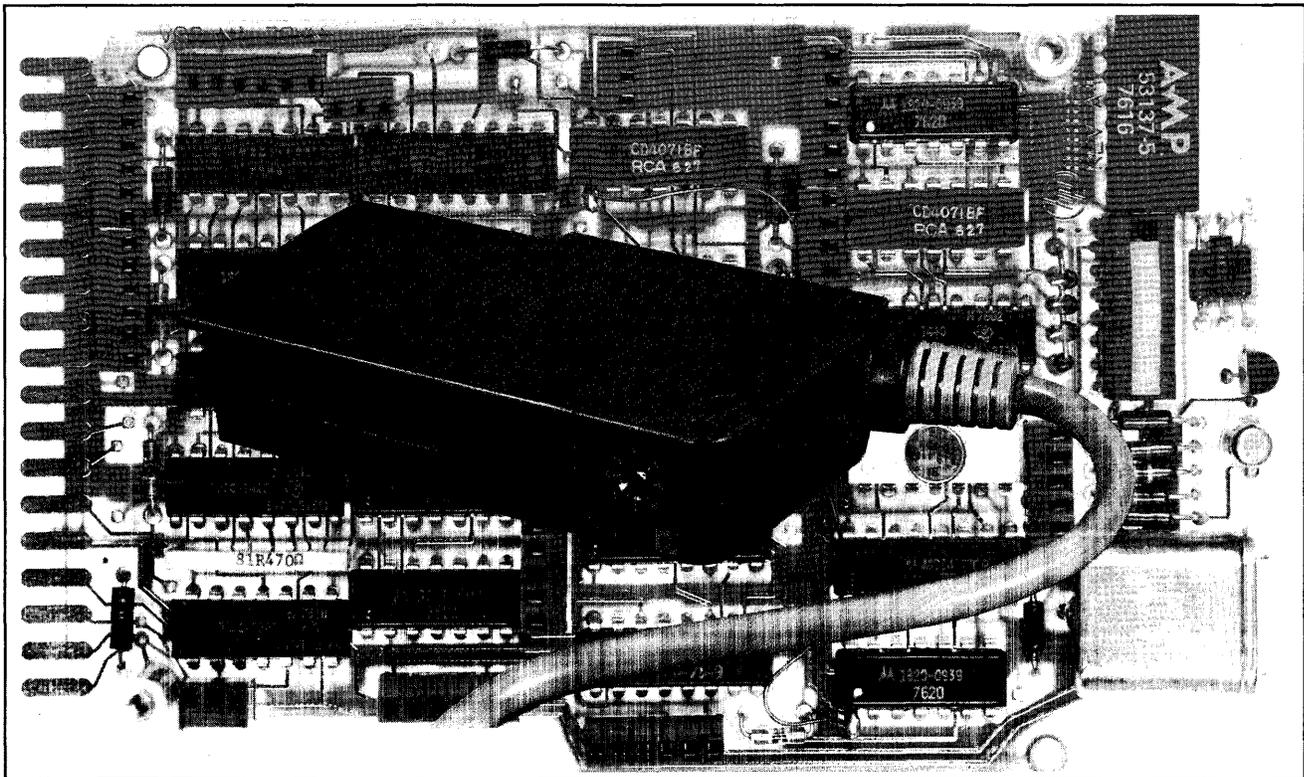


# Hewlett-Packard 98036A Serial I/O Interface Installation and Service Manual





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# 98036A Serial I/O Interface Installation and Service Manual



**Hewlett-Packard Desktop Computer Division**  
3404 East Harmony Road, Fort Collins, Colorado 80525  
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# Chapter 1

## General Information

### Introduction

This manual describes the installation and operation of the 98036A Serial I/O Interface when used with a 9825A Calculator and a data communications device. Theory of operation and troubleshooting chapters are also included to provide servicing information.

### Background on Data Communications

Data Communications is the means by which data is transmitted from one point to another. A computer can be hooked directly to a remote terminal using special transmission lines, but for long distances, this becomes impractical. Although common telephone lines can be used, there is one drawback: telephone lines are made for analog signals (e.g., the voice), not digital signals like those generated by a computer. A modem\*, or a signal converter, must be used for converting signals from digital to analog and vice-versa.

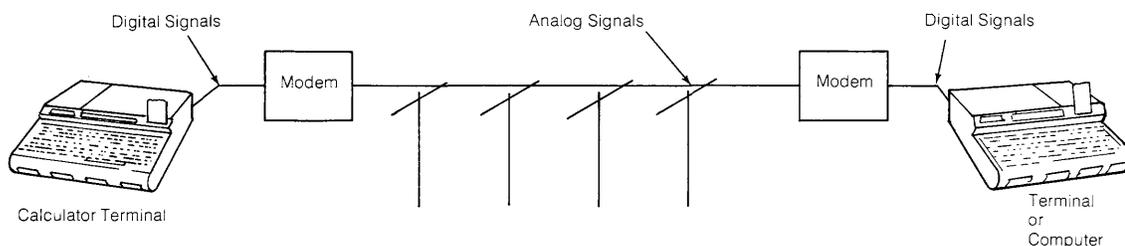


Figure 1. Modem Conversion Process

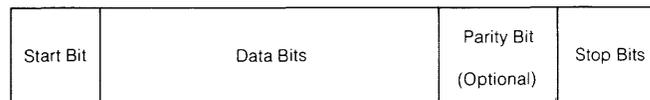
The modem converts outgoing digital signals to analog form and incoming analog signals to digital form (Figure 1). Since there are many different ways to do these conversions, it is important that what is converted to analog is reconverted to the correct digital form and vice-versa. So, the modem on one end of the telephone line must understand, or be compatible with, the modem on the other end.

Modems can be classified as asynchronous or synchronous, half- or full-duplex, and by data rate or modulation technique.

\*"Modem" is a contraction of the words modulator and demodulator.

## 2 General Information

Asynchronous transmission is often referred to as START-STOP. This is because the data is sent serially one character at a time along with start and stop bits. These start and stop bits are used to separate characters and to synchronize the receiver with the transmitter for each character since the modem itself does not provide clocking information. When the signal elements or bits of a character travel in sequence over the line, it is called a serial transmission. With the start and stop bits added, this is called serial start-stop or serial asynchronous, meaning each character is individually synchronized. This type of transmission is normally used at data rates less than 2400 bits per second.



**Asynchronous Mode Transmission**

Modems can operate in three different modes: simplex, where data is sent only or received only; half-duplex, where data can be both sent and received – but not simultaneously; and full-duplex, where data can be simultaneously transmitted and received, eliminating turn-around time.

Half-duplex is normally used for high speed batch transmission where fewer line turn-arounds are needed and full channel capacity (bandwidth) is needed for transmission in one direction. Full-duplex is often used for timesharing even though it seldom occurs that data is truly being transmitted and received simultaneously. The one case where simultaneous transmission does occur is when a “Break” is sent to the timeshare computer. A single dial-up line can be used for full-duplex but this limits the maximum data rate to about 300 bits per second. The reason for full - duplex timesharing is to provide transmission error checking by having the computer “echo” or retransmit each character input from the terminal.

The most commonly referenced operational characteristic of a modem is its speed or data rate expressed in bits per second (bps) or bauds. For simple low speed modulation techniques, one bit per second into a modem may equal one baud on the analog side. However, at higher data rates with more complex modulation techniques, it is possible to encode more than one bit per signal change (or baud) on the telephone line. In this case, bits per second (into the modem) and bauds (on the telephone line) are two different units. The following list gives a general classification of modems by speed:

Low Speed 75 – 1800 bits/second

Medium Speed 2000–4800 bits/second

High Speed 7200–9600 bits/second

## 98036A Description

The HP 98036A Serial I/O Interface allows the 9825A Calculator to communicate with serial asynchronous data communication devices. The 98036A is equipped with both RS-232C and 20ma current loop drivers and receivers for the data transmitter and receiver. Data can be transferred at bit rates of 75 to 9600 bits per second. The interface is capable of asynchronous communication. A universal receiver/transmitter integrated circuit (USART) is used to manipulate data and provide the basic hardware protocol for asynchronous operation. Either the General I/O ROM or the General and Extended I/O ROM combination must be installed in the calculator to use the interface. The interface is available with two cable configurations to allow the calculator to act as a data terminal or the digital portion of a modem\*.

## Specifications

Power Requirements: +5V at 300ma typ. 400 max.  
(from calculator) ±12V at 20ma typ. 40 max.

Operating Temperature Range: 0° C to 45° C

Bit Rates: 9600, 4800, 2400, 1800, 1200, 600, 300, 150, 110, and 75 bits per second.

Mode of Operation: Asynchronous

Data Buffer: Transmitter-one character  
Receiver-one character

Dimensions: Approximately 16.3 x 8.9 x 3.8cm (6.4 x 3.5 x 1.5 inches)

Net Weight: 4.16 kg (1 lb. 14 oz.)

Cable Length: 2 meters (6.5 ft)

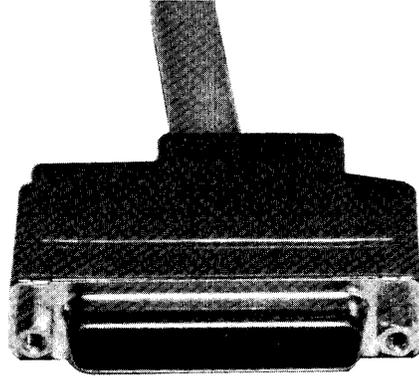
## Cable Options

The 98036A Interface is available in two configurations.

The standard 98036A Interface cable is shipped with a 2 meter (6.5 ft.) cable terminated with a standard female EIA 25 pin connector. The standard interface is connected between the calculator and data terminal.

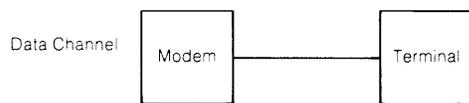
\*The calculator does not perform digital-to-analog or analog-to-digital conversions, it simply transmits and receives digital signals to and from a terminal.

#### 4 General Information

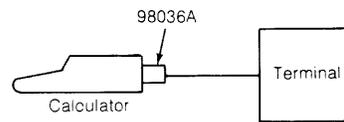


**Standard Cable Connector**

Using the standard interface cable, the calculator takes the place of a modem or computer communicating with a terminal.

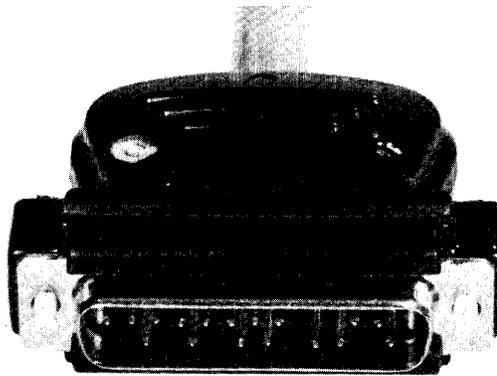


**Using Normal Data Communications**



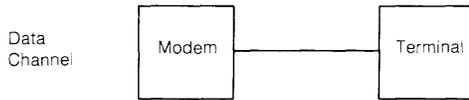
**Using 9825A/98036A (Standard)**

The 98036A Option 001 Interface cable is shipped with a 2 meter (6.5 ft.) cable terminated with a standard male EIA 25 pin connector. The option 001 interface is connected between the calculator and a modem.

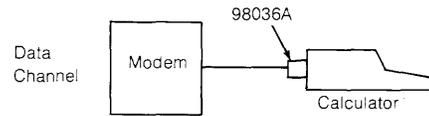


**Option 001 Cable Connector**

Using the option 001 interface cable, the calculator acts as a data terminal connected to a modem.



Using Normal Data Communications



Using 9825A/98036A (Option 001)

Here is a list of the signal lines and the corresponding connector pin numbers used in the standard and option 001 cables.

Table 1. Cable Signals

98036 Standard Cable  
(Female Connector Connects to Terminal)

Pin No.	Signal Name	Signal Direction
1	Protective Ground	N/A
2	Transmitted Data	Device to 98036
3	Received Data	98036 to Device
4	Request To Send	Device to 98036
5	Clear To Send	98036 to Device
6	Data Set Ready	98036 to Device
7	Signal Ground	N/A
8	Carrier Detect	98036 to Device
9-11	Unused	
12	Secondary Carrier Detect	98036 to Device
13-18	Unused	
19	Secondary Request to Send	Device to 98036
20	Data Terminal Ready	Device to 98036
21	Signal Quality Detect	98036 to Device
22	Ring Indicator	98036 to Device
23	Data Signal Rate Selector	Device to 98036
24	Transmitter Clock	Device to 98036
25	Unused	

**Table 1. Cable Signals (cont.)**

98036 Option 001 Cable  
(Male Connector Connects to Modem)

Pin No.	Signal Name	Signal Direction
1	Protective Ground	N/A
2	Transmitted Data	98036 to Device
3	Received Data	Device to 98036
4	Request to Send	98036 to Device
5	Clear To Send	Device to 98036
6	Data Set Ready	Device to 98036
7	Signal Ground	N/A
8	Carrier Detect	Device to 98036
9	Unused	
10	Unused	
11	Special Purpose	98036 to Device
12	Secondary Carrier Detect	Device to 98036
13	Unused	
14	Unused	
15	Transmitter Clock	Device to 98036
16	Unused	
17	Unused	
18	Unused	
19	Secondary Request To Send	98036 to Device
20	Data Terminal Ready	98036 to Device
21	Unused	
22	Ring Indicator	Device to 98036
23	Data Rate Select	98036 to Device
24	Unused	
25	Special Test	98036 to Device

## Chapter 2

# Installation

### Introduction

Before installing the interface in your system it will be necessary to configure the interface for your particular system or mode of operation. This chapter describes how to configure and install the 98036A Interface. The interface switches set the power-on default condition of the interface. This default condition is used when power is applied or the calculator is reset.

### Interface Housing Disassembly

To access the various interface configuration switches it is necessary to separate the interface housing cases. Use the procedure below and refer to Figure 2 to access the switches.

1. Remove the four screws that hold the rear housing to the front housing.
2. Pull the rear housing off the front housing slightly, disconnect the cable connector from the PC assembly and remove the rear housing.
3. Remove the remaining four screws in the front housing and separate the front housing cases.
4. Carefully separate the printed circuit assemblies.
5. The various interface switches are shown in Figure 3.
6. After setting the switches, reverse this procedure to assemble the interface. Be sure that the pins on the A2 assembly are properly seated in the connectors on the A1 assembly.

## 8 Installation

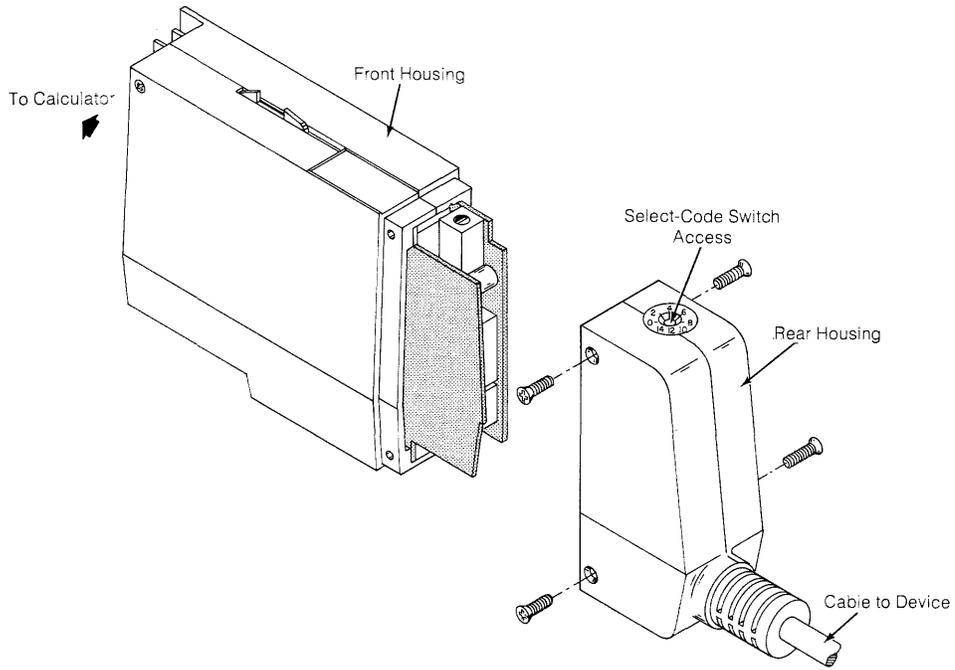


Figure 2. Interface Disassembly

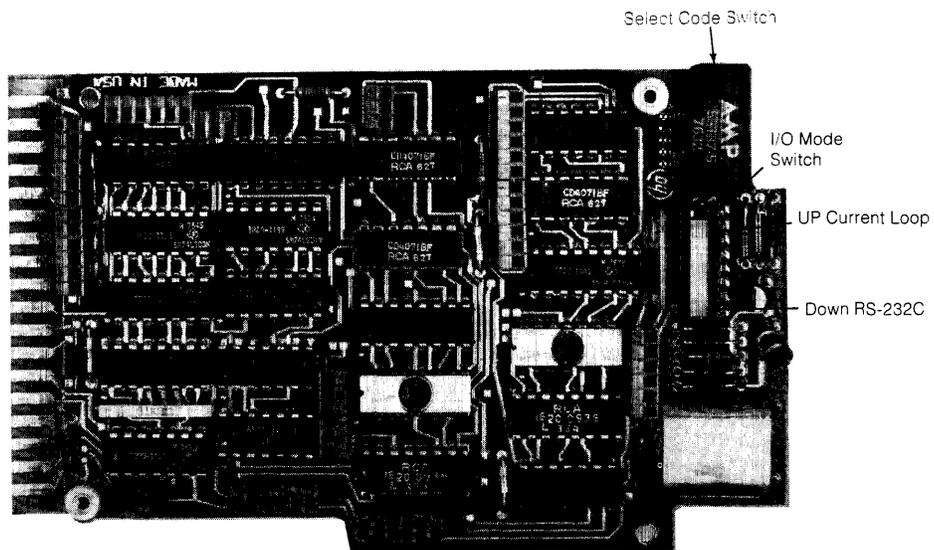


Figure 3. Interface Configuration Switches

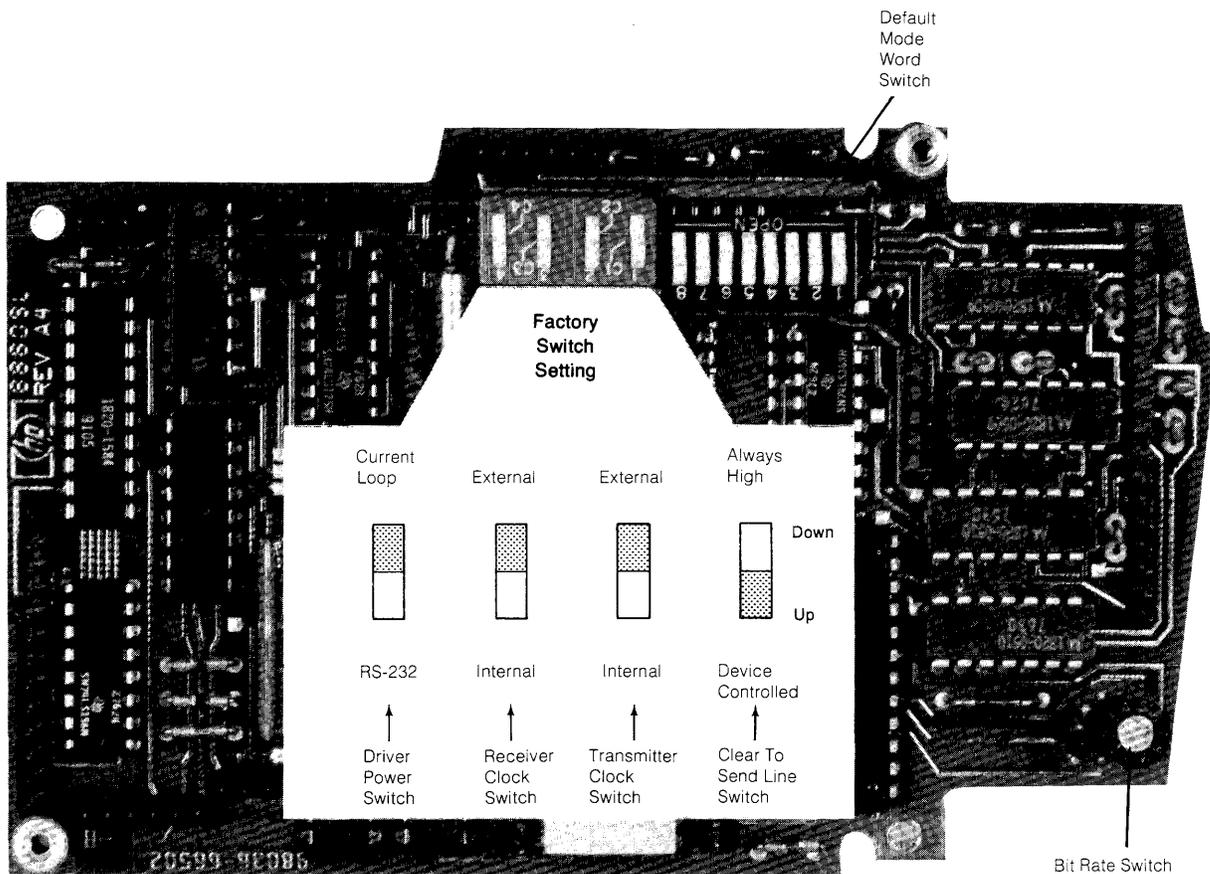


Figure 3. (cont.)

## Interface Configuration Switches

The following presentation describes how to set each of the interface configuration switches.

The questions below will help you determine how the interface switches should be set.

- What select code will you use?
- What is the bit rate?
- Will operation be RS-232 or current loop?
- Will the internal clock be used for the transmitter and receiver clock?
- Does your data communications device provide the clear to send line (option 001 cable)?
- Does your data communications device provide the data terminal ready line (standard cable)?

- What is the bit length of the characters to be transferred?
- Will parity be used?
- Even or odd parity?
- How many stop bits will be used?
- What bit rate factor will be used?

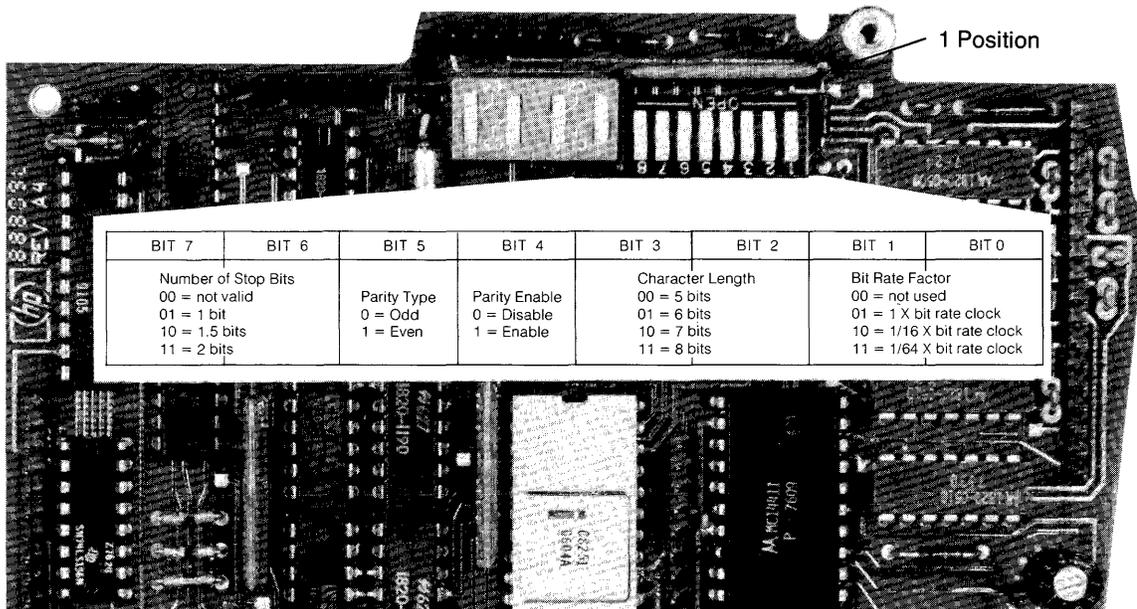
## Factory Switch Settings

The interface configuration switches are preset at the factory as follows:

- Select code (Standard cable) – 10
- Select code (Option 001 cable) – 11
- Bit rate – 300 bits/second
- RS-232 operation selected
- Internal transmitter and receiver clock used
- Clear to send line is pulled up
- Character length set to 8 bits
- Parity is disabled
- 2 stop bits are selected
- The bit rate factor is 1/64

## Mode Word Switches

The mode word switches (see Figure 3) determine the default mode word used by the interface. The mode word determines the mode of interface operation. The default mode word is used when power is applied to the interface or when the interface is reset. The default mode word can be overridden by subsequent mode words from the calculator. Here is a description of each mode word bit position.



Any switch set to the open position sets the switch to a logical 1 (high). Any switch set to the opposite position sets the switch to a logical 0 (low).

- Bits 7 and 6 – Determine the number of stop bits used.
- Bit 5 – Determines whether odd or even parity is to be used (when parity is enabled).
- Bit 4 – Enables or disables parity
- Bits 3 and 2 – Indicate the length of the characters that are to be transferred.
- Bits 1 and 0 – Determine the internal bit rate factors. Characters can be transferred at the rate of the bit rate clock, 1/16 the rate of the bit rate clock, or 1/64 the rate of the bit rate clock. The 1/64 position is recommended for increased immunity to signal distortion.

#### NOTE

Do not use the 1/64 bit rate factor setting when the bit rate is set to 4800 or 9600 bits per second. Use the 1/16 bit rate factor.

**NOTE**

Setting bits 1 and 0 both to zeros will result in erroneous interface operation. Do not operate the interface with bits 1 and 0 of the mode word both set to zero.

## Input/Output Mode Switch

Set the I/O mode switch (See Figure 3) for either RS-232C or 20ma current loop operation depending on the device to be connected to the interface.

The RS-232C position is used when the interface is to be connected to a data terminal or a modem.

The 20ma current loop position is used when the interface is to be connected to some teletype terminals. Only the transmit data and receive data lines are switched in current loop operation. The RS-232C control signals are not available in the current loop mode.

## RS-232C Driver Switch

If the I/O mode switch is set to the RS-232C position, the RS-232C driver switch must be set to the RS-232 position (see Figure 3).

If the I/O mode switch is set to the 20ma current loop position, the RS-232C driver switch must be set to the current loop position.

## Internal/External Clock Switches

External transmit and receive clocks may be used instead of the internal bit rate clock. This feature is not usually used for asynchronous operation. The external clock should have a 50% duty cycle. Be sure that the bit rate factor is the same as the external clock to bit rate ratio.

When either the transmit or receive clock switch is in the internal position, the internal bit rate clock is used. When either the transmit or receive clock switch is in the external position, an appropriate external clock must be input to the interface. See Table 1 for the cable signal line pin numbers.

## Clear to Send Switch

If the device connected to the interface does not provide the clear to send signal (data terminal read line), set the clear to send switch to the “always high” position. If the device does provide the clear to send signal, set the switch to the “device controlled” position.

## Bit Rate Switch

The bit rate can be set (through the hole on the side) without disassembling the interface. Set the bit rate switch to correspond to the bit rate of the data communications device connected to the interface. Here is a list of the available bit rates and switch positions to select each rate. Rotate the switch to the desired position with a small screwdriver.

Switch Position	Bit Rate	
1	9600	} Use 1/16 Bit Rate Factor (bits 0 and 1 of mode word)
2	4800	
3	2400	} Use 1/64 Bit Rate Factor (bits 0 and 1 of mode word)
4	1800	
5	1200	
6	600	
7	300	
8	150	
9	110	
0	75	

## Interface Select Code

The interface select code can be set (through the hole on the top) without disassembling the interface. The standard interface is preset to 10 at the factory. The Opton 001 interface is preset to 11 at the factory. The select code should be checked for the proper setting as required by your system. Each interface in your system must be set to a different select code. If necessary the select code can be set to any number of from 2 through 15 by rotating the switch to the desired position using a small screwdriver. A high interrupt priority select code (8 through 15) is recommended due to the nature of data communications.

### NOTE

Select codes 0 and 1 are internal calculator codes and must not be used.

## Interface Installation

After the interface configuration switches have been set, assemble the interface housing by reversing the disassembly procedure. Be sure that the pins on the A2 assembly are properly seated in the connectors on the A1 assembly. With the calculator switched off, install the interface housing into any one of the I/O slots on the back of the calculator. Connect the other end of the interface cable to an applicable data communications device (e.g., data terminal, modem).

## Recommended Circuits

The 98036A Interface is compatible with RS-232C data communication circuits. When using the 20ma current loop, the interface does not provide a +12V line for the teletype device. To operate the interface with the teletype, connect the teletype's data receiver and transmitter as shown in Figure 4.

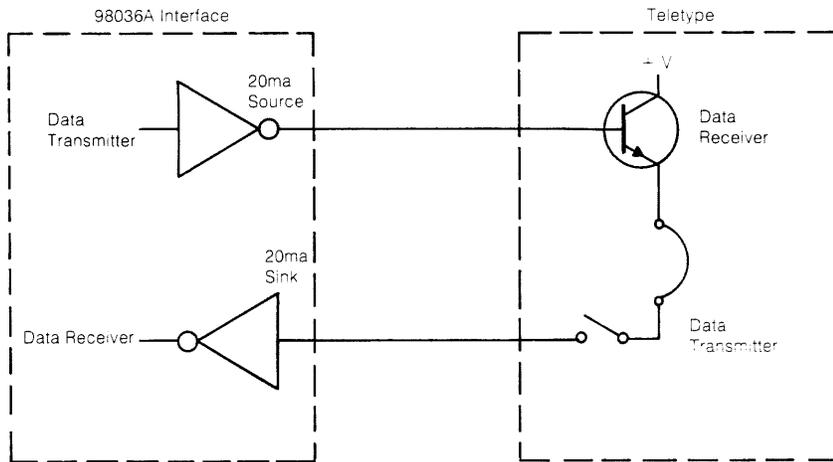


Figure 4. Current Loop Operation

# Chapter 3

## Operation

### Introduction

This chapter describes how to control and use the 98036A interface when it is connected to a 9825A Calculator and a serial data communications device. Either the General I/O or the General I/O and Extended I/O ROM must be installed in the calculator.

This chapter assumes that the user is familiar with the operation of the calculator and the General I/O or Extended I/O ROM.

### Interface Control

In brief, the 98036A is controlled by using the General I/O and Extended I/O ROM statements. By writing to and reading from the interface, internal interface registers (R4, R5, and R6) can be written into and read from to control and monitor the interface operation. R4 and R5 are controlled by General I/O ROM statements. R6 is controlled by Extended I/O statements. Each register is 8-bits long. Each register bit enables or disables an interface function or operation. In the following description of the registers, notice that some of the R4 and R6 bit definitions are different depending on whether the standard or option 001 cable is used.

Figure 5 is a summary of the R4, R5 and R6 registers. Figure 6 shows the sequence used to access each of the registers.

### Bit Position Values

Each 8-bit register (R4, R5 or R6) has a decimal value assigned to each bit. To set a bit in a register, output the decimal number equivalent to that bit. For example: to set bit 4 to a 1, output decimal 16.

Bit Position	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Decimal Value	128	64	32	16	8	4	2	1

## 16 Operation

To set bits 5, 4, and 1, add the values of those bits and output that decimal number (i.e.,  $32 + 16 + 2 = 50$ ).

In this manner, any bit or combination of bits can be set in the R4, R5 and R6 registers.

When writing into a register, all the register bits are accessed. Thus when changing a bit in a register, the entire register word must be sent. For example, setting only bit 3 of a register will clear all the other bits of that register. Always send the total value of a register when setting or changing a register.

## R5 Registers

There are two R5 registers. R5 OUT holds the interface control word. The interface control word is sent to the R5 OUT register using a write control (wtc) or write interface (wti) statement from the calculator.

### NOTE

The write control statement can not control bits 7, 6 and 4 of R5 OUT. The enable interrupt statement (eir) should be used to control these bits.

R5 IN holds the interface status word. The interface status word is read by the calculator with a read status (rds) statement.

Here is a description of the R5 OUT and R5 IN bit positions.

### R5 OUT Register

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Interface Interrupt Enable	—	Programmed Interface Reset	—	—	Interrupt Control 2 Receiver Control	Interrupt Control 1 Transmitted Control	R4 Control 0 = Data IN/ OUT 1 = Control/ Status

Bit 7 – When bit 7 is a 1, the interface is enabled to interrupt the calculator's operation. The enable interrupt statement usually used to set this bit. Either bit 1 or bit 2 should be a 1 when bit 7 is a 1.

Bit 6 – Not used

Bit 5 – When bit 5 is set to a 1, the interface is reset to the power up default condition. The power up default conditions are:

- The default mode word will be used.
- The USART control word is set to 5.
- All other registers are set to 0.

Bit 5 is reset during the interface reset.

Bits 4 and 3 – Not used.

Bit 2 – Enables the interface’s receiver for interrupt operation. When bit 2 is a 1 and the receiver is ready, an interrupt I/O operation will be performed (if bit 7 is also set). Bit 2 must be a 0 for normal programmed input operation.

Bit 1 – Enables the transmitter for interrupt operation. When bit 1 is a 1 and the transmitter is ready, an interrupt I/O operation will be performed (if bit 7 is also set). Bit 1 must be a 0 for normal programmed output operation.

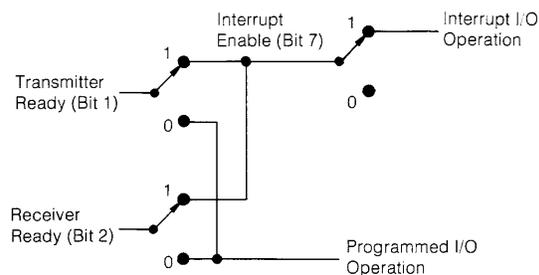
Bit 0 – Determines whether the next transfer to or from the calculator will be a data character or a control or status word. When bit 0 is a 1, access to the R4C through R4E registers is enabled. With this access established, control words can be set or changed and the USART status can be read. When bit 0 is a 0, data can be received or transmitted depending on how the USART control word R4D was set.

---

**NOTE**

Bit 1 and bit 2 of R5 OUT must be cleared for non-interrupt I/O operation.

---



## R5 IN Register

BIT 8	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Peripheral Status 1	Interface Interrupt Enable Status	∅	Interface I.D. ∅ Always ∅	Interface I.D. 1 Always 1	∅	∅	Control Status 2 Receiver Mode	Control Status 1 Transmitter Mode

Bit 8 – Is the interface status bit. This bit is always 1 when the interface is installed and operational in the calculator.

Bit 7 – Is a 1 when the interface interrupt is enabled (bit 7 of R5 OUT).

Bit 6 – Not used, always 0.

Bits 5 and 4 – Identify the interface as a serial interface. Bit 5 is always 0 and bit 4 is always 1.

Bits 3 and 2 – Not used, always 0.

Bit 1 – Is a 1 when the receiver interrupt control is enabled (bit 2 of R5 OUT).

Bit 0 – Is a 1 when the transmitter interrupt control is enabled (bit 1 of R5 OUT).

## R4 Registers

There are five R4 registers which are physically located in the USART chip.

### R4A Data Output

R4A is the data output buffer. Each data character sent from the calculator enters this register before it is sent serially to the data communications device. A write or write binary statement is used to output characters from the calculator to this register. All 8-bits of the R4A register are used for the data character.

### R4B Data Input

R4B is the data input buffer. Serial data received from a data communications device is assembled into an 8-bit character before it is sent to the calculator. The R4B register stores the received character until it is sent to the calculator. A read or read binary statement from the calculator is used to input a character from this register. All 8-bits of the R4B register are used for the data character.

**NOTE**

R4C through R4E allow configuration of the 98036A via the 9825A. These registers are set to default conditions when power is applied or the calculator is reset. They can be changed under program control.

**R4C Mode Word**

R4C is the mode word buffer. The mode word determines the mode of operation of the interface. A mode word is sent to the interface using a write binary statement from the calculator. A mode word from the calculator will override the default mode word that was set (from the default mode word switches) during an interface reset. Here is a description of the R4C bit positions.

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Number of Stop Bits 00 = not valid 01 = 1 bit 10 = 1.5 bits 11 = 2 bits		Parity Type 0 = Odd 1 = Even	Parity Enable 0 = Disable 1 = Enable	Character Length 00 = 5 bits 01 = 6 bits 10 = 7 bits 11 = 8 bits		Bit Rate Factor 00 = not used 01 = 1 X bit rate clock 10 = 1/16 X bit rate clock 11 = 1/64 X bit rate clock	

Bits 7 and 6 – Determine the number of stop bits used.

Bit 5 – Determines whether odd or even parity is to be used (when parity is enabled).

Bit 4 – Enables or disables parity.

Bits 3 and 2 – Should be set to indicate the length of the characters that are to be transferred.

Bits 1 and 0 – Determine the rate at which characters will be transferred. Characters can be transferred at the rate of the bit rate clock, 1/16 the rate of the bit rate clock or 1/64 the rate of the bit rate clock. The 1/64 position is recommended for increased immunity to signal distortion.

**NOTE**

Do not use the 1/64 bit rate factor setting when the bit rate is set to 4800 or 9600 bits per second. Use the 1/16 bit rate factor.

**NOTE**

Setting bits 1 and 0 both to zeros will result in erroneous interface operation. Do not operate the interface with bits 1 and 0 of the mode word both set to zero.

**R4D USART Control Word**

R4D holds the USART control word. The USART is the integrated circuit in the interface that transmits and receives data in the proper format. The R4D register is accessed when bit 0 of R5 OUT is a one. A write binary statement is used to output the USART control word from the calculator. Here is a description of the R4D bit positions.

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Always 0	USART Reset	Clear To Send Pin 5 (Standard) Request To Send Pin 4 (Option 001)	Reset Status Bits of USART Status Word	Send Break Character	Enable Data Receiver	Data Set Ready Pin 6 (Standard) Data Terminal Ready Pin 20 (Option 001)	Enable Data Transmitter

Bit 7 – Bit 7 is not used and must always be a 0.

Bit 6 – Is used to reset the USART. When bit 6 is a 1, the USART is forced into an idle mode. The next byte sent to the interface will be accepted as a mode word in R4C.

Bit 5 – This is a programmable RS-232 signal. In the case of the standard cable, the signal is sent to the device on the clear to send line (pin 5). In the case of the option 001 cable, the signal is sent to the device on the request to send line (pin 4).

Bit 4 – Status bits 3, 4 and 5 of R4E are reset to 0.

Bit 3 – Enables the USART to output a break to the data communications device. This causes a continuous space character to be output.

Bit 2 – When this bit is a 1, it allows the interface to receive characters for transfer to the calculator.

Bit 1 – Using the standard cable, when bit 1 is a 1, a data set ready signal is sent to the data terminal on pin 6 of the terminal connector. Using the option 001 cable, when bit 1 is a 1, a data terminal ready signal is sent to the modem on pin 20 of the modem connector.

Bit 0 – The USART transmitter (R4A) is enabled when this bit is a 1.

**NOTE**

The power-up default control word is 5. Bits 0 and 2 are set.

**R4E USART Status Word**

R4E is the USART status word. The status word can be accessed when bit 0 of R5 OUT is a 1. A read binary statement from the calculator is used to input the status word to the calculator. Here is a description of the R4E bit positions.

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Request To Send Pin 4 (Standard) Data Set Ready Pin 6 (Option 001)	Always 0	Framing Error	Overrun Error	Parity Error	Transmitter Empty	Receiver Ready	Transmitter Ready

Bit 7 – Using the standard cable, bit 7 indicates the status of the request to send line, pin 4 of the terminal connector. Using the option 001 cable, bit 7 indicates the status of the data set ready line, pin 6 of the modem connector.

Bit 6 – Not used, always 0.

Bit 5 – This bit is a 1 when the received data did not contain the proper number of stop bits or when a break has been received.

Bit 4 – This bit is a 1 when data is received before the data receiver buffer is empty (overrun error).

Bit 3 – This bit is a 1 when a parity error occurs.

Bit 2 – This bit is a 1 when the USART's data transmitter buffer is empty.

Bit 1 – When a 1, this bit indicates that the USART's data receiver is ready with a received character.

Bit 0 – This bit is a 1 when the USART's data transmitter buffer is ready to transmit data.

## R6 Registers

There are two R6 registers. The R6 registers are accessed by a read interface (rdi) or write interface (wti) statement. These statements are found in the Extended I/O ROM. Without these statements the R6 registers can not be accessed.

R6 OUT is controlled by the calculator and is used to send control information to the data communications device. The contents of R6 OUT can be changed by sending a write interface statement (wti) to the interface from the calculator. The control information is then sent to the data communications device.

R6 IN monitors the RS-232 status lines from the data communications device. By executing read interface statement (rdi) the contents of the register are input to the calculator.

Here is a description of the R6 OUT and R6 IN bit positions for both the standard and option 001 cables. Remember, when using the standard cable, the 9825A/98036A acts like a modem in communicating with a terminal and when using the option 001 cable, the 9825A/98036A acts like a terminal connected to a modem.

### R6 OUT Register (standard cable)

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
—	—	—	Half/Full Speed Control (Interface)	Ring Indicator Pin 22	Signal Quality Detect Pin 21	Secondary Line Signal Detect Pin 12	Line Signal Detect Pin 8

Bits 7 thru 5 – Not used.

Bit 4 – This bit is used to signal the interface that either half or full speed data transfer is being done. (See R6 IN, bit 1.) When bit 4 is a 0, normal bit rate clock speed is being used. When bit 4 is a 1, data transfer is half the switch selected bit rate clock speed. Bit 4 information is used internally by the interface.

Bit 3 – Normally indicates a ringing signal to the data terminal on pin 22 of the terminal connector when bit 3 is a 1. Since no ringing signal is involved in this application, this bit is not normally used, however it is available.

Bit 2 – Normally is used to indicate to the data terminal whether or not there is a high probability of an error in the data received by the modem. If bit 2 is a 1, the received data is probably in error. This signal is sent to the terminal on pin 21 of the terminal connector. Since no data channel is involved in this application this bit is not normally used however it is available.

Bit 1 – Normally indicates to the data terminal that the secondary channel carrier is being sent, when bit 1 is a 1. This signal is sent to the data terminal on pin 12 of the terminal connector. The secondary channel in this application is a pseudo-channel since no carrier is involved.

Bit 0 – Normally indicates to the data terminal that the primary channel carrier is being received, when bit 0 is a 1. This signal is sent to the data terminal on pin 8 of the terminal connector. The primary channel in this application is a pseudo-channel since no carrier is involved.

### R6 IN Register (standard cable)

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Always 1	Always 0	Data Signal Rate Select Pin 23	Secondary Request To Send Pin 19				

Bits 7 thru 2 – Not used.

Bit 1 – This signal is sent to the interface from the data terminal on pin 23 of the terminal connector. This signal is used when the terminal has two data signaling rates or two ranges of data signaling rates. When bit 1 is a 1, the higher data signaling rate or range of rates is selected.

Bit 0 – This signal is sent to the interface from the data terminal on pin 19 of the terminal connector. When bit 0 is a 1, the secondary request to send line is raised high indicating to the interface that the terminal has information to send.

### R6 OUT Register (option 001 cable)

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
—	—	—	Half/Full Speed Control	Special Purpose Pin 25	Data Signal Rate Select (U.K.) Pin 11	Data Signal Rate Select Pin 23	Secondary Request To Send Pin 19

Bits 7 thru 5 – Not used.

Bit 4 – This bit is used to signal the interface that either half or full speed data transfer is in effect (see R6 OUT, bit 1). When this bit is a 0, normal bit rate clock speed is being used. When bit 4 is a 1, data transfer is half the switch selected bit rate. Bit 4 information is used internally by the interface.

Bit 3 – Is used for any special purpose that may arise. This bit is output to pin 25 of the modem connector.

Bit 2 – This signal is sent from the interface to the modem on pin 11 of the modem connector. Pin 11 is used in the United Kingdom for the Data Signal Rate Select signal. The signal is used to select between two data signaling rates or two ranges of data signaling rates. When bit 2 is a 1, the higher data signaling rate or range of data signaling rates of the modem is requested.

Bit 1 – This signal is sent from the interface to the modem on pin 23 of the modem connector. Pin 23 is used for the Data Signal Rate Select signal. The signal is used to select between two data signaling rates or two ranges of data signaling rates. When bit 1 is a 1, the higher data signaling rate of the modem is requested.

Bit 0 – Is sent from the interface to the modem on pin 19 of the modem connector. When this signal is a 1, the secondary request to send signal is sent to the modem indicating to the modem that the calculator has information to send.

### R6 IN Register (option 001 cable)

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Always 1	Secondary Line Signal Detect Pin 12	Ring Indicator Pin 22	Line Signal Detect Pin 8				

Bits 7 thru 3 – Not used.

Bit 2 – This signal is sent to the interface from the modem on pin 12 of the modem connector. When bit 2 is a 1, it indicates that the secondary channel carrier is being received.

Bit 1 – This signal indicates to the interface that a ringing signal is being received by the modem when bit 1 is a 1. The signal is sent to the interface on pin 22 of the modem connector.

Bit 0 – This signal, carrier detect, indicates to the interface that the modem is receiving an acceptable signal, when bit 0 is a 1. This signal is sent to the interface on pin 8 of the modem connector.

## 9825A/98036A Operation

Here are some example programs using the 9825A Calculator. The programs show how each register on the interface can be accessed. Also refer to figures 5 and 6 for assistance. Table 2 is a summary of the 9825A statements used to control the 98036A Interface. See the 9825A General I/O ROM and Extended I/O ROM Manuals for more details on the statements listed in Table 2.

**Table 2. 9825A/98036A Statements**

General I/O	Basic Syntax	Use
Write	wrt	Transfers data to the data communications device when R5 OUT bit 0 = 0 and transmitter ready.
Write Binary	wtb	Transfers data as in write statement. Also used to change R4C and D when R5 OUT bit 0 = 1.
Write Control	wtc	Used to change the R5 OUT register
List	list#	Used to list calculator programs on the data communications device when R5 OUT bit 0 = 0 and transmitter ready.
Read	red	Reads data from the data communications device when R5 OUT bit 0 = 0 and receiver ready.
Read Binary	rdb	Used to read R4E, USART status word, when R5 OUT bit 0 = 1.
Read Status	rds	Used to read interface status word, R5 IN.
Extended I/O	Basic Syntax	Use
Write Interface	wti	Used to change the R6 OUT register.
Read Interface	rdi	Used to read the R6 IN register.
Enable Interrupt	eir	Enables the interface to interrupt calculator operation.
Transfer	tfr	Used to transfer data from a calculator buffer to a data communications device or from a data communications device to a calculator buffer.

### Examples

#### Setting the Interface Control Word, R5 OUT

wtc 10,1                      Sets bit 0 of R5 OUT. Enables access to R4D and R4E.  
wtc 10,32                      Sets bit 5 of R5 OUT. Resets the interface to power-up default condition.

#### Reading the Interface Status Word, R5 IN

rds (10)+A;dspA              Displays the decimal value of R5 IN.

**NOTE**

Bit 8 of the R5 IN register (interface status bit) is a 1 when the interface is installed and operational. The bit 8 value is decimal 256.

**Setting the USART Control Word R4D**

```

wrc 10,1      Sets bit 0 of R5 OUT. Enables access to R4D (control mode set).
wrb 10,8      Sets bit 3 of R4D. Break character sent.
wait 200
wrb 10,37     New R4D control word set, break is cancelled,
              transmitter and receiver are enable.
wrc 10,0      Clears bit 0 of R5 OUT (data mode set).

```

```

wrc 10,1      Sets bit 0 of R5 OUT. Enables access to R4D (control mode set).
wrb 10,5      Sets bits 0 and 2 of R4D. Enables the transmitter and receiver.
wrc 10,0      Clears bit 0 of R5 OUT (data mode set).

```

**Setting the Mode Word R4C**

```

wrc 10,1      Sets Bit 0 of R5 OUT. Enables access to R4D (control mode set).
wrb 10,64     Sets Bit 6 of R4D. Resets USART and enables access to R4C.
wrb 10,207    Sets bits 7, 6, 3, 2, 1 and 0 of R4C. Selects 2 stop bits, no parity,
              8 bit character and 1/64 bit rate factor.
wrb 10,37     New R4D control word set.
wrc 10,0      Clears bit 0 of R5 OUT. Data mode set.

```

**Reading the USART Status Word R4E**

```

wrc 10,1      Sets Bit 0 of R5 OUT. Enables access to R4E (control mode set).
dsp rdb(10)   Displays the decimal value of R4E.
wrc 10,0      Clears bit 0 of R5 OUT (data mode set).

```

**Writing and Reading Data**

Once R4C and D have been set properly, clear bit 0 of R5 OUT, then read and write data using the read or write statements. The interface is enabled to transmit and receive data when power is applied to the interface.

**Setting the R6 OUT Register**

wti 0,10               Selects select code 10.  
wti 6,4                 Sets R6 to 4 (bit 2).

**Reading the R6 IN Register**

wti 0,10               Selects select code 10.  
rdi (6)→A            Reads the contents of R6 IN.

The following example program can be used to transfer data when the 9825A is connected to either a terminal or modem via the 98036A. The Strings, Extended I/O and General I/O ROMs are required.

Before using the program, ensure that the 98036A configuration switches are set to be compatible with the terminal (or modem) operation. Also, ensure that the correct 98036A cable is used. This program assumes that the 98036A Interface select code is set to 11.

After loading the program in the calculator memory, press .

The  key on the calculator is defined as the escape key. Use this key to send escape characters to the terminal.

The  key on the calculator is defined as the control key. Use this key to send a control characters to the terminal.

The calculator's store key is used for a carriage return.

The calculator's execute key is used for a line feed.

The calculator's back key is used as a backspace.

Data is transferred from the calculator by pressing store (carriage return).

Data from the terminal or modem is printed on the calculator's printer after a carriage return/linefeed is given.

**NOTE**

A carriage return must be sent after each 80 characters sent from the calculator, or the program's string length will be exceeded.

```

0: lká
1: wtc 11,1
2: wtb 11,37
3: wtc 11,0
4: dim L$[96],C[255],u$[96],A$[80],B$[80]
5: " "→B$[1,80]
6: gsb "string"
7: "start input transfer":
8: oni 11,"in"
9: eir 11,4
10: buf "in",L$,1
11: tfr 11,"in",80,13
12: "keyboard loop":
13: wti 0,u
14: 0→P
15: "key":rai 4→K
16: if rai 4#K;jmp -1
17: if (rdi 4→C)#K;jmp -2
18: if C=66 or C=194;gsb "control"
19: wtb 11,C[C]→P;cnar(P)→A$[Z+1→Z,Z]
20: dsp A$[max(1,len(A$)-31),max(32,len(A$))]
21: if C[C]=13;" "→A$;0→Z;dsp A$
22: if rdi 4=C;jmp 0
23: gtc "key"
24: "in":
25: prt L$;" "→L$[1,80]
26: buf "in"
27: eir 11,4
28: tfr 11,"in",80,13
29: iret
30: "string":
31: for I=1 to 58
32: I→C[I]
33: next I
34: for I=78 to 87
35: I-30→C[I]
36: next I
37: for I=88 to 96
38: 32→C[I]
39: next I
40: for I=97 to 122
41: I→C[I]
42: next I
43: for I=123 to 175
44: 32→C[I]
45: next I
46: for I=176 to 185
47: I-144→C[I]
48: next I
49: for I=186 to 224
50: 32→C[I]
51: next I
52: for I=225 to 250
53: num(char(I-160))→C[I]
54: next I
55: 13→C[141];10→C[138]
56: for I=206 to 216
57: I-158→C[I]
58: next I
59: 60→C[172];123→C[123];94→C[94];32→C[7]
60: 47→C[47]→C[175];40→C[40]→C[168];41→C[41]→C[169];92→C[222];62→C[174]
61: 101→C[96]→C[224];125→C[125]→C[253];43→C[43]→C[171];45→C[45]→C[173]
62: 27→C[65]→C[193];63→C[63]
63: 64→C[183];91→C[184];93→C[185]
64: 39→C[176];8→C[20]→C[148];61→C[61]→C[189]
65: 59→C[59]→C[187];58→C[191];46→C[88]→C[216]
66: ret
67: "control":
68: if (rdi 4→M)=C;jmp -1
69: if rdi 4#M;jmp -1
70: if (C[M]→C)<64 or C>90;beep;jmp 2
71: wtb 11,C-64
72: if rdi 4=M;jmp 0
73: ret
74: end
*31822

```

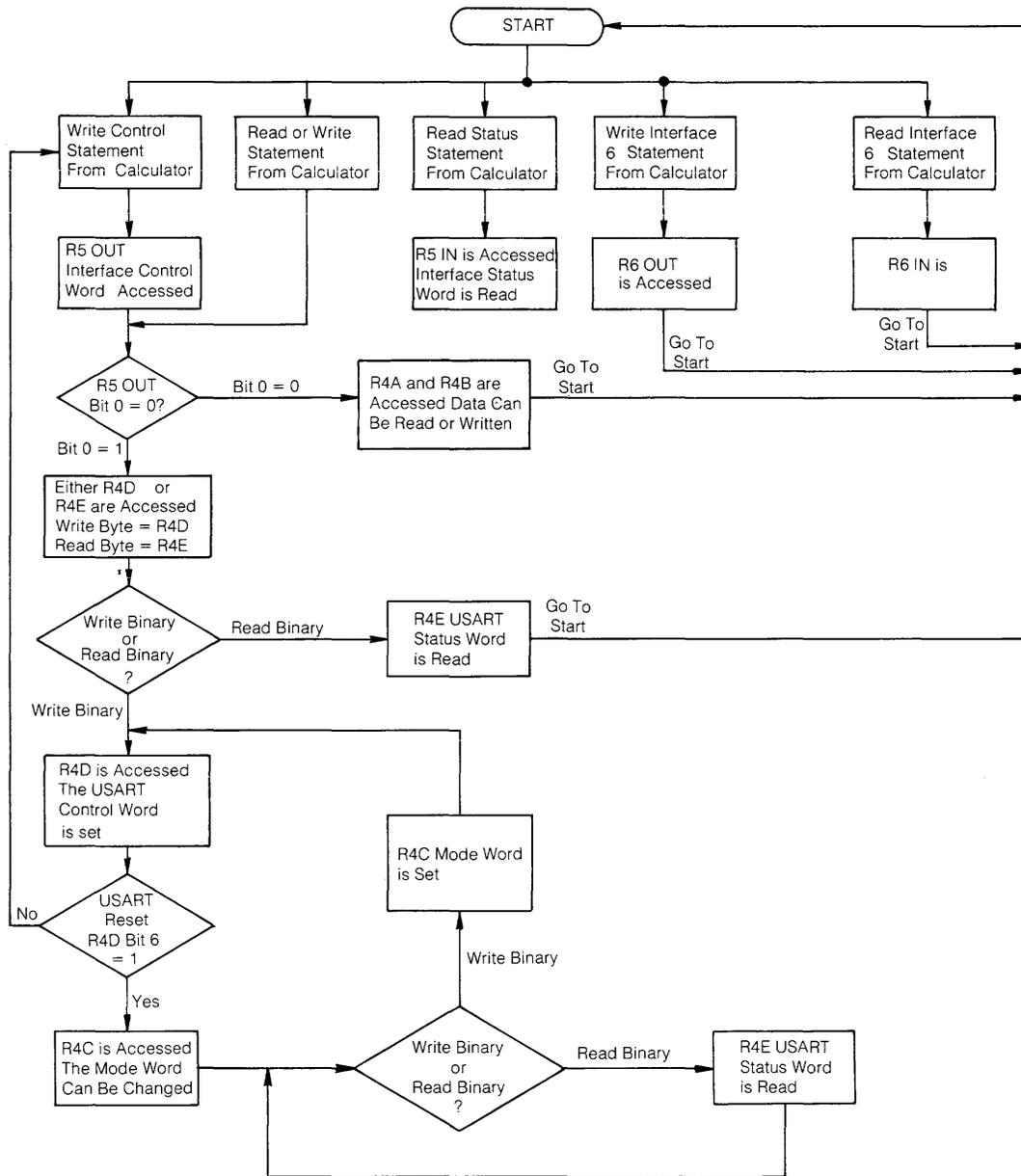


Figure 6. Register Access

## R5 Registers

### R5 OUT Register

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Interface Interrupt Enable		Programmed Interface Reset			Interrupt Control 2 Receiver Control	Interrupt Control 1 Transmitted Control	R4 Control 0 = Data IN/OUT 1 = Control/Status

### R5 IN Register

BIT 8	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Peripheral Status 1	Interface Interrupt Enable Status	∅	Interface I.D. ∅	Interface I.D. 1	∅	∅	Control Status 2 Receiver Mode	Control Status 1 Transmitter Mode

## R4 Registers

### R4C Mode Word

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Number of Stop Bits 00 = not valid 01 = 1 bit 10 = 1.5 bits 11 = 2 bits		Parity Type 0 = Odd 1 = Even	Parity Enable 0 = Disable 1 = Enable	Character Length 00 = 5 bits 01 = 6 bits 10 = 7 bits 11 = 8 bits		Bit Rate Factor 00 = not used 01 = 1 X bit rate clock 10 = 1/16 X bit rate clock 11 = 1/64 X bit rate clock	

### R4D USART Control Word

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Always 0	USART Reset	Clear To Send Pin 5 (Standard) Request To Send Pin 4 (Option 001)	Reset Status Bits of USART Status Word	Send Break Character	Enable Data Receiver	Data Set Ready Pin 6 (Standard) Data Terminal Ready Pin 20 (Option 001)	Enable Data Transmitter

### R4E USART Status Word

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Request To Send Pin 4 (Standard) Data Set Ready Pin 6 (Option 001)	Always 0	Framing Error	Overrun Error	Parity Error	Transmitter Empty	Receiver Ready	Transmitter Ready

## R6 Registers

### R6 OUT Register (standard cable)

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
—	—	—	Half/Full Speed Control (Interface)	Ring Indicator Pin 22	Signal Quality Detect Pin 21	Secondary Line Signal Detect Pin 12	Line Signal Detect Pin 8

### R6 IN Register (standard cable)

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Always 1	Always 0	Data Signal Rate Select Pin 23	Secondary Request To Send Pin 19				

### R6 OUT Register (option 001 cable)

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
—	—	—	Half/Full Speed Control	Special Purpose Pin 25	Data Signal Rate Select (U.K.) Pin 11	Data Signal Rate Select Pin 23	Secondary Request To Send Pin 19

### R6 IN Register (option 001 cable)

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Always 1	Secondary Line Signal Detect Pin 12	Ring Indicator Pin 22	Line Signal Detect Pin 8				

Bit Position	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
Decimal Value	128	64	32	16	8	4	2	1

Figure 5. Register Summary

# Chapter 4

## Theory of Operation

### Introduction

This chapter describes the 98036A theory of operation. Refer to the block diagrams and the 98036A schematic diagram when reading this chapter.

The 98036A Serial Interface converts 8-bit parallel data from the calculator into a serial bit stream compatible with RS-232C hardware protocol. A Universal Receiver/Transmitter (USART) is the heart of the interface, performing the serial-to-parallel and parallel-to-serial conversions. Only the 8 least significant bits of the 16-bit calculator I/O bus are used by the interface.

### Interface Registers

The calculator communicates with the interface through the R4, R5 and R6 registers. The registers have been assigned the following basic duties.

R4 - Primary Data Register

R5 - Interface Control and Status Register

R6 - Secondary Data Register

The 98036A has an extended set of registers, expanding the R4 register into five unidirectional registers (from the calculator's viewpoint), R4A through R4E. Bit configurations for the R4 registers are detailed in chapter 3. The actual location of R4A through R4E is in the USART integrated circuit.

The R4 OUT register (U26 and U27) holds the data from the calculator until the USART can accept the transfer.

The R4 IN register (U29 and U30) holds received data until requested by the calculator.

The least significant bit of the R5 OUT register (U10) is the control/data bit (C/D), which defines which R4 register will be accessed. Bits 1 and 2 are the interrupt control bits (INC1 and INC2) which allow the transmitter or receiver in the USART to be interrupt driven. Bit 7 is the interrupt enable, allowing the interface to interrupt the calculator based on conditions defined by the INC1 and INC2 bits.

The R5 IN register is not really a register but a group of tri-state buffers connected to indicate various internal states of the 98036A. These gates are in U24 and U32.

R6 OUT is a partially implemented register used for controlling those RS-232C functions needed for more complex serial links. U28 comprises bits 0 through 3 of R6 OUT. Bit 4 is used to control the half/full speed feature of the interface. This feature, implemented in U7, U20 and U21, will cut the bit rate of the interface in half when bit 4 of R6OUT is set. This is accomplished by either routing the bit rate clock directly to the USART or through a flip-flop divider (U21), and then to the USART.

R6 IN is not a register but is similar to R5 IN, being composed of tri-state gates. These gates are connected to RS-232-to-TTL level translators and report the real-time condition of the associated RS-232C status lines. These tri-state gates are in U35.

## Register Control

The calculator control signals DOUT, IOSB, IC1 and IC2 indicate the current interface register operation to be performed. No operations will be performed by the 98036A unless the peripheral address lines (PA0 through PA3) match the select code on the select code switch S1. A match generates the My Peripheral Address (MYPA) signal which activates the register control decoder, U2.

The register control decoder takes the four calculator control signals mentioned above and generates four output register strobe signals and four input register activation signals.

## Flag Circuits

Normally, if the interface is busy, the flag (FLG) line is low. In some cases, it may be desirable to operate the 98036A under programmed I/O in one direction and under interrupt driven I/O in the other direction. A section of the 98036A being operated under interrupt does not have control of the flag line and may therefore be operated independently of the other section. During this simultaneous operation, the tri-state USART data bus is controlled by the linked R4 state machines which control bus direction. At worst case, there may be a 2 microsecond delay in granting the bus to a requesting section, which is well within the minimum character time in the interface, (approximately 1 millisecond). This character time varies with the bit rate

and is important due to the nature of the RS-232 link. The calculator usually has no control of the remote device, which may suddenly decide to transmit a block of text. If each character is not removed before the next received character is assembled, an overwrite will occur and the original character will be lost. This is why the operation of the receiver under interrupt is a good idea.

## Interrupt Circuits

The interrupt poll responder (U22) has a two level interrupt scheme. Interfaces with select codes 2 through 7 (1 and 0 are illegal) are low priority while interfaces with select codes 8 through 15 are high priority. The 98036A select code is set as a high priority device from the factory to reduce the possibility of character overwrite. The select code however is easily changed. An interrupt is requested by the interface pulling an interrupt request line. If the interface has low priority, it will pull interrupt request low (IRL). If the interface has a high priority, it will pull interrupt request high (IRH). The calculator will respond by pulling interrupt poll (INT) and signifying whether a high or low level poll is taking place by placing the peripheral address line PA3 at the proper level. The interfaces that have interrupted at that level respond by pulling the appropriate data line, for example if interface 3 requested service, it would pull IOD3.

Interrupt control in the 98036A is implemented in U4, U10, U13 and a gate from U9. U22 is the interrupt poll responder.

## Clock Generator

The interface timing signals are all generated by the bit rate generator, U36. This includes the USART master clock, the state machine clocks and the bit rate clocks. U36 is a crystal controlled oscillator/divider.

## I/O Drivers-Receivers

The signals inside the 98036A are all in the 0 to +5 volt range. Since the RS-232C specifications call for at least a  $\pm 3$  volt swing, signal level translation is required. This is supplied by U37, U38, U39 and U40. The teletype-current-loop driver is composed of a discrete, switched 20ma. current source. The current receiver is a simple resistor divider with a zener diode clamp.

## Setting Registers

Here is a description of the typical operations that occur in the interface when writing to and reading from the R4, R5, and R6 registers. The following sequence will be described:

- write control statement to set bit 0 of R5 OUT.
- write binary statement to set bit 6 of R4D, resetting the USART.
- write binary statement to set the mode word R4C.
- write binary statement to set the USART control word R4D.
- read binary statement to read USART status R4E.
- write control statement to clear bit 0 of R5 OUT.
- read status statement to read interface status R5 IN.
- write interface statement to change R6 OUT.
- read interface statement to read R6 IN.

Before any operation is started, the select code from the calculator on the PA lines must match the interface select code. A match generates MYP A INT from U5 pin 3.

A write control statement from the calculator results in an R5 strobe signal (R5SB) from pin 11 of U2.

The R5SB signal clocks the R5 OUT register (U10) on U10 pin 9. Since we want to set R5 OUT bit 0 to a 1, IOD1 should be high. Bit 1 (U10 pin 15) is high when R5SB clocks U10. U14C is enabled and pin 12 of the USART (C/D) goes high. This sets the USART to accept the next byte as a control word.

A write binary statement to reset the USART (Bit 6 of R4D) will result in IOD6 going high. The R4 OUT strobe (R4SB) is generated to clock the IOD line information into R4 OUT (U26 and U27).

R4SB also generates WR1 from U16 pin 13 and GEN from U17 pin 1. WR1 strobes pin 10 (WR) of the USART. GEN enables the R4 OUT data to be sent to the USART on the D lines. Since the C/D line (pin 12) of the USART is set, this data byte is interpreted as a control word to R4D.

Since the previous byte reset the USART, the next write binary statement will be used as the mode word (R4C). This byte is input in the same sequence as described in the preceding paragraph.

The next byte after the mode word is handled in the same manner. This is the new control word for the USART (R4D).

While bit 0 of R5 OUT is set, the USART status word, R4E can be read. The read binary statement generates R4 IN from pin 4 of U2 which resets U19 pin 4 to a 0. Then D OUT from the calculator goes to a 0. The R7SB signal (U2 pin 9) generates RD on pin 2 of U16 and GEN of pin 1 of U17. The RD signal sets pin 13 of the USART and clocks the R4 IN register (U29 and U30). When D OUT returns high, another R4 IN strobe is generated which enables the R4 IN tri-state gates (U29 and U30). The status word is then sent to the calculator on the IOD lines.

Executing a write control statement with a decimal value of 0 will enable the interface to transmit and receive data. U10 pin 15 will be a 0 and the C/D line to pin 12 of the USART will be a 0.

## Transmitting Data

Data transmitted to the data communications device is handled in the same manner as sending data to R4C and R4D. The only difference is that pin 12 of the USART (C/D) is 0.

## Receiving Data

Data received from the data communications device is handled in the same manner as reading the R4E register. The only difference is that pin 12 of the USART (C/D) is 0.

A write interface 6 statement from the calculator will generate R6SB on pin 10 of U2. This clocks the R6 OUT register (U28) and sends information to the RS-232 signal lines.

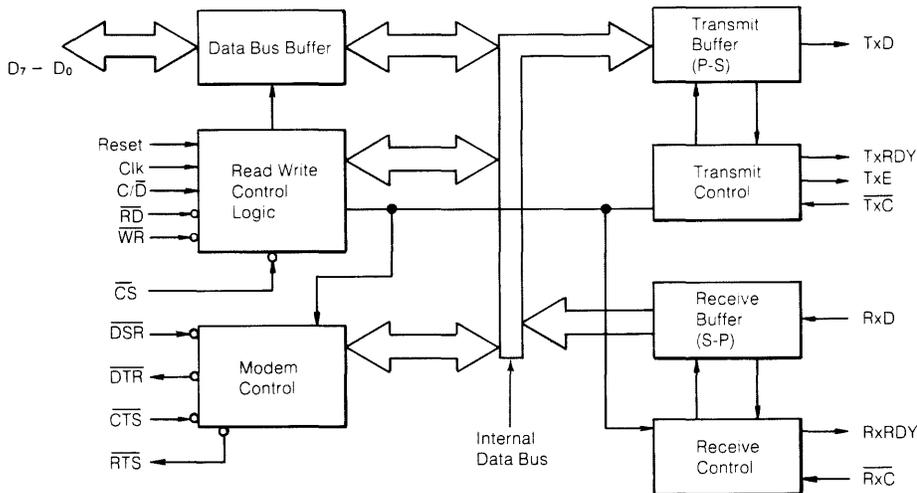
A read interface statement from the calculator will generate R6 IN on pin 6 of U2. This enables the R6 IN register (U35, U37 and U38). The R6 IN information is sent to the calculator on the IOD lines.

## Reset

An interface reset (R5 OUT bit 5) generates BUSY 2 from U5 pin 11 and RESET from U12 pin 6. RESET is applied to pin 21 of the USART (U31) to reset the USART latches. C/D from U14 pin 10 sets the USART to the control mode (pin 12 = 1) so the default control word and mode word can be written in the USART. WR2 from U6 pin 4 enables the default words to be written. MSEN from U6 pin 10 enables the default mode word from U34 and U33 to be written into the USART. CSEN from U6 pin 3 enables the default control word (decimal 5) from U33 and U32 to be written into the USART. The last step of the reset operation is to set the C/D line to a 0 to enable data transfer.

## The USART

The USART (U31) is the heart of the interface. Once the control and mode words are set, the USART provides the asynchronous mode format and the parallel-to-serial and serial-to-parallel data conversions. Here is a block diagram of the USART and a brief description of the mnemonics.



Pin Name	Pin Function
D7-D0	Data Bus (8 bits)
C/D	Control or Data is to be Written or Read
RD	Read Data Command
WR	Write Data or Control Command
CS	Chip Enable
CLK	Clock Pulse (TTL)
RESET	Reset
TxC	Transmitter Clock
TxD	Transmitter Data
RxC	Receiver Clock
RxD	Receiver Data
RxRDY	Receiver Ready (has character for interface)
TxRDY	Transmitter Ready (ready for char. from interface)

Pin Name	Pin Function
DSR	Data Set Ready
DTR	Data Terminal Ready
RTS	Request to Send Data
CTS	Clear to Send Data
TxE	Transmitter Empty
Vcc	+5 Volt Supply
GND	Ground

Figure 8. USART Block Diagram

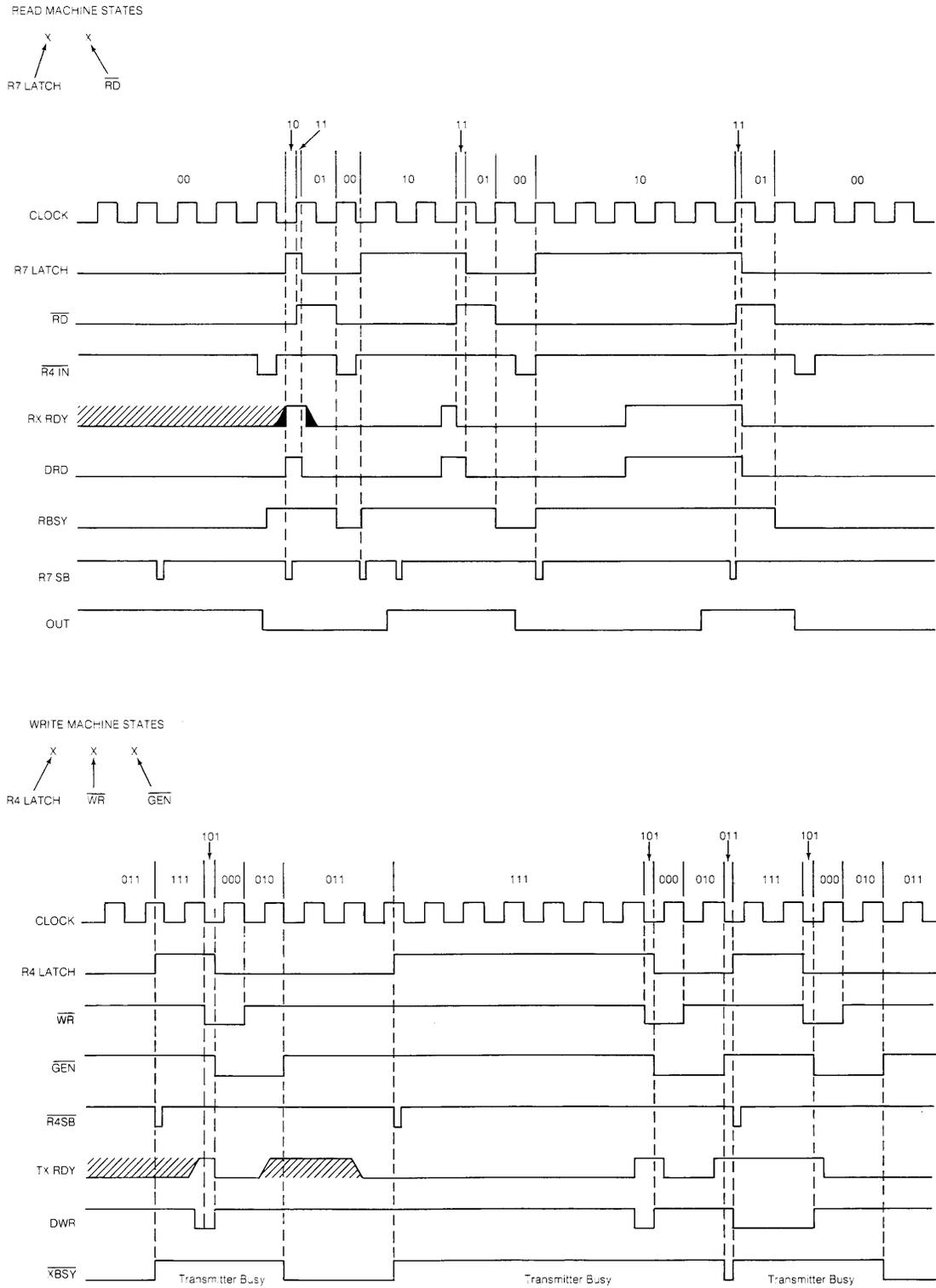
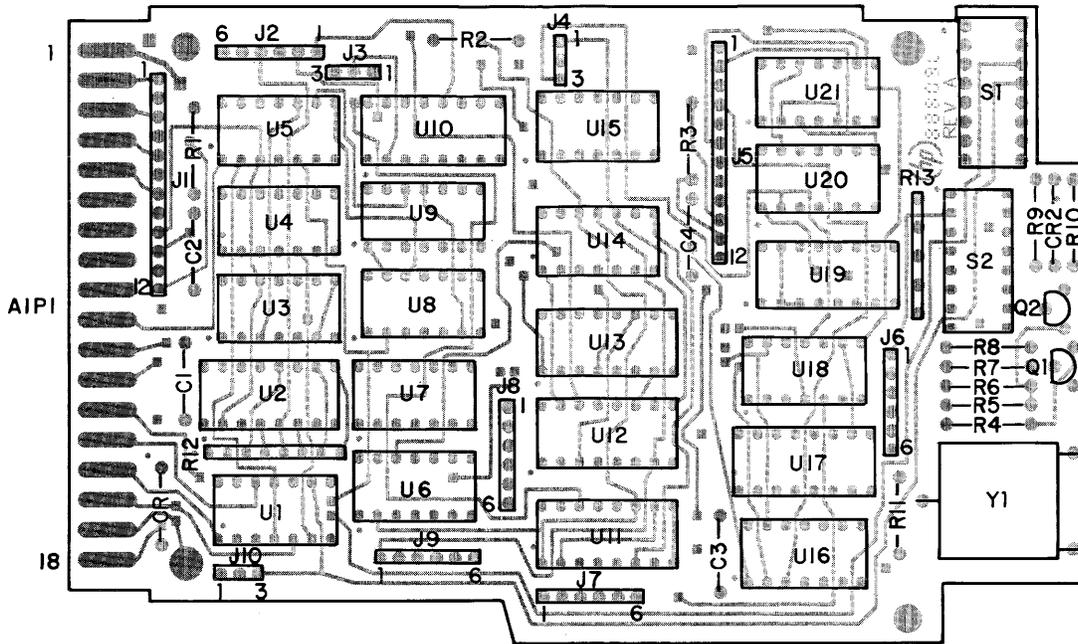


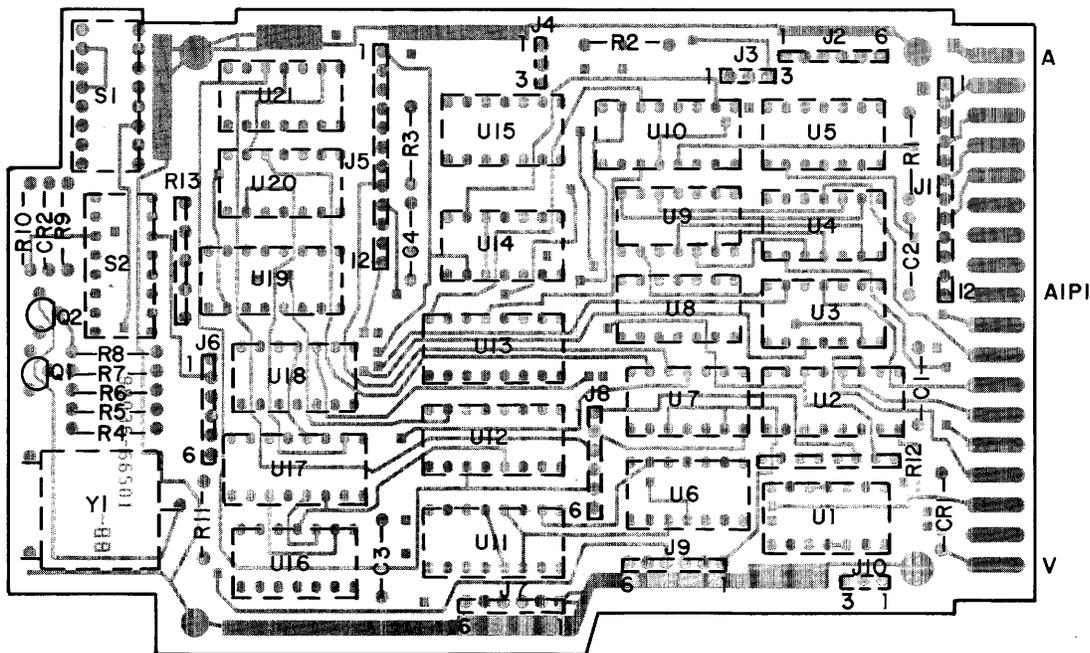
Figure 9. 98036A Timing Diagram



COMPONENT SIDE

A1

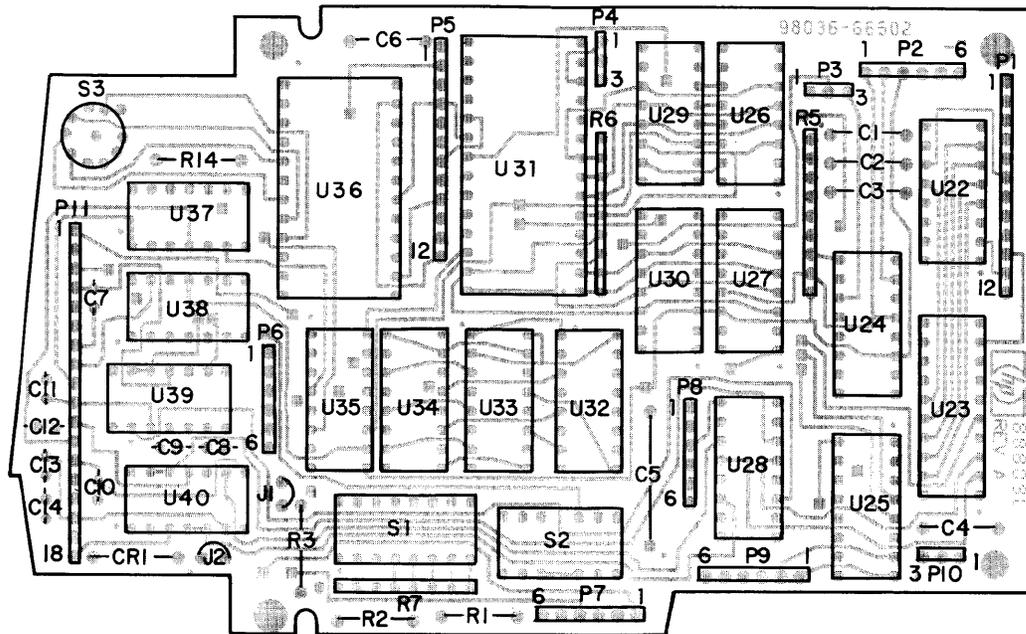
-hp- Part No. 98036-66501 Rev A



CIRCUIT SIDE

A1

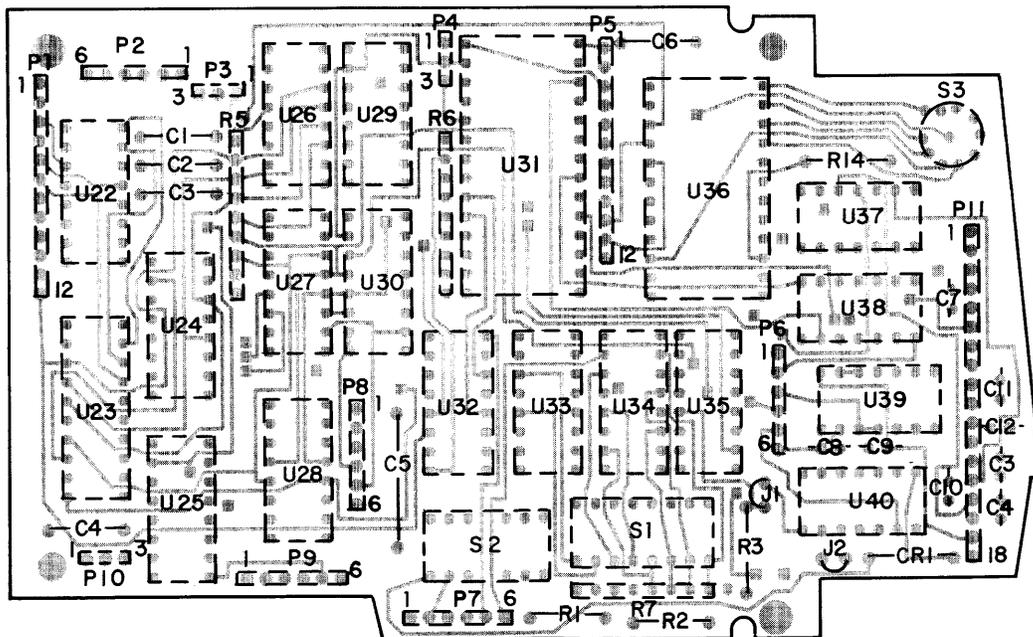
-hp- Part No. 98036-66501 Rev A



## COMPONENT SIDE

A2

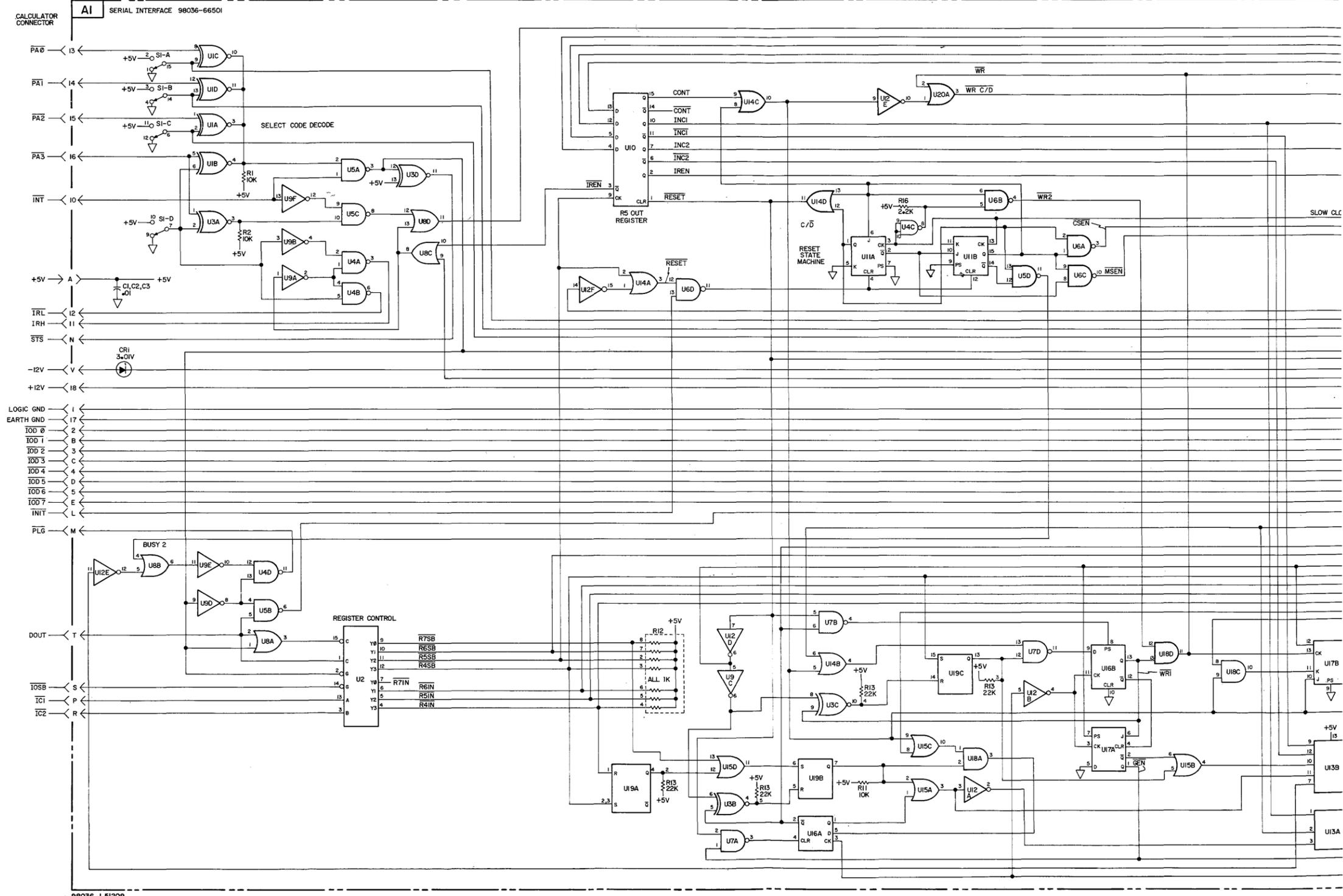
-hp- Part No. 98036-66502 Rev A

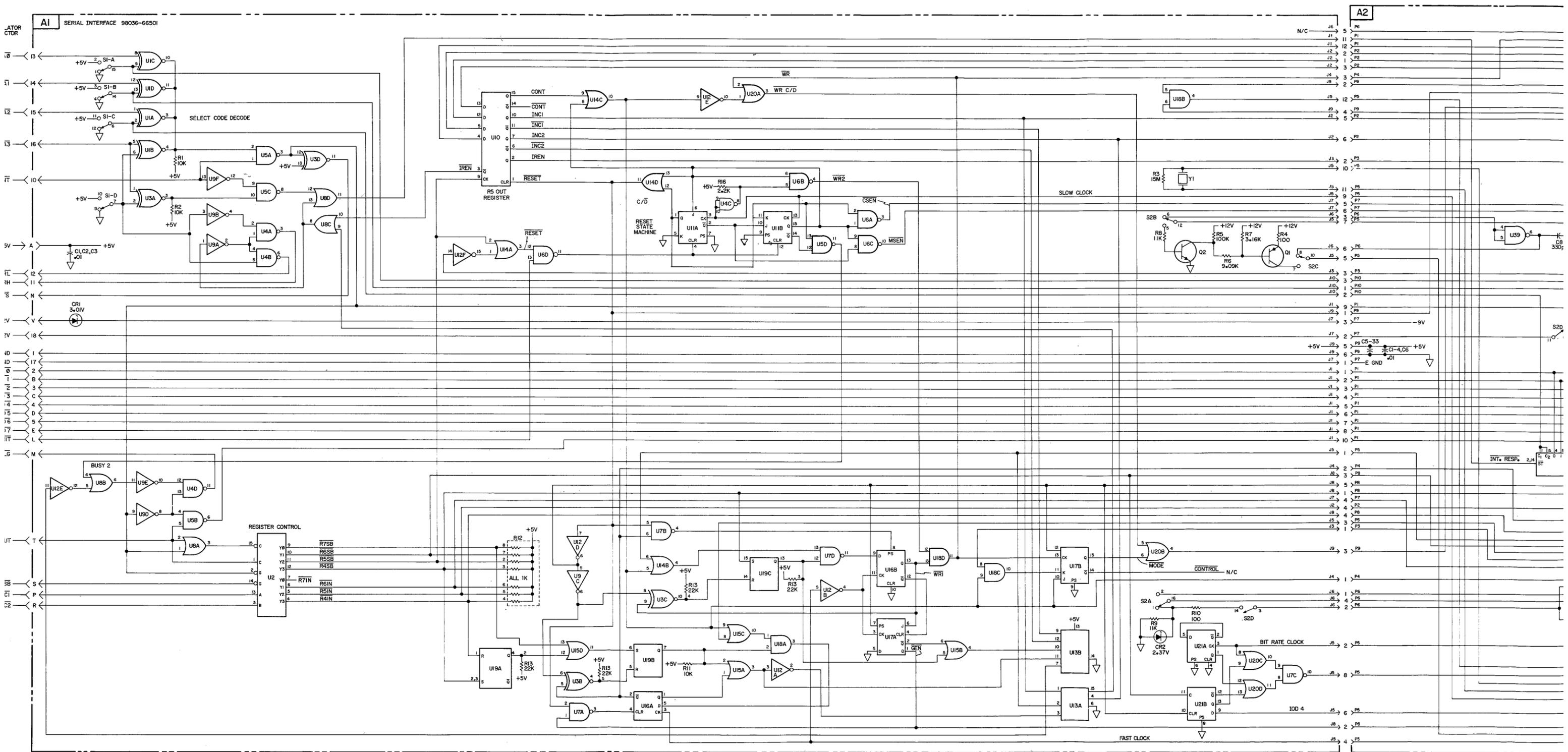


## CIRCUIT SIDE

A2

-hp- Part No. 98036-66502 Rev A





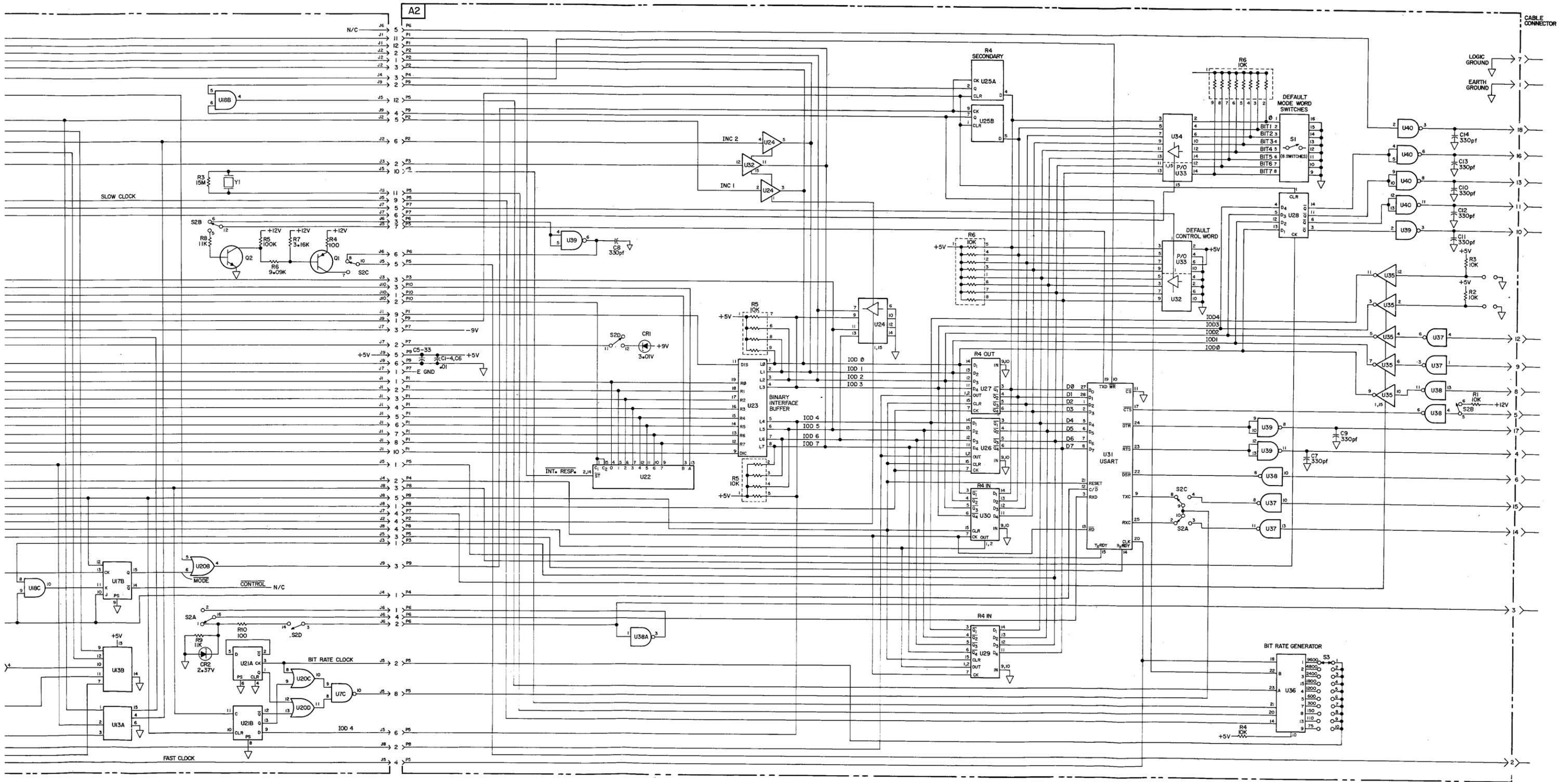


Figure 10. 98036A Interface Schematic Diagram

## Cable Wiring

Standard Cable

Interface Connector Pin No.	Terminal Connector Pin No.	Signal
1	1	Earth Ground
3	2	Transmitted Data
2	3	Received Data
6	4	Request to Send
4	5	Clear to Send
17	6	Data Set Ready
7	7	Logic Ground
16	8	Carrier Detect
13	12	Secondary Carrier Detect
8	19	Secondary Request to Send
5	20	Data Terminal Ready
11	21	Signal Quality Detect
10	22	Ring Indicator
9	23	Data Signal Rate Select

Option 001 Cable

Interface Connector Pin No.	Terminal Connector Pin No.	Signal
1	1	Earth Ground
2	2	Transmitted Data
3	3	Received Data
4	4	Request to Send
5	5	Clear to Send
6	6	Data Set Ready
7	7	Signal Ground
8	8	Carrier Detect
11	11	Data Rate Select (U.K.)
12	12	Secondary Carrier Detect
15	15	Transmitter Clock
14	17	Receiver Clock
16	19	Secondary Request to Send
17	20	Data Terminal Ready
9	22	Ring Indicator
13	23	Data Rate Select
10	25	Vadic Special Test

## Chapter 5

# Troubleshooting and Repair

### Introduction

The following procedures assume that the calculator, ROM(s) and peripheral device are operating correctly. If necessary, disconnect the interface from the calculator and perform all other applicable test procedures before assuming that the interface is defective.

### Recommended Equipment

The following is a list of equipment that will aid in troubleshooting the 98036A Serial Interface.

1. Oscilloscope or Logic Probe
2. Test Connector 98241-67936
3. Extender Board 98241-67901
4. Calculator and applicable ROM(s)

For checking most signals within the interface, any general purpose oscilloscope or logic probe can be used, if it is capable of indicating the presence of TTL level signals with pulse widths greater than 100ns.

### Test Program

The following program on Page 43 can be used to test the operation of the interface.

To use the program, follow this procedure.

1. Disconnect the rear housing and cable from the interface.
2. Remove the front housing covers and separate the printed circuit assemblies.

3. Set the interface switches to the factory switch settings described on Page 10.
4. Connect the printed circuit assemblies together and install the front housing covers.
5. Install the test connector (98241-67936) on the connector that the interface cable usually connects to (see Figure 11).

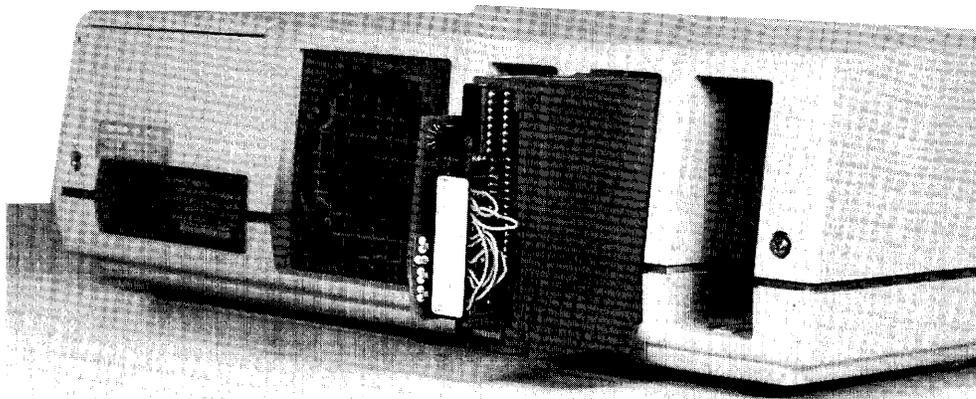
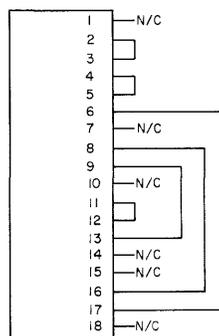


Figure 11. Test Connector Installed

6. Switch the calculator off and install the interface assembly into one of the I/O slots on the back of the calculator.
7. Switch the calculator on; then load and run the test program shown below.

If the interface fails the test, check the interface switch settings and run the test program again. If the program still indicates errors, refer to the schematic diagram (Figure 10) and the theory of operation (Chapter 4) to help you find the trouble.

### Test Connector



A flowchart of the program follows the program listing.

```

0: prt "98036A SELF TEST      PROGRAM";spc
1: prt "SET BIT RATE TO 2400 BAUD";prt "POSITION #3";spc 3
2: ent "Select Code",A
3: wtc A,1;wtb A,37;wtc A,0
4: fxd 0
5: sfg 0
6: gsb "Sub 1"
7: cfg 0
8: 63→B;0→Z
9: "Reset C":0→C;Z+1→Z
10: if Z=5;1→Z
11: "Loop":wtc A,1
12: B+1→B
13: C+1→C
14: if C=1;gto "SKIP"
15: if C=2;gto "SKIP"
16: wtb A,64
17: wtb A,B
18: wtb A,37
19: wtc A,0
20: gsb "Sub 1"
21: "SKIP":if B=255;gto "Control"
22: if C=4;gto "Reset C"
23: gto "Loop"
24: "Sub 1":0→X
25: "wrt":wtb A,X
26: wtc A,1
27: 0→Y
28: "Read":if (rdb(A)→N)=7;gto "Cont"
29: wait 10
30: if (Y+1→Y)=12;sfg 1;wtc A,53;wtc A,0;jmp 4
31: gto "Read"
32: "Cont":wtc A,0
33: if (rdb(A)→M)#X;sfg 2
34: if C=1;Z+1→Z
35: if Z=5;1→Z
36: X+1→X
37: if flg1 or flg2;sfg 3
38: if flg0 and not flg3;fmt 1,"DEFAULT MODE ",f3.0," GOOD";wrt .1,X;jmp 8
39: if flg0 and flg1;dsp "DEFAULT MODE",X,"STATUS ERROR";beep;wait 2000
40: if flg0 and flg1;jmp 6
41: if flg0 and flg2;dsp "DEFAULT MODE",X,"READ ERROR";beep;wait 2000
42: if flg0 and flg2;jmp 5
43: if not flg3;fmt 2,"MODE",2f4.0," GOOD";wrt .2,B,X
44: if flg1;dsp "MODE",B,X,"STATUS ERROR";beep;wait 2000
45: if flg2;dsp "MODE",B,X,"READ ERROR";beep;wait 2000
46: cfg 1;cfg 2;cfg 3
47: if X=31 and Z=1;gto "Ret"
48: if X=63 and Z=2;gto "Ret"
49: if X=127 and Z=3;gto "Ret"
50: if X=255;gto "Ret"
51: gto "Wrt"
52: "Ret":wait 1000;ret
53: "Control":wtc A,1
54: if rdb(A)#5;dsp "Status Error";wait 2000
55: wtb A,2
56: if rdb(A)#133;dsp "DSR ERROR";wait 2000
57: wtb A,13
58: wtc A,0
59: wait 100
60: if rdb(A)#0;dsp "BREAK ERROR";wait 2000
61: wtc A,1
62: if rdb(A)>63;dsp "DSR ERROR";wait 2000
63: wtb A,16
64: if rdb(A)>7;dsp "RESET ERROR";wait 2000
65: wtb A,64;0→E
66: wtb A,77
67: wtb A,37
68: wtc A,0
69: wtb A,255
70: wait 200
71: wtc A,1
72: if E=1;jmp 3
73: if (rdb(A)→W)#7;dsp "OVERFLOW",E,"ERROR";wait 2000
74: E+1→E;jmp -6
75: if rdb(A)#23;dsp "OVERFLOW",E,"ERROR";wait 2000
76: wtb A,21
77: if rdb(A)>7;dsp "RESET 1 ERROR";wait 2000
78: wtc A,0
79: dsp "TEST ENDED"
80: end
*22530

```

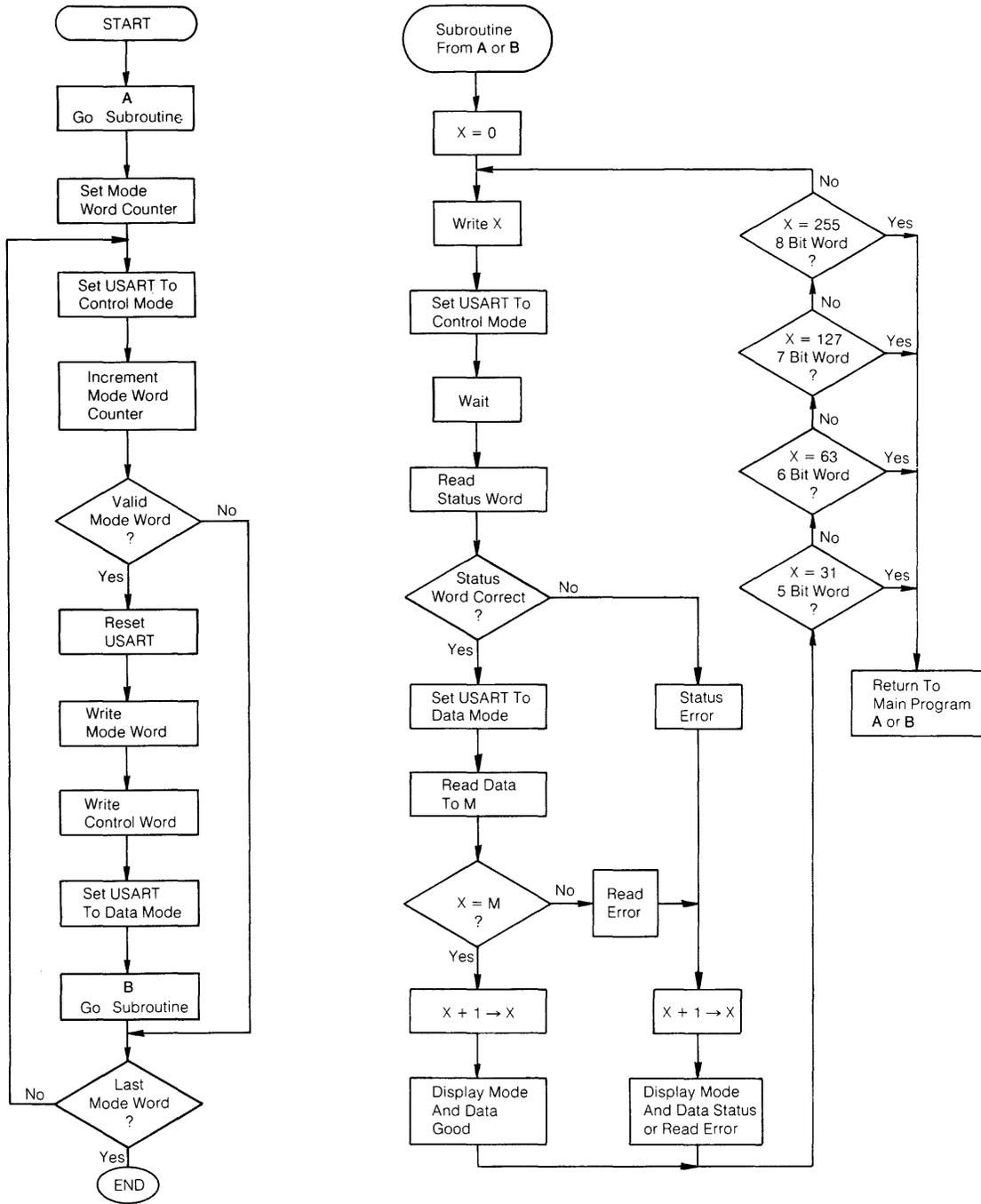


Figure 12. Test Program Flowchart

## Troubleshooting

To perform tests or checks on the interface, remove the front housing covers from the interface circuit assemblies. Use the Extender Board (98241-67901) to reconnect the interface to the calculator (see Figure 13).

### Broken Trace Repair

If one or more traces are open or have high resistance, the trace should be bridged using insulated wire on the back of the boards where possible.

#### NOTE

The boards are of multi-layer construction and, therefore, require good soldering technique to prevent damage.

#### CAUTION

TO HELP PREVENT DAMAGE TO THE CIRCUIT BOARDS  
USE A LOW-TEMPERATURE SOLDERING IRON WHEN  
MAKING REPAIRS OR REPLACING PARTS.

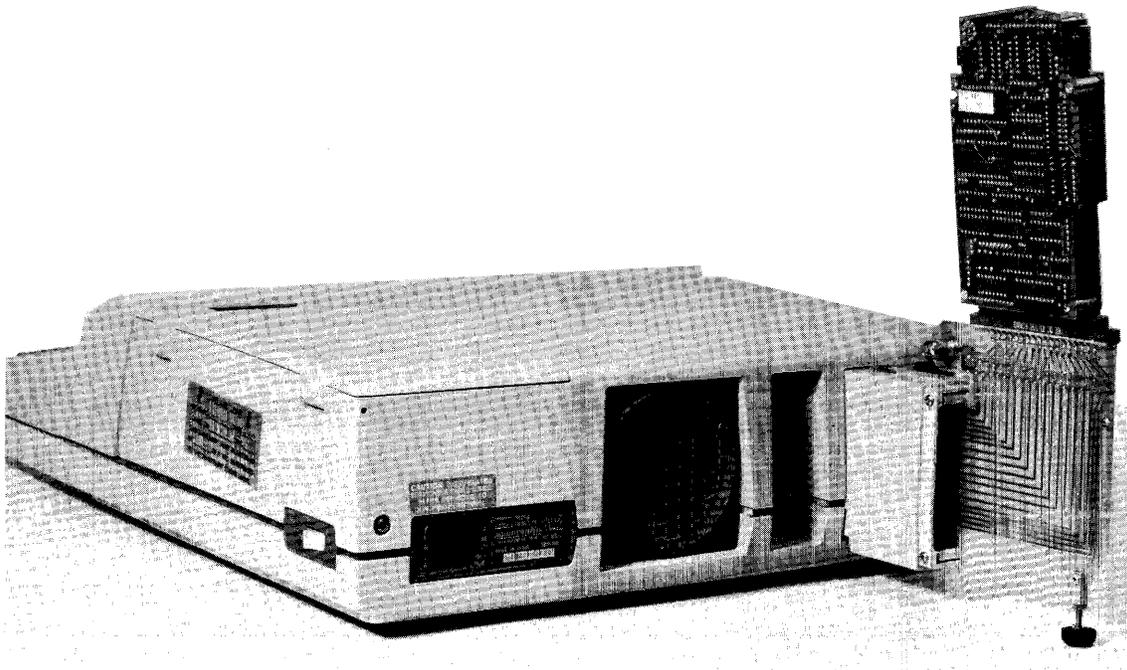


Figure 13. Interface Test Setup

## Replaceable Parts

Table 3 lists the 98036A Interface mechanical and electrical parts. The numbers in the quantity column indicate the total quantity of a part used on a particular interface assembly. The quantity is given only the first time the part number is listed.

Table 3. Replaceable Parts

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
<b>A1</b>	<b>98036-66501</b>		<b>Interface Assembly</b>		
C1 thru C4	0160-3847	4	C-F: 01UF 25V		
CR1	1902-3030	1	DIO: BKDN-3.01V		
CR2	1902-3002	1	DIO: BKDN-2.37V		
Q1	1853-0010	1	XSTR: PNP SM4713		
Q2	1854-0215	1	XSTR: 2N3904		
R1, R2	0757-0442	3	R-F: 10K 1%		
R3	0683-1565	1	R-F: 15M 5%		
R4	0757-0401	2	R-F: 100 1%		
R5	0757-0465	1	R-F: 100K 1%		
R6	0757-0288	1	R-F: 9.09K 1%		
R7	0757-0279	1	R-F: 3.16K 1%		
R8, R9	0757-0443	2	R-F: 11K 1%		
R10	0757-0401		R-F: 100 1%		
R11	0757-0442		R-F: 10K 1%		
R12	1810-0203	1	R-Network		
R13	1810-0139	1	R-Network		
S1	3100-3364	1	Select Code Switch		
S2	3101-2179	1	Switch, Current Loop		
U1	1820-1297	2	IC: 74LS266		
U2	1820-1427	1	IC: 74LS156		
U3	1820-1297		IC: 74LS266		
U4	1820-1198	1	IC: 74LS03		
U5	1820-1197	1	IC: 74LS00		
U6, U7	1820-0949	2	IC: CD4011		
U8	1820-1208	1	IC: 74LS32		
U9	1820-1199	1	IC: 74LS04		
U10	1820-1562	1	IC: 74C175		
U11	1820-0938	1	IC: CD4027		
U12	1820-1145	1	IC: CD4049		
U13	1820-1386	1	IC: MC14506		
U14, U15	1820-1483	3	IC: CD4071		
U16	1820-0939	2	IC: CD4013		
U17	1820-0938		IC: CD4027		
U18	1820-1486	1	IC: CD4081		
U19	1820-1440	1	IC: SN74LS279		
U20	1820-1483		IC: CD4071		
U21	1820-0939		IC: CD4013		
Y1	0410-1004	1	XTAL		
	1251-4215	9	6 Pin Connector		
	1251-4216	3	3 Pin Connector		
<b>A2</b>	<b>98036-66502</b>		<b>Control Assembly</b>		
C1 thru C4	0160-3847	5	C-F: .01UF 25V		
C5	0180-0229	1	C-F: 33UF 10V		
C6	0160-3847		C-F: .01UF 25V		
C7 thru C14	0160-3694	8	C-F: 330PF 10%		
CR1	1902-3030	1	DIO: BKDN 3.01V		
R1 thru R4	0757-0442	4	R-F: 10K 1%		
R5 thru R9	1810-0269	3	R-Network		
S1	3101-1983	1	Switch, Default Mode Word		
S2	3101-2172	1	Switch, Toggle		
S3	3100-3378	1	Switch, Bit Rate		

Table 3. Replaceable Parts (cont.)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
U22	1820-1427	1	IC: 74LS156		
U23	1820-1584	1	IC: Binary Interface Buffer		
U24	1820-1266	4	IC: 80C97		
U25	1820-1562	1	IC: 74C175		
U26, U27	1820-1190	4	IC: 74C173		
U28	1820-1195	1	IC: 74LS175		
U29, U30	1820-1190		IC: 74C173		
U31	1820-1844	1	IC: USART		
U32 thru U34	1820-1266		IC: 80C97		
U35	1820-1492	1	IC: 74LS368		
U36	1820-1779	1	IC: Bit Rate Generator MC14411		
U37, U38	1820-0510	2	IC: MC1489		
U39, U40	1820-0509	2	IC: MC1488		
P11	1251-3691	1	Connector Header		
P1 thru P10	1251-4326	2	Connector Pins (36 pins per connector)		
	<b>98036-67901</b>		<b>Front Housing Assembly</b> (Includes A1 and A2)		
	2200-0536	8	Screw, 4-40		
	7120-5911	1	Label		
	7120-5171	1	Plate, USA		
	5040-8163	1	Right Case		
	5040-8158	1	Spring Latch		
	5040-8161	1	Left Case		
	7120-5717	1	Front Label		
	<b>98036-67902</b>		<b>Rear Housing Assembly</b>		
	2200-0510	2	Screw, 4-40		
	5040-8174	1	Left Cover		
	5040-8211	1	Right Cover (with hole)		
	7120-5718	1	Rear Label		
	98036-61601	1	Cable Assembly (standard)		
	<b>98036-61601</b>		<b>Cable Assembly (standard)</b>		
	1251-0392	1	Connector Hood		
	1251-0688	17	Terminal Connector		
	1251-2942	2	Connector Lock		
	1251-3396	1	Connector Body		
	1251-3399	17	Contact Connector		
	1251-3808	1	Polarizing Plug		
	1251-4701	1	Rod Housing		
	1251-4702	1	Locking Rod		
	5040-7859	1	Molded Cable		
	<b>98036-67903</b>		<b>Rear Housing Assembly (Option 001)</b>		
	7120-5719	1	Rear Label, Option 001		
	5040-7803	1	Left Cover		
	5040-8211	1	Right Cover (With Hole)		
	98036-61602	1	Option Cable Assembly		
	<b>98036-61602</b>		<b>Option Cable Assembly</b>		
	1251-1438	1	Connector Hood		
	1251-3397	17	Contact Connector		
	1251-0063	1	Connector Body		
	1251-3399	25	Connector Contact		
	1251-3808	1	Polarizing Plug		
	1251-4701	1	Rod Housing		
	1251-4702	1	Locking Rod		
	5040-7859	1	Molded Cable		

