground loop" creating mysterious failure modes.

Use of the differential outputs *STEP* and *DIR* may not require shielding, but when no shield is present, using twisted pairs of wires would give some protection from electrical interference.

Note: There is no Shield connection on the two auxiliary RS-232 port connectors. Cabling to these ports should be shielded at the other end of the cable to insure the integrity of transmissions.

2.6 Analog Input Details

2.6.1 CONFIGURING ANALOG INPUTS

Figure 2.4 below depicts the circuit schematic of a typical analog input channel. Each channel consists of an input attenuator, the amplifier, and an output attenuator. In the factory configuration, the input attenuator divides the input signal voltage by ten. The amplifier multiplies the attenuated input signal by ten, and the output attenuator divides it again by four while adding an offset voltage. This offset makes a zero volt input correspond to midrange (2.5 VDC) of the Analog to Digital Converter. Resolution is 78.025 mV.

Total signal voltage range into the ADC must be 0 to 5 VDC. Voltages outside this range are "clipped" by the circuit to protect the ADC. In the figure below, if the resistor marked R1 is removed from the circuit, the input attenuator is eliminated. This increases the input resolution for low level signals by a factor of 10. Input range becomes -1 to +1 volt.

If the resistors marked R2 and R3 in the figure are removed, the output attenuation is reduced from a factor of 4 to a factor of 2, and the offset is eliminated. Input range is reduced to 0 to 1 volt. Resolution becomes 3.90625 mV.

The intent of this circuit arrangement is to allow two bipolar and two single ended input ranges.

Figure 2.4 Analog input circuit

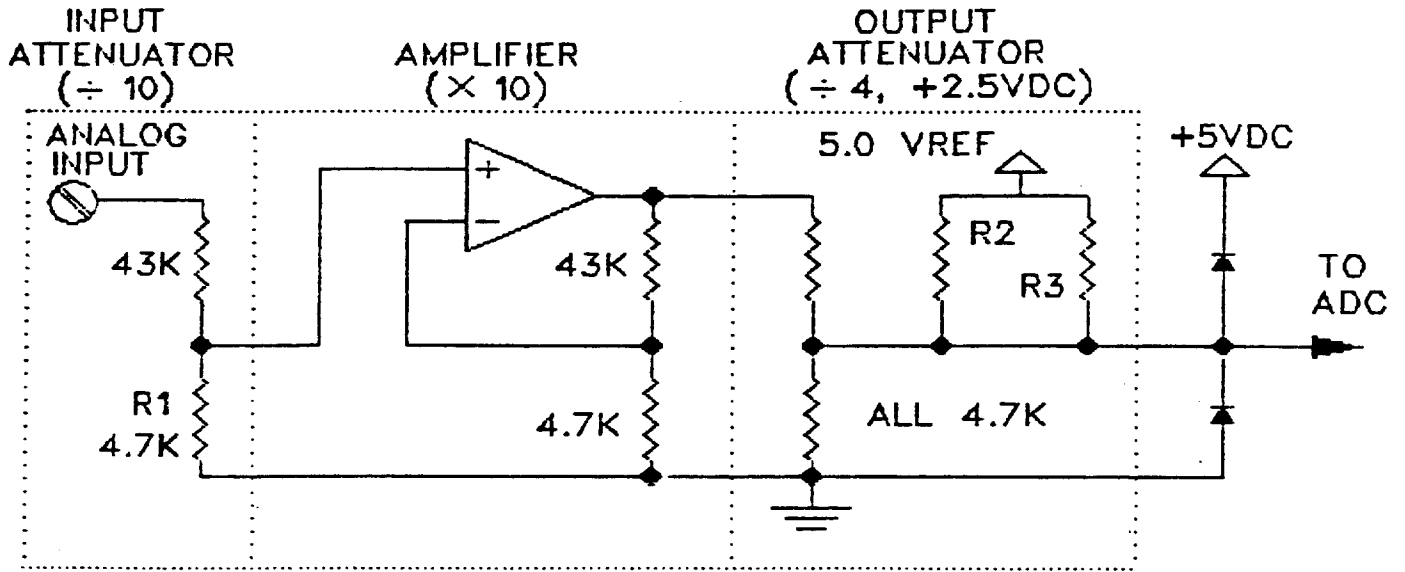
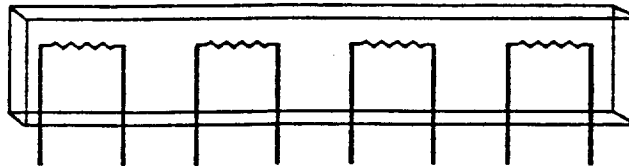


Figure 2.5 Resistor network circuit (Bourns 4308R-102-472)



The input attenuation network which can be removed is referred to as U47. Removing this network will eliminate the input attenuator for all four channels. Removable Output attenuation networks are referred to as U45 and U46. Network U46 provides output attenuation and offset for channels *IN#1* and *IN#2*, network U45 for channels *IN#3* and *IN#4*. All resistor networks may be located on the circuit board using the circuit assembly drawing in Appendix E. The internal network circuit is shown in Figure 2.5 above.

Installing and removing various resistor networks has the following effect:

<u>Installed</u>	<u><i>IN#1</i></u>	<u><i>IN#2</i></u>	<u><i>IN#3</i></u>	<u><i>IN#4</i></u>
U47,U46,U45	±10 VDC	±10 VDC	±10 VDC	±10 VDC
U47,U46	±10 VDC	±10 VDC	10 VDC	10 VDC
U47,U45	10 VDC	10 VDC	±10 VDC	±10 VDC
U46,U45	±1 VDC	±1 VDC	±1 VDC	±1 VDC
U47	10 VDC	10 VDC	10 VDC	10 VDC
U46	±1 VDC	±1 VDC	1 VDC	1 VDC
U45	1 VDC	1 VDC	±1 VDC	±1 VDC

The input attenuator is simply a voltage divider circuit using standard component values in a ratio of 9 to 1. Selection of resistance values for R1 in the figure would allow controlling the amount of input attenuation according to the formula:

$$\text{Attenuation factor} = 43,000 + R1 / R1$$

The factory value for R1 is 4,700 ohms. Resistors used in the Model 52 are Single In-line Package (SIP) networks. The adventurous hardware designer may attempt selection of discrete resistors for installation in place of the network to achieve different attenuation levels for each input channel.

Step by step approach:

1. Determine the actual input signal voltage range
2. Configure the output offset attenuator for bipolar or single ended input signals
3. Configure the input attenuator to account for amplifier gain and output attenuation

Final signal voltage for measurement should be restricted to the 0 to 5 volt range. The ADC is protected from excessive positive or negative voltages, but these will be outside the measurement range.

2.6.2 ANALOG INPUT ACCURACY

The basic accuracy of the Model 52 analog inputs depends on the accuracy of the following components:

- ADC0809 Analog to Digital Converter - ± 1 LSB
(0.4% of full scale)
- AD584 Voltage Reference - ± 15 mV
(0.3% of full scale)
- Resistor networks - $\pm 2\%$

Clearly the absolute accuracy is limited by the accuracy of the resistive components. Although the absolute accuracy is only 2% from network to network, the tolerance between resistors in the same network will be more like 0.1%. The distribution of resistive networks in the Model 52 analog input circuit is such that each channel will behave like the other three to this tolerance.

Improved accuracy can therefore be obtained by using the analog inputs in a relative measurement mode, where a voltage reference is connected to one of the four channels. This technique calls for measuring the reference and determine whatever corrections may be needed. This correction is then applied to measurements made on the other channels. Any resulting errors will be due to variation between single resistors within a resistor network.