PC® MOUSE Implementation Using COP800

National Semiconductor
Application Note 681
Alvin Chan
June 1990

ABSTRACT

The mouse is a very convenient and popular device used in data entry in desktop computers and workstations. For desktop publishing, CAD, paint or drawing programs, using the mouse is inevitable. This application note will describe how to use the COP822C microcontroller to implement a mouse controller.

INTRODUCTION

Mouse Systems was the first company to introduce a mouse for PCs. Together with Microsoft and Logitech, they are the most popular vendors in the PC mouse market. Most mainstream PC programs that use pointing devices are able to support the communication protocols laid down by Mouse Systems and Microsoft.

A typical mouse consists of a microcontroller and its associated circuitry, which are a few capacitors, resistors and transistors. Accompanying the electronics are the mechanical parts, consisting of buttons, roller ball and two disks with slots. Together they perform several major functions: motion detection, host communication, power supply, and button status detection.

MOTION DETECTION

Motion detection with a mouse consists of four commonly known mechanisms. They are the mechanical mouse, the opto-mechanical mouse, the optical mouse and the wheel mouse.

The optical mouse differs from the rest as it requires no mechanical parts. It uses a special pad with a reflective surface and grid lines. Light emitted from the LEDs at the bottom of the mouse is reflected by the surface and movement is detected with photo-transistors.

The mechanical and the opto-mechanical mouse use a roller ball. The ball presses against two rollers which are connected to two disks for the encoding of horizontal and vertical motion. The mechanical mouse has contact points on the disks. As the disks move they touch the contact bars, which in turn generates signals to the microcontroller. The opto-mechanical mouse uses disks that contain evenly spaced slots. Each disk has a pair of LEDs on one side and a pair of photo-transistors on the other side.

The wheel mouse has the same operation as the mechanical mouse except that the ball is eliminated and the rollers are rotated against the outside surface on which the mouse is placed.

HOST COMMUNICATION

Besides having different operating mechanisms, the mouse also has different modes of communication with the host. It can be done through the system bus, the serial port or a special connector. The bus mouse takes up an expansion slot in the PC. The serial mouse uses one of the COM ports.

Although the rest of this report will be based on the opto-mechanical mouse using the serial port connection, the same principle applies to the mechanical and the wheel mouse.

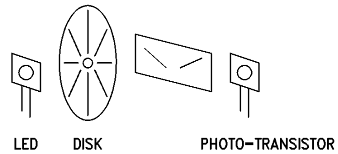
MOTION DETECTION FOR THE OPTO-MECHANICAL MOUSE

The mechanical parts of the opto-mechanical mouse actually consist of one roller ball, two rollers connected to the disks and two pieces of plastic with two slots on each one for LED light to pass through. The two slots are cut so that they form a 90 degree phase difference. The LEDs and the photo-transistors are separated by the disks and the plastic. As the disks move, light pulses are received by the photo-transistors. The microcontroller can then use these quadrature signals to decode the movement of the mouse.

Figure 1a shows the arrangement of the LEDs, disks, plastic and photo-transistors. The shaft connecting the disk and the ball is shown separately on *Figure 1b*. *Figure 2* shows the signals obtained from the photo-transistors when the mouse moves. The signals will not be exactly square waves because of unstable hand movements.

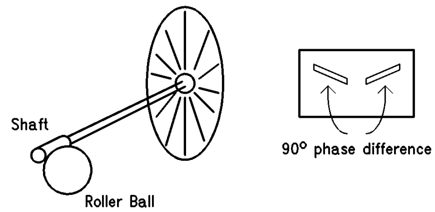
PC® is a registered trademark of International Business Machines Corporation.

 RRD-B30M75/Printed in U. S. A.



TL/DD/10799-1

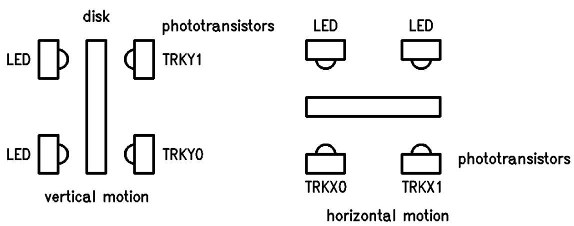
a



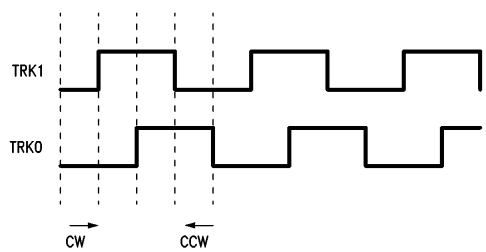
TL/DD/10799-2

b

FIGURE 1



TL/DD/10799-3



TL/DD/10799-4

Signals at phototransistors are similar for vertical and horizontal motion.
Track 1 leads track 0 by 90 degrees

FIGURE 2

RESOLUTION, TRACKING SPEED AND BAUD RATE

The resolution of the mouse is defined as the number of movement counts the mouse can provide for each fixed distance travelled. It is dependent on the physical dimension of the ball and the rollers. It can be calculated by measuring the sizes of the mechanical parts.

An example for the calculation can be shown by making the following assumptions:

- The disks have 40 slots and 40 spokes
- Each spoke has two data counts
  (This will be explained in the section ''An Algorithm for Detecting Movements'')
- Each slot also has two data counts
- The roller has a diameter of 5mm

For each revolution of the roller, there will be $40 \times 2 \times 2 = 160$ counts of data movement. At the same time, the mouse would have travelled a distance of $\pi \times 5 = 15.7$mm. Therefore the resolution of the mouse is $15.7/160 = 0.098$mm per count. This is equivalent to 259 counts or dots per inch (dpi).

The tracking speed is defined as the fastest speed that the mouse can move without the microcontroller losing track of the movement. This depends on how fast the microcontroller can sample the pulses from the photo-transistors. The effect of a slow tracking speed will contribute to jerking movements of the cursor on the screen.

The baud rate is fixed by the software and the protocol of the mouse type that is being emulated. For mouse systems and microsoft mouse, they are both 1200. Baud rate will affect both the resolution and the tracking speed. The internal movement counter may overflow while the mouse is still sending the last report with a slow baud rate. With a fast baud rate, more reports can be sent for a certain distance moved and the cursor should appear to be smoother.

POWER SUPPLY FOR THE SERIAL MOUSE

Since the serial port of the PC has no power supply lines, the RTS, CTS, DTR and DSR RS232 interface lines are utilized. Therefore the microcontroller and the mouse hardware should have very little power consumption. National Semiconductor's COP822C fits into this category perfectly. The voltage level in the RS232 lines can be either positive or negative. When they are positive, the power supply can be obtained by clamping down with diodes. When they are negative, a 555 timer is used as an oscillator to transform the voltage level to positive. The 1988 National Semiconductor Linear 3 Databook has an example of how to generate a variable duty cycle oscillator using the LMC555 in page 5-282.

While the RTS and DTR lines are used to provide the voltage for the mouse hardware, the TXD line of the host is utilized as the source for the communication signals. When idle, the TXD line is in the mark state, which is the most negative voltage. A pnp transistor can be used to drive the voltage of the RXD pin to a voltage level that is compatible with the RS232 interface standard.

AN ALGORITHM FOR DETECTING MOVEMENTS

The input signal of the photo-transistors is similar to that shown in *Figure 2*. Track 1 leads track 0 by 90 degrees. Movement is recorded as either of the tracks changes state. State tables can be generated for clockwise and counterclockwise motions.

With the two tracks being 90 degrees out of phase, there could be a total of four possible track states. It can be observed that the binary values formed by combining the present and previous states are unique for clockwise and counter-clockwise motion. A sixteen entry jump table can be formed to increment or decrement the position of the cursor. If the value obtained does not correspond to either the clockwise or counter-clockwise movement, it could be treated as noise. In that case either there is noise on the microcontroller input pins or the microcontroller is tracking motions faster than the movement of the mouse. A possible algorithm can be generated as follows. The number of instruction cycles for some instructions are shown on the left.

$(TRK1, TRK0)_t$		$(TRK1, TRK0)_{t-1}$ CCW		Binary Value
0	1	0	0	4
1	1	0	1	D
1	0	1	1	B
0	0	1	0	2

$(TRK1, TRK0)_t$		$(TRK1, TRK0)_{t-1}$ CW		Binary Value
1	0	0	0	8
0	0	0	1	1
0	1	1	1	7
1	1	1	0	E

```
CYCLES  ;************************************************
        ;       SAMPLE SENSOR INPUT
        ;       INC OR DEC THE POSITION
        ;************************************************
        ;
        SENSOR:
1               LD      B,#GTEMP
3               LD      A,PORTGP
1               RRC     A
2               AND     A,#03C          ; G6,G5,G4,G3
1               X       A, [B]          ; (GTEMP)
        ;
2               LD      A, [B+]         ; (GTEMP) X IN 3,2
1               RRC     A
1               RRC     A
2               AND     A, #03
1               OR      A, [B]          ; (TRACKS)
2               OR      A, #0B0         ; X MOVEMENT TABLE
3               JID
        ;
        NOISEX: JP      YDIR
        ;
3       INCX:   LD      A,XINC
1               INC     A
3               JP      COMX
        ;
        DECX:   LD      A,XINC
                DEC     A
        COMX:
2               IFEQ    A, #080
1               JP      YDIR
3               X       A, XINC
1               LD      B, #CHANGE
1               SBIT    RPT, [B]
1               LD      B, #TRACKS
        ;
        YDIR:
2               LD      A, [B-]         ; (TRACKS) Y IN 5, 4
1               SWAP    A
1               RRC     A
1               RRC     A
1               RRC     A
2               AND     A, #0C0
1               OR      A, [B]          ; (GTEMP)
```

```
1               SWAP    A
2               OR      A, #0C0         ; Y MOVEMENT TABLE
3               JID
        ;
        NOISEY: JP      ESENS
        ;
3       INCY:   LD      A, YINC
1               INC     A
3               JP      COMY
        DECY:
                LD      A, YINC
                DEC     A
        COMY:
2               IFEQ    A, #080
1               JP      ESENS
3               X       A, YINC
1               LD      B, #CHANGE
1               SBIT    RPT, [B]
1               LD      B, #GTEMP
        ESENS:
2               LD      A, [B+]         ; (GTEMP) IN5, 4, 1, 0
1               X       A, [B]          ; (TRACKS) NEW TRACK STATUS
5               RET
        ;
                .=0B0
        MOVEMX:
                .ADDR   NOISEX          ; 0
                .ADDR   INCX            ; 1
                .ADDR   DECX            ; 2
                .ADDR   NOISEX          ; 3
                .ADDR   DECX            ; 4
                .ADDR   NOISEX          ; 5
                .ADDR   NOISEX          ; 6
                .ADDR   INCX            ; 7
                .ADDR   INCX            ; 8
                .ADDR   NOISEX          ; 9
                .ADDR   NOISEX          ; A
                .ADDR   DECX            ; B
                .ADDR   NOISEX          ; C
                .ADDR   DECX            ; D
                .ADDR   INCX            ; E
                .ADDR   NOISEX          ; F
        ;
                .=0C0
        MOVEMY:
                .ADDR   NOISEY          ; 0
                .ADDR   INCY            ; 1
                .ADDR   DECY            ; 2
                .ADDR   NOISEY          ; 3
                .ADDR   DECY            ; 4
                .ADDR   NOISEY          ; 5
                .ADDR   NOISEY          ; 6
                .ADDR   INCY            ; 7
                .ADDR   INCY            ; 8
                .ADDR   NOISEY          ; 9
                .ADDR   NOISEY          ; A
                .ADDR   DECY            ; B
                .ADDR   NOISEY          ; C
                .ADDR   DECY            ; D
                .ADDR   INCY            ; E
                .ADDR   NOISEY          ; F
```

Going through the longest route in the sensor routine takes 75 instruction cycles. So at 5 MHz the microcontroller can track movement changes within 150 µs by using this algorithm.

MOUSE PROTOCOLS

Since most programs in the PC support the mouse systems and microsoft mouse, these two protocols will be discussed here. The protocols are byte-oriented and each byte is framed by one start-bit and two stop-bits. The most commonly used reporting mode is that a report will be sent if there is any change in the status of the position or of the buttons.

MICROSOFT COMPATIBLE DATA FORMAT

6	5	4	3	2	1	0	Bit Number
1	L	R	Y7	Y6	X7	X6	Byte 1
0	X5	X4	X3	X2	X1	X0	Byte 2
0	Y5	Y4	Y3	Y2	Y1	Y0	Byte 3

L, R = Key data (Left, Right key) 1 = key depressed

X0–X7 = X distance 8-bit two's complement value −128 to +127

Y0–Y7 = Y distance 8-bit two's complement value −128 to +127

Positive = South

In the Microsoft Compatible Format, data is transferred in the form of seven-bit bytes. Y movement is positive to the south and negative to the north.

FIVE BYTE PACKED BINARY FORMAT (MOUSE SYSTEMS CORP)

7	6	5	4	3	2	1	0	Bit Number
1	0	0	0	0	L*	M*	R*	Byte 1
X7	X6	X5	X4	X3	X2	X1	X0	Byte 2
Y7	Y6	Y5	Y4	Y3	Y2	Y1	Y0	Byte 3
X7	X6	X5	X4	X3	X2	X1	X0	Byte 4
Y7	Y6	Y5	Y4	Y3	Y2	Y1	Y0	Byte 5

L*, M*, R* = Key data (Left, Middle, Right key), 0 = key depressed

X0–X7 = X distance 8-bit two's complement value −127 to +127

Y0–Y7 = Y distance 8-bit two's complement value −127 to +127

In the Five Byte Packed Binary Format data is transferred in the form of eight-bit bytes (eight data bits without parity). Bytes 4 and 5 are the movement of the mouse during the transmission of the first report.

THE COP822C MICROCONTROLLER

The COP822C is an 8-bit microcontroller with 20 pins, of which 16 are I/O pins. The I/O pins are separated into two ports, port L and port G. Port G has built-in Schmitt-triggered inputs. There is 1k of ROM and 64 bytes of RAM. In the mouse application, the COP822C's features used can be summarized below. Port G is used for the photo-transistor's input. Pin G0 is used as the external interrupt input to monitor the RTS signal for the microsoft compatible protocol. The internal timer can be used for baud rate timing and interrupt generation. The COP822C draws only 4 mA at a crystal frequency of 5 MHz. The instruction cycle time when operating at this frequency is 2 µs.

A MOUSE EXAMPLE

The I/O pins for the COP822C are assigned as follows:

Pin	Function
G0	Interrupt Input (Monitoring RTS Toggle)
G1	Reserved for Input Data (TXD of Host)
G2	Output Data (RXD of Host)
G3–G6	LED Sensor Input
L0–L2	Button Input
L3	Jumper Input (for Default Mouse Mode)

The timer is assigned for baud rate generation. It is configured in the PWM auto-reload mode (with no G3 toggle output) with a value of 1A0 hex in both the timer and the auto-reload register. When operating at 5 MHz, it is equivalent to 833 µs or 1200 baud. When the timer counts down, an interrupt is generated and the service routine will indicate in a timer status byte that it is time for the next bit. The subroutine that handles the transmission will look at this status byte to send the data.

The other interrupt comes from the G0 pin. This is implemented to satisfy the microsoft mouse requirement. As the RTS line toggles, it causes the microcontroller to be interrupted. The response to the toggling is the transmission of the character "M" to indicate the presence of the mouse.

The main program starts by doing some initializations. Then it loops through four subroutines that send the report, sense the movement, sense the buttons, and set up the report format.

Subroutine "SDATA" uses a state table to determine what is to be transmitted. There are 11 or 12 states because microsoft has only 7 data bits and mouse systems has 8. The state table is shown below:

SENDST	State
0	IDLE
1	START BIT
2–8	DATA (FOR MICROSOFT)
2–9	DATA (FOR MOUSE SYSTEMS)
9–10	STOP BIT (FOR MICROSOFT)
10–11	STOP BIT (FOR MOUSE SYSTEMS)
11	NEXT WORD (FOR MICROSOFT)
12	NEXT WORD (FOR MOUSE SYSTEMS)

The G2 pin is set to the level according to the state and the data bit that is transmitted.

Subroutine "SENSOR" checks the input pins connected to the LEDs. The horizontal direction is checked first followed by the vertical direction. Two jump tables are needed to decode the binary value formed by combining the present and previous status of the wheels. The movements are recorded in two counters.

Subroutines "BUTUS" and "BUTMS" are used for polling the button input. They compare the button input with the value polled last time and set up a flag if the value changes. Two subroutines are used for the ease of setting up reports for different mice. The same applies for subroutines "SRPTMS" and "SRPTUS" which set up the report format for transmission. The status change flag is checked and the report is formatted according to the mouse protocol. The movement counters are then cleared. Since the sign of the vertical movement of mouse systems and microsoft is reversed, the counter value in subroutine "SRPTMS" is complemented to form the right value.

There is an extra subroutine "SY2RPT" which sets up the last two bytes in the mouse systems' report. It is called after the first three bytes of the report are sent.

The efficiency of the mouse depends solely on the effectiveness of the software to loop through sensing and transmission subroutines. For the COP822C, one of the most effective addressing modes is the B register indirect mode. It uses only one byte and one instruction cycle. With autoincrement or autodecrement, it uses one byte and two instruction cycles. In order to utilize this addressing mode more often, the organization of the RAM data has to be carefully thought out. In the mouse example, it can be seen that by placing related variables next to each other, the saving of code and execution time is significant. Also, if the RAM data can fit in the first 16 bytes, the load B immediate instruction is also more efficient. The subroutine "SRPTMS" is shown below and it can be seen that more than half the instructions are B register indirect which are efficient and compact.

```
;
;     VARIABLES
;
      WORDPT   =       000       ;WORD POINTER
      WORD1    =       001       ;BUFFER TO STORE REPORTS
      WORD2    =       002
      WORD3    =       003
      CHANGE   =       004       ;MOVEMENT CHANGE OR BUTTON PRESSED
      XINC     =       005       ;X DIRECTION COUNTER
      YINC     =       006       ;Y DIRECTION COUNTER
      NUMWORD  =       007       ;NUMER OF BYTES TO SEND
      SENDST   =       008       ;SERIAL PROTOCOL STATE
;
;******************************************************
;     SUBROUTINE SET UP REPORT 'SRPT' FOR MOUSE SYSTEMS
;     CHANGE OF STATUS DETECTED
;     SET UP THE FIRST 3 WORDS FOR REPORTING
;     IF IN IDLE STATE
;******************************************************
;
SRPTMS:
      LD       A,CHANGE
      IFEQ     A, #0             ; EXIT IF NO CHANGE
      RET
;
      RBIT     GIE, PSW          ; DISABLE INTERRUPT
      LD       B, #WORDPT
      LD       [B+], #01         ; (WORDPT) SET WORD POINTER
      LD       A, BUTSTAT
      X        A, [B+]           ; (WORD1)
;
      LD       A, XINC
      X        A, [B+]           ; (WORD2)
;
      SC
      CLR      A
      SUBC     A, YINC           ; FOR MOUSE SYSTEM NEG Y
      X        A, [B+]           ; (WORD3)
;
      RBIT     RPT, [B]          ; (CHANGE) RESET CHANGE OF STATUS
      SBIT     SYRPT, [B]                   ; (CHANGE)
      LD       A, [B+]           ; INC B
      LD       [B+], #0          ; (XINC)
      LD       [B+], #0          ; (YINC)
;
      LD       [B+], #03         ; (NUMWORD) SEND 3 BYTES
      LD       [B], #01          ; (SENDST) SET TO START BIT STATE
;     SBIT     GIE, PSW          ; ENABLE INTERRUPT
      RET
;
```

CONCLUSION

The COP822C has been used as a mouse controller. The code presented is a minimum requirement for implementing a mouse systems and microsoft compatible mouse. About 550 bytes of ROM code has been used. The remaining ROM area can be used for internal diagnostics and for communicating with the host's mouse driver program. The unused I/O pins can be used to turn the LED's on only when necessary to save extra power. This report demonstrated the use of the efficient instruction set of the COP800 family. It can be seen that the architecture of the COP822C is most suitable for implementing a mouse controller. The table below summarizes the advantages of the COP822C.

Feature	Advantage
Port G	Schmitt Triggered Input for Photo-Transistors
G0	External Interrupt for RTS Toggling
Timer	For Baud Rate Generation
Low Power	4 mA at 5 MHz
Small Size	20-Pin DIP

REFERENCE

The mouse still reigns over data entry—Electronic Engineering Times, October 1988.

MICE for mainstream applications—PC Magazine, August 1987.

Logimouse C7 Technical Reference Manual—Logitech, January 1986.

APPENDIX A—MEMORY UTILIZATION

RAM Variables

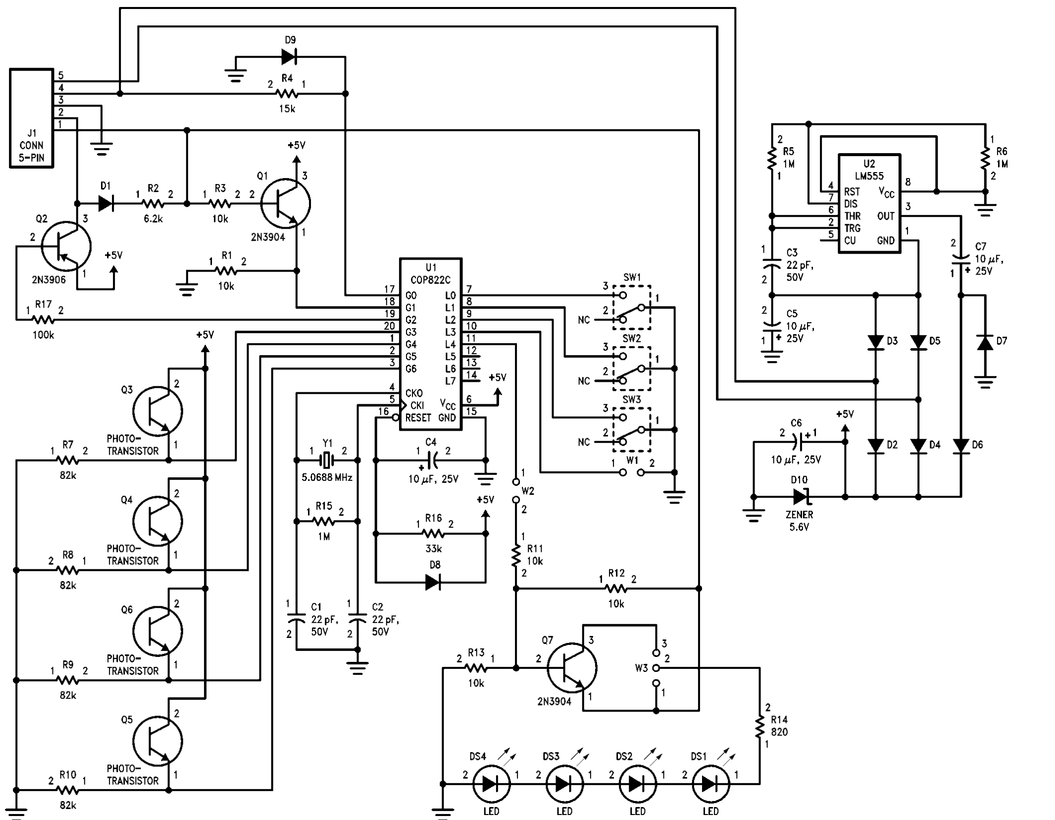
TEMP	=	0F1	Work Space
ASAVE	=	0F4	Save A Register
PSSAVE	=	0F6	Save PSW Register
WORDPT	=	000	Word Pointer
WORD1	=	001	Buffer to Store Report
WORD2	=	002	Buffer
WORD3	=	003	Buffer
CHANGE	=	004	Movement or Button Change
XINC	=	005	X Direction Counter
YINC	=	006	Y Direction Counter
NUMWORD	=	007	Number of Bytes to Send
SENDST	=	008	Serial Protocol State
TSTATUS	=	00A	Counter Status
MTYPE	=	00B	Mouse Type
GTEMP	=	00C	Track Input from G Port
TRACKS	=	00D	Previous Track Status
BTEMP	=	00E	Button Input from L Port
BUTSTAT	=	00F	Previous Button Status

APPENDIX B—SUBROUTINE SUMMARY

Subroutine	Location	Function
MLOOP	03D	Main Program Loop
SENSOR	077	Sample Photo-Transistor Input
INTRP	0FF	Interrupt Service Routines
SRPTUS	136	Set Up Report for Microsoft
SRPTMS	16C	Set Up 1st 3 Bytes Report for Mouse Systems
SDATA	191	Drive Data Transmission Pin According to Bit Value of Report
SY2RPT	1D1	Set Up Last 2 Bytes Report for Mouse Systems
BUTUS	200	Sample Button Input for Microsoft
BUTMS	210	Sample Button Input for Mouse Systems

APPENDIX C—SYSTEM SCHEMATIC, SYSTEM

Flowchart, complete program listing.



TL/DD/10799–5

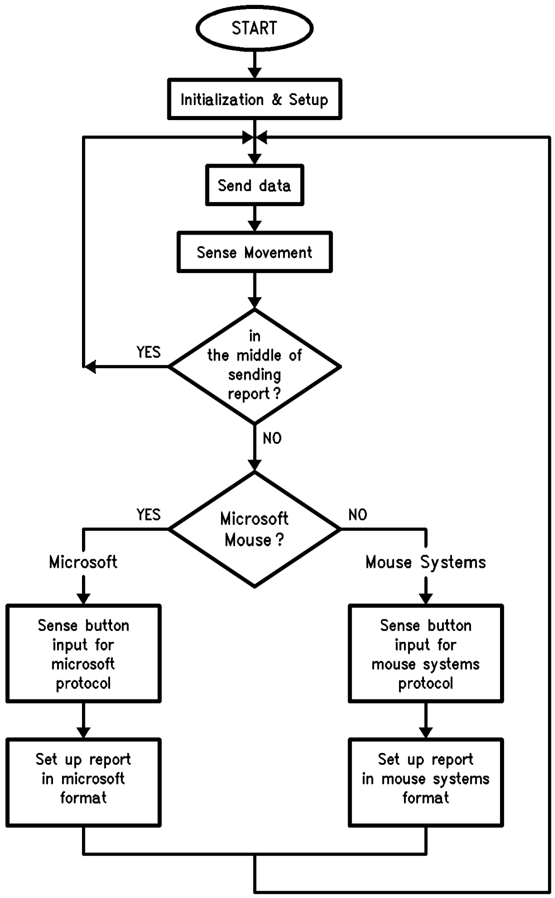
Note 1: All diodes are 1N4148.

Note 2: All resistor values are in ohms, 5%, 1⁄8W.

Note: Unless otherwised specified

FIGURE 3. System Schematic

Flowchart for Mouse Systems and Microsoft Mouse



TL/DD/10799–6

```
NATIONAL SEMICONDUCTOR CORPORATION
COP800 CROSS ASSEMBLER,REV:D1,12 OCT 88
AMOUSE


                 ;
                 ;       MICROSOFT AND MOUSE SYSTEM COMPATIBLE MOUSE
                 ;       02/14/89
                 ;       NAME : AMOUSE.MAC
                 ;
                         .TITLE AMOUSE
                         .CHIP 820
                 ;
                 ;
00D0             PORTLD  =       0D0     ; PORT L DATA
00D1             PORTLC  =       0D1     ; PORT L CONFIG
00D2             PORTLP  =       0D2     ; PORT L PIN
                 ;
00D4             PORTGD  =       0D4     ; PORT G DATA
00D5             PORTGC  =       0D5     ; PORT G CONFIG
00D6             PORTGP  =       0D6     ; PORT G PIN
                 ;
00EA             TMRLO   =       0EA     ; TIMER LOW BYTE
00EB             TMRHI   =       0EB     ; TIMER HIGH BYTE
00EC             TAULO   =       0EC     ; TIMER REGISTER LOW BYTE
00ED             TAUHI   =       0ED     ; TIMER REGISTER HIGH BYTE
                 ;
00EE             CNTRL   =       0EE     ; CONTROL REGISTER
00EF             PSW     =       0EF     ; PSW REGISTER
                 ;
                 ;       CONSTANT DECLARE
                 ;
0000             INTR    =       0
0003             TIO     =       3
0004             SO      =       4
0005             SK      =       5
0006             SI      =       6
0007             CKO     =       7
                 ;
0007             TSEL    =       7
0006             CSEL    =       6
0005             TEDG    =       5
0004             TRUN    =       4
0003             MSEL    =       3
0002             IEDG    =       2
0001             S1      =       1
0000             S0      =       0
                 ;
0007             HCARRY  =       7
0006             CARRY   =       6
0005             TPND    =       5
0004             ENTI    =       4
0003             IPND    =       3
0002             BUSY    =       2
0001             ENI     =       1
0000             GIE     =       0
```

TL/DD/10799–7

```
                  ;
                  ;       TSTATUS BITS
                  ;
0002              TBAUB   =       2       ;BAUD RATE TIMER BIT
                  ;
0000              RPT     =       0       ;REPORT BIT OF CHANGE (CHANGE)
0001              SYRPT   =       1       ;SET UP MOUSE SYSTEM LAST 2 WORDS (CHANGE)
0007              USOFT   =       7       ;MICROSOFT (MTYPE)
0002              XMT     =       2       ;G2 AS XMT BIT (PORTGD)
                  ;
0003              SW      =       3       ;SLIDE SWITCH (PORTLP,MTYPE)
                  ;
                  ;       REGISTER ASSIGNMENTS
                  ;
00F0                      RSVD    =       0F0
00F1                      TEMP    =       0F1
00F3                      TBAU    =       0F3     ;BAUD RATE TIMER
00F4                      ASAVE   =       0F4     ;SAVE A
00F5                      BSAVE   =       0F5     ;SAVE B
00F6                      PSSAVE  =       0F6     ;SAVE PSW
                  ;
                  ;       VARIABLES
                  ;
0000                      WORDPT  =       000     ;WORD POINTER
0001                      WORD1   =       001     ;BUFFER TO STORE REPORTS
0002                      WORD2   =       002
0003                      WORD3   =       003
                  ;
0004                      CHANGE  =       004     ;MOVEMENT CHANGE OR BUTTON PRESSED
0005                      XINC    =       005     ;X DIRECTION COUNTER
0006                      YINC    =       006     ;Y DIRECTION COUNTER
0007                      NUMWORD =       007     ;NUMBER OF BYTES TO SEND
0008                      SENDST  =       008     ;SERIAL PROTOCOL STATE
                  ;
0009                      TBAUR   =       009     ;BAUD RATE TIMER RELOAD
000A                      TSTATUS =       00A     ;COUNTER STATUS
000B                      MTYPE   =       00B     ;MOUSE TYPE
                  ;
000C                      GTEMP   =       00C     ;TRACK INPUT FROM G
000D                      TRACKS  =       00D     ;PREVIOUS TRACK STATUS
                  ;
000E                      BTEMP   =       00E     ;BUTTON INPUT
000F                      BUTSTAT =       00F     ;PREVIOUS BUTTON STATUS
                  ;
                  ;
                  ; MOST POSITIVE = SPACE = HI = ON = 0 = START BIT = RBIT
                  ; MOST NEGATIVE = MARK = LO = OFF = 1 = STOP BIT = SBIT
                  ;
                  ;       MICROSOFT FORMAT
                  ;
                  ;       1  L  R  Y7  Y6  X7  X6
```

TL/DD/10799–8

```
                        ;       0  X5 .............  X0
                        ;       0  Y5 .............  Y0
                        ;
                        ;       1200 BAUD 7 BIT NO PARITY 2 STOP BITS
                        ;
                        ;       MOUSE SYSTEMS FORMAT (FIVE BYTE PACKED BINARY)
                        ;
                        ;       1  0   0   0   0   L*  M*  R*
                        ;       X7 ......................  X0
                        ;       Y7 ......................  Y0
                        ;       X7 ......................  X0
                        ;       Y7 ......................  Y0
                        ;
                        ;       1200 BAUD 7 BIT NO PARITY 2 STOP BITS
                        ;
                        ;       G6,G5,G4,G3 ARE SENSOR INPUTS
                        ;
                        ;       L0, L1 AND L2 ARE BUTTON INPUTS
                        ;
                        ;       G0 IS INTERRUPT INPUT FOR DETECTING RTS TOGGLE
                        ;
                        ;       USE G2 AS TRANSMIT
                        ;
                        ;       G1 USED FOR RECEIVING COMMANDS FROM HOST (RESERVED)
                        ;
                        START:
0000 DD2F                       LD      SP,#02F
0002 BCEF00                     LD      PSW,#0          ;DISABLE INTR
0005 BCEE80                     LD      CNTRL,#080      ;10000000 - AUTORELOAD
                                                        ;RISING EDGE EXT INT
0008 BCD504                     LD      PORTGC,#004     ;G2 AS OUTPUT, OTHERS AS HI-Z
000B BCD404                     LD      PORTGD,#004     ;G2 DATA 1 "MARK"
                        ;
000E BCD130                     LD      PORTLC,#030     ;HI-Z INPUTS FOR L6-7,OUTPUT L4,5
0011 BCD00F                     LD      PORTLD,#0F      ;WEAK PULL UP FOR L0-3
                        ;
                        ;       INIT RAM
                        ;
0014 5B                         LD      B,#CHANGE
0015 9A00                       LD      [B+],#0         ;(CHANGE)
0017 9A00                       LD      [B+],#0         ;(XINC)
0019 9A00                       LD      [B+],#0         ;(YINC)
001B BC0A00                     LD      TSTATUS,#0
                        ;
001E 9DD6                       LD      A,PORTGP
0020 B0                         RRC     A
0021 953C                       AND     A,#03C          ;NOW IN 6,5,4,3
0023 9C0D                       X       A,TRACKS        ;GET INITIAL VALUE OF SENSORS
                        ;
0025 3067                       JSR     SELECT          ;SELECT MOUSE TYPE
                        ;
```

TL/DD/10799-9

```
                         ;*****************************************************
                         ;
                         ;      CRYSTAL FREQ = 4.96 MHZ  2.016 US INST CYCLE
                         ;      FOR 1200 BAUD - TIMER = 413 COUNT
                         ;
                         ;*****************************************************
                         ;
                         LTIMER:
0027 DEEA                       LD      B,#TMRLO
0029 9A9D                       LD      [B+],#09D       ;FOR 2.016 US CYCLE
002B 9A01                       LD      [B+],#01
002D 9A9D                       LD      [B+],#09D
002F 9E01                       LD      [B],#01
                         ;
0031 BC0800                     LD      SENDST,#0       ;SET TO IDLE STATE
0034 9DEF                       LD      A,PSW
0036 9713                       OR      A,#013          ;ENABLE INTRS SET GIE
0038 9CEF                       X       A,PSW
003A BDEE7C                     SBIT    TRUN,CNTRL      ;START TIMER
                         ;
                         MLOOP:
003D BCD03F                     LD      PORTLD,#03F     ;TURN ON LED (NOT USED)
0040 3191                       JSR     SDATA
0042 3077                       JSR     SENSOR
0044 9D08                       LD      A,SENDST        ;IF SENDING REPORT
0046 9300                       IFGT    A,#0            ;JUST DO SENSOR
0048 F4                         JP      MLOOP
                         ;
0049 9DD2                       LD      A,PORTLP        ;GET INPUT FROM BUTTONS (L0,L1,L2)
004B B0                         RRC     A               ;PUT IN CARRY FOR CHECKING
004C 51                         LD      B,#BTEMP        ;PREPARATION TO SEE WHAT BUTTON IS PRESSED
                         ;
004D BD0B77                     IFBIT   USOFT,MTYPE
0050 0B                         JP      LPUS
                         ;
0051 3210                       JSR     BUTMS           ;MOUSE SYSTEMS
0053 316C                       JSR     SRPTMS
                         ;
0055 BDD273                     IFBIT   SW,PORTLP
0058 E4                         JP      MLOOP           ;CONTINUE IF NO CHANGE IN SWITCH
0059 306B                       JSR     USM             ;ELSE NEW SET UP
005B E1                         JP      MLOOP
                         LPUS:
005C 3200                       JSR     BUTUS           ;MICROSOFT
005E 3136                       JSR     SRPTUS
                         ;
0060 BDD273                     IFBIT   SW,PORTLP
0063 3071                       JSR     SYM             ;IF CHANGED IN SWITCH, NEW SET UP
0065 203D            +          JP      MLOOP
                         ;
                         ;**************************************************
```

TL/DD/10799–10

```
                      ;       SELECT MOUSE TYPE
                      ;***************************************************
                      ;
                      SELECT:
0067 BDD273                   IFBIT   SW,PORTLP       ;CHECK JUMPER
006A 06                       JP      SYM
                      ;
                      USM:
006B 54                       LD      B,#MTYPE
006C 7F                       SBIT    USOFT,[B]       ;(MTYPE) IS MICROSOFT MOUSE
006D BC0F87                   LD      BUTSTAT,#087    ;NO KEY PRESSED
0070 8E                       RET
                      ;
                      SYM:
0071 54                       LD      B,#MTYPE
0072 6F                       RBIT    USOFT,[B]       ;(MTYPE) IS MOUSE SYSTEMS
0073 BC0F00                   LD      BUTSTAT,#0      ;NO KEY PRESSED
0076 8E                       RET
                      ;
                      ;***************************************************
                      ;       SAMPLE SENSOR INPUT
                      ;       INC OR DEC THE POSITION
                      ;       -127 IS USED INSTEAD OF -128 IN CHECKING
                      ;       NEGATIVE GOING POSITION SO THAT BOTH
                      ;       MICROSOFT AND MOUSE SYSTEMS FIT IN
                      ;***************************************************
                      ;
                      SENSOR:
0077 53                       LD      B,#GTEMP
0078 9DD6                     LD      A,PORTGP
007A BCD00F                   LD      PORTLD,#0F      ;(NOT USED) TURN OFF LED
007D B0                       RRC     A
007E 953C                     AND     A,#03C          ;G5,G4,G3,G2
0080 A6                       X       A,[B]           ;(GTEMP)
                      ;
                      ;
                      ;               (TRK1,TRK0)t-1  (TRK1,TRK0)t
                      ;       CCW       0    1          0    0       4
                      ;                 1    1          0    1       D
                      ;                 1    0          1    1       B
                      ;                 0    0          1    0       2
                      ;
                      ;       CW        1    0          0    0       8
                      ;                 0    0          0    1       1
                      ;                 0    1          1    1       7
                      ;                 1    1          1    0       E
                      ;
0081 AA                       LD      A,[B+]          ;(GTEMP) X IN 3,2
0082 B0                       RRC     A
0083 B0                       RRC     A
0084 9503                     AND     A,#03           ;GET X TRACKS
```

TL/DD/10799–11

```
0086 87                 OR      A,[B]           ;OVERLAY WITH PREVIOUS (TRACKS)
0087 97B0               OR      A,#0B0          ;X MOVEMENT TABLE
0089 A5                 JID
                ;
008A 0F         NOISEX: JP      YDIR
                ;
                INCX:
008B 9D05               LD      A,XINC
008D 8A                 INC     A
008E 03                 JP      COMX            ;CHECK IF LIMIT IS REACHED
                DECX:
008F 9D05               LD      A,XINC
0091 8B                 DEC     A
                COMX:                           ;CHECK FOR LIMIT
0092 9250               IFEQ    A,#80
0094 05                 JP      YDIR            ;YES DO NOTHING
0095 9C05               X       A,XINC          ;ELSE NEW POSITION
0097 5B                 LD      B,#CHANGE
0098 78                 SBIT    RPT,[B]         ;(CHANGE)
0099 52                 LD      B,#TRACKS
                ;
                YDIR:
009A 52                 LD      B,#TRACKS
009B AB                 LD      A,[B-]          ;(TRACKS) Y IN 5,4
009C 65                 SWAP    A
009D B0                 RRC     A
009E B0                 RRC     A
009F B0                 RRC     A
00A0 95C0               AND     A,#0C0
00A2 87                 OR      A,[B]           ;(GTEMP)
00A3 65                 SWAP    A
00A4 97C0               OR      A,#0C0          ;Y MOVEMENT TABLE
00A6 A5                 JID
                ;
     00B0               .=0B0
                MOVEMX:
00B0 8A                 .ADDR   NOISEX          ;0
00B1 8F                 .ADDR   DECX            ;1
00B2 8B                 .ADDR   INCX            ;2
00B3 8A                 .ADDR   NOISEX          ;3
00B4 8B                 .ADDR   INCX            ;4
00B5 8A                 .ADDR   NOISEX          ;5
00B6 8A                 .ADDR   NOISEX          ;6
00B7 8F                 .ADDR   DECX            ;7
00B8 8F                 .ADDR   DECX            ;8
00B9 8A                 .ADDR   NOISEX          ;9
00BA 8A                 .ADDR   NOISEX          ;A
00BB 8B                 .ADDR   INCX            ;B
00BC 8A                 .ADDR   NOISEX          ;C
00BD 8B                 .ADDR   INCX            ;D
00BE 8F                 .ADDR   DECX            ;E
```

TL/DD/10799–12

```
00BF 8A                  .ADDR   NOISEX          ;F
                 ;
     00C0                .=0C0
                 MOVEMY:
00C0 D0                  .ADDR   NOISEY          ;0
00C1 D1                  .ADDR   INCY            ;1
00C2 D5                  .ADDR   DECY            ;2
00C3 D0                  .ADDR   NOISEY          ;3
00C4 D5                  .ADDR   DECY            ;4
00C5 D0                  .ADDR   NOISEY          ;5
00C6 D0                  .ADDR   NOISEY          ;6
00C7 D1                  .ADDR   INCY            ;7
00C8 D1                  .ADDR   INCY            ;8
00C9 D0                  .ADDR   NOISEY          ;9
00CA D0                  .ADDR   NOISEY          ;A
00CB D5                  .ADDR   DECY            ;B
00CC D0                  .ADDR   NOISEY          ;C
00CD D5                  .ADDR   DECY            ;D
00CE D1                  .ADDR   INCY            ;E
00CF D0                  .ADDR   NOISEY          ;F
                 ;
00D0 0F          NOISEY: JP      ESENS
                 ;
00D1 9D06        INCY:   LD      A,YINC
00D3 8A                  INC     A
00D4 03                  JP      COMY
                 DECY:
00D5 9D06                LD      A,YINC
00D7 8B                  DEC     A
                 COMY:
00D8 9280                IFEQ    A,#080
00DA 05                  JP      ESENS
00DB 9C06                X       A,YINC
00DD 5B                  LD      B,#CHANGE
00DE 78                  SBIT    RPT,[B]         ;(CHANGE)
00DF 53                  LD      B,#GTEMP
                 ;
                 ESENS:
00E0 53                  LD      B,#GTEMP
00E1 AA                  LD      A,[B+]          ;(GTEMP) IN 5,4,1,0
00E2 A6                  X       A,[B]           ;(TRACKS)NEW TRACK STATUS
00E3 8E                  RET
                 ;
                 ;
     00FF                .=0FF
                 ;
                 ;**************************************************
                 ;       INTERRUPT ROUTINES
                 ;**************************************************
                 ;
00FF 9CF4        INTRP:  X       A,ASAVE
```

TL/DD/10799–13

```
                         ;
0101 BDEF75                     IFBIT   TPND,PSW
0104 07                         JP      TINTR
0105 BDEF73                     IFBIT   IPND,PSW
0108 0A                         JP      XINTR
                         ;
                         INTRET:                        ;INTERRUPT RETURN
0109 9DF4                       LD      A,ASAVE
010B 8F                         RETI
                         ;
                         ;**************************************************
                         ;      TIMER INTERRUPT
                         ;      UPDATE ALL THE COUNTERS
                         ;**************************************************
                         ;
                         TINTR:
010C BDEF6D                     RBIT    TPND,PSW
010F BD0A7A                     SBIT    TBAUB,TSTATUS   ;SET BIT IN TSTATUS
0112 F6                         JP      INTRET
                         ;
                         ;********************************************************
                         ;      EXTERNAL INTERRUPT
                         ;      RESPONSE TO RTS TOGGLING
                         ;      BY SENDING AN 'M' 4DH
                         ;********************************************************
                         ;
0113 BDEF6B              XINTR: RBIT    IPND,PSW
0116 BD0B77                     IFBIT   USOFT,MTYPE     ;ONLY IF MICROSOFT PROTOCOL
0119 01                         JP      XINTR1          ;CONTINUE
011A EE                         JP      INTRET          ;ELSE DO NOTHING
                         XINTR1:
011B BC01FF                     LD      WORD1,#0FF      ;ALL MARK
011E BC024D                     LD      WORD2,#'M'
0121 BC0702                     LD      NUMWORD,#02
                         ;
0124 9D08                       LD      A,SENDST
0126 9200                       IFEQ    A,#0            ;IF IDLE, SEND 'M'
0128 05                         JP      RTSR2
                         ;
0129 BC0001                     LD      WORDPT,#WORD1   ;FAKE CONTINUE LAST CHAR
012C 2109          +            JP      INTRET
                         ;
                         RTSR2:
012E BC0002                     LD      WORDPT,#WORD2   ;'M' ONLY
0131 BC0801                     LD      SENDST,#01
0134 2109          +            JP      INTRET
                         ;
                         ;********************************************************
                         ;      SUBROUTINE SET UP REPORT 'SRPT' FOR MICROSOFT
                         ;                                         -------------
                         ;      CHANGE OF STATUS DETECTED
```

TL/DD/10799–14

```
                        ;       SET UP THE 3 WORDS FOR REPORTING IF IN IDLE STATE
                        ;*********************************************************
                        ;
                        SRPTUS:
0136 5B                         LD      B,#CHANGE
0137 70                         IFBIT   RPT,[B]
0138 01                         JP      SRUS1
0139 8E                         RET                     ;EXIT IF NOT CHANGE
                        ;
                        SRUS1:
013A BDEF68                     RBIT    GIE,PSW         ;DISABLE INTERRUPT
013D 5F                         LD      B,#WORDPT
013E 9A01                       LD      [B+],#WORD1     ;(WORDPT)SET WORD POINTER
0140 9D05                       LD      A,XINC
0142 65                         SWAP    A
0143 B0                         RRC     A
0144 B0                         RRC     A
0145 9503                       AND     A,#03           ;X7,X6
0147 A6                         X       A,[B]           ;(WORD1)
                        ;
0148 9D06                       LD      A,YINC
014A 65                         SWAP    A
014B 950C                       AND     A,#0C           ;Y7,Y6
014D 87                         OR      A,[B]           ;(WORD1)
014E 9740                       OR      A,#040          ;SET BIT 6
0150 BD0F87                     OR      A,BUTSTAT       ;GET BUTTON STATUS
0153 A2                         X       A,[B+]          ;(WORD1)
                        ;
0154 9D05                       LD      A,XINC
0156 953F                       AND     A,#03F          ;X0-X5
0158 A2                         X       A,[B+]          ;(WORD2)
                        ;
0159 9D06                       LD      A,YINC
015B 953F                       AND     A,#03F          ;Y0-Y5
015D A2                         X       A,[B+]          ;(WORD3)
015E 68                         RBIT    RPT,[B]         ;(CHANGE)RESET CHANGE OF STATUS
015F AA                         LD      A,[B+]          ;INC B
0160 9A00                       LD      [B+],#0         ;(XINC)
0162 9A00                       LD      [B+],#0         ;(YINC)
                        ;
0164 9A03                       LD      [B+],#03        ;(NUMWORD)SEND 3 BYTES
0166 9E01                       LD      [B],#01         ;(SENDST)SET TO START BIT STATE
                        ;
0168 BDEF78                     SBIT    GIE,PSW         ;ENABLE INTERRUPT
016B 8E                         RET
                        ;
                        ;*********************************************************
                        ;       SUBROUTINE SET UP REPORT 'SRPT' FOR MOUSE SYSTEMS
                        ;                                       -----------------
                        ;       CHANGE OF STATUS DETECTED
                        ;       SET UP THE FIRST 3 WORDS FOR REPORTING
```

TL/DD/10799–15

```
                        ;       IF IN IDLE STATE
                        ;**********************************************************
                        ;
                        SRPTMS:
016C 5B                         LD      B,#CHANGE
016D 70                         IFBIT   RPT,[B]
016E 01                         JP      SRMS1
016F 8E                         RET                     ;EXIT IF NO CHANGE
                        ;
                        SRMS1:
0170 BDEF68                     RBIT    GIE,PSW         ;DISABLE INTERRUPT
0173 5F                         LD      B,#WORDPT
0174 9A01                       LD      [B+],#WORD1     ;(WORDPT)SET WORD POINTER
0176 9D0F                       LD      A,BUTSTAT
0178 A2                         X       A,[B+]          ;(WORD1)
                        ;
0179 9D05                       LD      A,XINC
017B A2                         X       A,[B+]          ;(WORD2)
                        ;
017C A1                         SC
017D 64                         CLR     A
017E BD0681                     SUBC    A,YINC          ;FOR MOUSE SYSTEM NEG Y
0181 A2                         X       A,[B+]          ;(WORD3)
                        ;
0182 68                         RBIT    RPT,[B]         ;(CHANGE)RESET CHANGE OF STATUS
0183 79                         SBIT    SYRPT,[B]       ;(CHANGE)
0184 AA                         LD      A,[B+]          ;INC B
0185 9A00                       LD      [B+],#0         ;(XINC)
0187 9A00                       LD      [B+],#0         ;(YINC)
                        ;
0189 9A03                       LD      [B+],#03        ;(NUMWORD)SEND 3 BYTES
018B 9E01                       LD      [B],#01         ;(SENDST)SET TO START BIT STATE
                        ;
018D BDEF78                     SBIT    GIE,PSW         ;ENABLE INTERRUPT
0190 8E                         RET
                        ;
                        ;
                        ;**********************************************************
                        ;       SUBROUTINE TO SEND DATA 'SDATA'
                        ;       CHECK THE BIT TO SEND AND DRIVE THE OUTPUT TO THE
                        ;       DESIRED VALUE
                        ;
                        ;       SENDST          STATE
                        ;         0             IDLE
                        ;         1             START BIT
                        ;         2-8           DATA
                        ;         2-9           DATA    (FOR MOUSE SYSTEMS)
                        ;         9-10          STOP BIT
                        ;         10-11         STOP BIT   (FOR MOUSE SYSTEMS)
                        ;         11            NEXT WORD
                        ;         12            NEXT WORD  (FOR MOUSE SYSTEMS)
```

TL/DD/10799-16

```
                     ;
                     ;**********************************************************
                     ;
0191 55              SDATA:  LD      B,#TSTATUS
0192 72                      IFBIT   TBAUB,[B]        ;(TSTATUS)CHECK IF BAUD RATE TIMER ENDS
0193 01                      JP      SDATA1
0194 8E                      RET
                     ;
                     SDATA1:
0195 6A                      RBIT    TBAUB,[B]        ;(TSTATUS)
0196 AA                      LD      A,[B+]           ;INC B TO (MTYPE)
0197 9D08                    LD      A,SENDST
0199 97F0                    OR      A,#0F0
019B A5                      JID
                     ;
019C 8E              IDLE:   RET                      ;EXIT IF IDLE
                     ;
019D 77              STAT9:  IFBIT   USOFT,[B]        ;(MTYPE)
019E 16                      JP      STOPB
                     DATAB:
019F 9D00                    LD      A,WORDPT
01A1 9CFE                    X       A,B              ;B POINTS TO THE WORD
                     ;
01A3 A0                      RC
01A4 AE                      LD      A,[B]
01A5 B0                      RRC     A                ;XMIT LEAST SIG BIT
01A6 A6                      X       A,[B]
01A7 DED4                    LD      B,#PORTGD
01A9 88                      IFC
01AA 7A                      SBIT    XMT,[B]
01AB 89                      IFNC
01AC 6A                      RBIT    XMT,[B]
                     ;
01AD 9D08            NEXT:   LD      A,SENDST
01AF 8A                      INC     A
01B0 9C08                    X       A,SENDST
01B2 8E                      RET                      ;EXIT
                     ;
01B3 77              STAT11: IFBIT   USOFT,[B]        ;(MTYPE)
01B4 04                      JP      NXWORD
                     ;
01B5 BDD47A          STOPB:  SBIT    XMT,PORTGD
01B8 F4                      JP      NEXT
                     ;
01B9 9D00            NXWORD: LD      A,WORDPT
01BB 8A                      INC     A
01BC BD0783                  IFGT    A,NUMWORD        ;NUMBER OF WORDS TO SEND
01BF 09                      JP      ENDRPT           ;END OF REPORT
01C0 9C00                    X       A,WORDPT
01C2 BC0801                  LD      SENDST,#01       ;SEND START BIT
                     ;
```

TL/DD/10799–17

```
01C5 BDD46A      STARTB: RBIT    XMT,PORTGD      ;SEND START BIT
01C8 E4                  JP      NEXT
                 ;
01C9 BD0471      ENDRPT: IFBIT   SYRPT,CHANGE
01CC 04                  JP      SY2RPT
                 ;
01CD BC0800              LD      SENDST,#0
01D0 8E                  RET
                 ;
                 ;**************************************************
                 ;       SET UP LAST 2 WORDS IN MOUSE SYSTEM FORMAT
                 ;**************************************************
                 ;
                 SY2RPT:
01D1 BDEF68              RBIT    GIE,PSW         ;DISABLE INTERRUPT
                 ;
01D4 5F                  LD      B,#WORDPT
01D5 9A01                LD      [B+],#WORD1     ;(WORDPT)SET WORD POINTER
01D7 9D05                LD      A,XINC
01D9 A2                  X       A,[B+]          ;(WORD1)
                 ;
01DA A1                  SC
01DB 64                  CLR     A
01DC BD0681              SUBC    A,YINC          ;FOR MOUSE SYSTEM NEG Y
01DF A2                  X       A,[B+]          ;(WORD2)
                 ;
01E0 AA                  LD      A,[B+]          ;INC B
01E1 69                  RBIT    SYRPT,[B]       ;(CHANGE)RESET CHANGE OF STATUS
01E2 AA                  LD      A,[B+]          ;INC B
01E3 9A00                LD      [B+],#0         ;XINC
01E5 9A00                LD      [B+],#0         ;YINC
                 ;
01E7 9A02                LD      [B+],#02        ;(NUMWORD)SEND 2 BYTES
01E9 9E01                LD      [B],#01         ;(SENDST)SET TO START BIT STATE
                 ;
01EB BDEF78              SBIT    GIE,PSW         ;ENABLE INTERRUPT
01EE 21C5      +         JP      STARTB
                 ;
     01F0                .=01F0
                 ;
01F0 9C                  .ADDR   IDLE            ;0
01F1 C5                  .ADDR   STARTB          ;1
01F2 9F                  .ADDR   DATAB           ;2
01F3 9F                  .ADDR   DATAB           ;3
01F4 9F                  .ADDR   DATAB           ;4
01F5 9F                  .ADDR   DATAB           ;5
01F6 9F                  .ADDR   DATAB           ;6
01F7 9F                  .ADDR   DATAB           ;7
01F8 9F                  .ADDR   DATAB           ;8
01F9 9D                  .ADDR   STAT9           ;9
01FA B5                  .ADDR   STOPB           ;10
```

TL/DD/10799–18

```
01FB B3                 .ADDR   STAT11          ;11
01FC B9                 .ADDR   NXWORD          ;12
01FD 9C                 .ADDR   IDLE            ;13
01FE 9C                 .ADDR   IDLE            ;14
01FF 9C                 .ADDR   IDLE            ;15
                ;
                ;
                ;**************************************************
                ;       SAMPLE BUTTON INPUT     FOR MICROSOFT
                ;                               -------------
                ;       INDICATE BUTTON STATUS
                ;**************************************************
                ;
                BUTUS:
0200 9E00               LD      [B],#0          ;(BTEMP), (A=PORTLP, CARRY ROTATED)
0202 89                 IFNC                    ;MICROSOFT: 1=KEY DEPRESSED
0203 7D                 SBIT    5,[B]           ;(BTEMP)
                ;
0204 B0                 RRC     A
0205 B0                 RRC     A
0206 89                 IFNC
0207 7C                 SBIT    4,[B]           ;(BTEMP)
                ;
0208 AA                 LD      A,[B+]          ;(BTEMP)
0209 82                 IFEQ    A,[B]           ;(BUTSTAT)
020A 8E                 RET                     ;NO CHANGE
                ;
020B A6                 X       A,[B]           ;(BUTSTAT)
020C BD0478             SBIT    RPT,CHANGE      ;INDICATE TO SEND DATA
020F 8E                 RET
                ;
                ;
                ;**************************************************
                ;       SAMPLE BUTTON INPUT     FOR MOUSE SYSTEMS
                ;                               -----------------
                ;       INDICATE BUTTON STATUS
                ;**************************************************
                ;
                BUTMS:
0210 9E87               LD      [B],#087        ;(BTEMP)
                ;
0212 89                 IFNC                    ;MOUSE SYSTEM: 0=KEY DEPRESSED
0213 6A                 RBIT    2,[B]           ;(BTEMP)
                ;
0214 B0                 RRC     A
0215 89                 IFNC
0216 69                 RBIT    1,[B]           ;(BTEMP)
                ;
0217 B0                 RRC     A
0218 89                 IFNC
0219 68                 RBIT    0,[B]           ;(BTEMP)
```

TL/DD/10799–19

```
                         ;
021A AA                         LD      A,[B+]          ;(BTEMP)
021B 82                         IFEQ    A,[B]           ;(BUTSTAT)
021C 8E                         RET                     ;NO CHANGE
                         ;
021D A6                         X       A,[B]           ;(BUTSTAT)
021E BD0478                     SBIT    RPT,CHANGE      ;INDICATE TO SEND DATA
0221 8E                         RET
                         ;
                         ;***********************************************************
                         ;
     03D0                       .=03D0
03D0 28                         .BYTE   '(C) 1990 NATIONAL SEMICONDUCTOR AMOUSE VER 1.0'
03D1 43
03D2 29
03D3 20
03D4 31
03D5 39
03D6 39
03D7 30
03D8 20
03D9 4E
03DA 41
03DB 54
03DC 49
03DD 4F
03DE 4E
03DF 41
03E0 4C
03E1 20
03E2 53
03E3 45
03E4 4D
03E5 49
03E6 43
03E7 4F
03E8 4E
03E9 44
03EA 55
03EB 43
03EC 54
03ED 4F
03EE 52
03EF 20
03F0 41
03F1 4D
03F2 4F
03F3 55
03F4 53
03F5 45
03F6 20
03F7 56
03F8 45
03F9 52
03FA 20
03FB 31
03FC 2E
03FD 30
                         ;
                                .END
```

TL/DD/10799-20

TL/DD/10799-21

```
NATIONAL SEMICONDUCTOR CORPORATION
COP800 CROSS ASSEMBLER,REV:D1,12 OCT 88
AMOUSE
SYMBOL TABLE

ASAVE  00F4        B      00FE        BSAVE  00F5  *     BTEMP  000E
BUSY   0002  *     BUTMS  0210        BUTSTA 000F        BUTUS  0200
CARRY  0006  *     CHANGE 0004        CKO    0007  *     CNTRL  00EE
COMX   0092        COMY   00D8        CSEL   0006  *     DATAB  019F
DECX   008F        DECY   00D5        ENDRPT 01C9        ENI    0001  *
ENTI   0004  *     ESENS  00E0        GIE    0000        GTEMP  000C
HCARRY 0007  *     IDLE   019C        IEDG   0002  *     INCX   008B
INCY   00D1        INTR   0000  *     INTRET 0109        INTRP  00FF  *
IPND   0003        LPUS   005C        LTIMER 0027  *     MLOOP  003D
MOVEMX 00B0  *     MOVEMY 00C0  *     MSEL   0003  *     MTYPE  000B
NEXT   01AD        NOISEX 008A        NOISEY 00D0        NUMWOR 0007
NXWORD 01B9        PORTGC 00D5        PORTGD 00D4        PORTGP 00D6
PORTLC 00D1        PORTLD 00D0        PORTLP 00D2        PSSAVE 00F6  *
PSW    00EF        RPT    0000        RSVD   00F0  *     RTSR2  012E
S0     0000  *     S1     0001  *     SDATA  0191        SDATA1 0195
SELECT 0067        SENDST 0008        SENSOR 0077        SI     0006  *
SK     0005  *     SO     0004  *     SP     00FD        SRMS1  0170
SRPTMS 016C        SRPTUS 0136        SRUS1  013A        START  0000  *
STARTB 01C5        STAT11 01B3        STAT9  019D        STOPB  01B5
SW     0003        SY2RPT 01D1        SYM    0071        SYRPT  0001
TAUHI  00ED  *     TAULO  00EC  *     TBAU   00F3  *     TBAUB  0002
TBAUR  0009  *     TEDG   0005  *     TEMP   00F1  *     TINTR  010C
TIO    0003  *     TMRHI  00EB  *     TMRLO  00EA        TPND   0005
TRACKS 000D        TRUN   0004        TSEL   0007  *     TSTATU 000A
USM    006B        USOFT  0007        WORD1  0001        WORD2  0002
WORD3  0003  *     WORDPT 0000        X      00FC        XINC   0005
XINTR  0113        XINTR1 011B        XMT    0002        YDIR   009A
YINC   0006
```

TL/DD/10799–22

```
NATIONAL SEMICONDUCTOR CORPORATION
COP800 CROSS ASSEMBLER,REV:D1,12 OCT 88
AMOUSE
MACRO TABLE


   NO WARNING LINES

   NO ERROR LINES

  556  ROM BYTES USED

SOURCE CHECKSUM = 987A
OBJECT CHECKSUM = 0A39

INPUT   FILE D:BMOUSE.MAC
LISTING FILE D:BMOUSE.PRN
OBJECT  FILE D:BMOUSE.LM
```

TL/DD/10799–23

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

National Semiconductor Corporation
2900 Semiconductor Drive
P.O. Box 58090
Santa Clara, CA 95052-8090
Tel: 1(800) 272-9959
TWX: (910) 339-9240

National Semiconductor GmbH
Livry-Gargan-Str. 10
D-82256 Fürstenfeldbruck
Germany
Tel: (81-41) 35-0
Telex: 527649
Fax: (81-41) 35-1

National Semiconductor Japan Ltd.
Sumitomo Chemical Engineering Center
Bldg. 7F
1-7-1, Nakase, Mihama-Ku
Chiba-City,
Ciba Prefecture 261
Tel: (043) 299-2300
Fax: (043) 299-2500

National Semiconductor Hong Kong Ltd.
13th Floor, Straight Block,
Ocean Centre, 5 Canton Rd.
Tsimshatsui, Kowloon
Hong Kong
Tel: (852) 2737-1600
Fax: (852) 2736-9960

National Semiconductores Do Brazil Ltda.
Rue Deputado Lacorda Franco
120-3A
Sao Paulo-SP
Brazil 05418-000
Tel: (55-11) 212-5066
Telex: 391-1131931 NSBR BR
Fax: (55-11) 212-1181

National Semiconductor (Australia) Pty, Ltd.
Building 16
Business Park Drive
Monash Business Park
Nottinghill, Melbourne
Victoria 3168 Australia
Tel: (3) 558-9999
Fax: (3) 558-9998