# AT89S8252 In-System Programming

Microcontroller

Application Note

## Introduction

This application note illustrates the in-system programmability of the Atmel AT89SXXXX (S-series) microcontrollers. A method is shown by which an AT89S8252 in an application may be programmed remotely over a standard telephone line.

The software for this application note may be obtained by downloading from:
Atmel BBS (408) 436-4309 or
Website: http://www.atmel.com

## An Example Application

The application shown in Figure 1 is a simple implementation of a moving display. This application was selected for its simplicity and ability to show graphically the results of in-system programming. The text to be displayed is programmed into the AT89S8252 microcontroller as part of its firmware, and can be changed by reprogramming the device.

The displayed text is presented in one of two modes, selected by a switch. In the first mode, one character at a time enters the display from the right and moves quickly to the left through each element of the display to its final position in the assembled message. In the second mode, the message moves through the display, from right to left, with the display acting as a window onto the message. This mode is familiar as the method often used in displays of stock prices.

The text is displayed on four DL1414T, four-element, 17-segment alphanumeric displays with integral decoders and drivers. This yields 16 total display elements, each capable of displaying digits 0-9, the upper case alphabet, and punctuation characters. The displayable character codes are ASCII 20-5F (hexadecimal).

A power-on reset circuit and a 6-MHz crystal complete the application. Neither external program memory nor external data memory is used.

### Modifications to the Application to Support In-System Programming

The AT89S8252 microcontroller features an SPI port, through which on-chip Flash memory and EEPROM may be programmed. To program the microcontroller, RST is held high while commands, addresses and data are applied to the SPI port. For command format and timing requirements, refer to the Atmel AT89S8252 Microcontroller data sheet.

Figure 2 shows the example application modified for in-system programming. The microcontroller reset circuit has been eliminated and RST is controlled by the programmer. The absence of a reset circuit requires that the programmer reset the microcontroller when power is first applied to the application. An optional connection ($\overline{\text{SHUTDN}}$) to an AT89S8252 interrupt input has been provided to allow the programmer to signal the microcontroller prior to programming. The resident firmware responds to the interrupt by displaying a message ("PROGRAMMING") indicating that programming is in progress.

A simple latch, composed of four OR gates, has been added between the outputs of the microcontroller and the display control inputs. The latch holds the display control signals inactive when RST is asserted, eliminating erratic operation of the displays during programming. No isolation of the display address or data inputs is required, since these inputs are ignored by the displays when the control signals are inactive. After programming, when RST is deasserted, the microcontroller I/O ports are high as

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the latch becomes transparent. Since the display control inputs are inactive high, the display contents are not disturbed until the new firmware writes the displays. Although not essential in this application, it might be imperative in some applications that the state of the peripheral circuitry not be disturbed during programming.

Finally, programmer access has been provided to three AT89S8252 SPI port pins: P1.5/MOSI, P1.6/MISO and P1.7/SCK. SPI port pin P1.4/$\overline{\text{SS}}$ is not used during programming. In the example application, the SPI port pins are available for use in programming the microcontroller. Applications which utilize the SPI port pins must be modified by the addition of circuitry which will isolate the SPI port when RST is asserted, freeing the pins for use in programming the microcontroller. Circuitry which is added to support programming must appear transparent to the application during normal operation.

The code for the modified display application is shown in Appendix 2.

**Figure 1.** AT89S8252 Moving Display Application Example

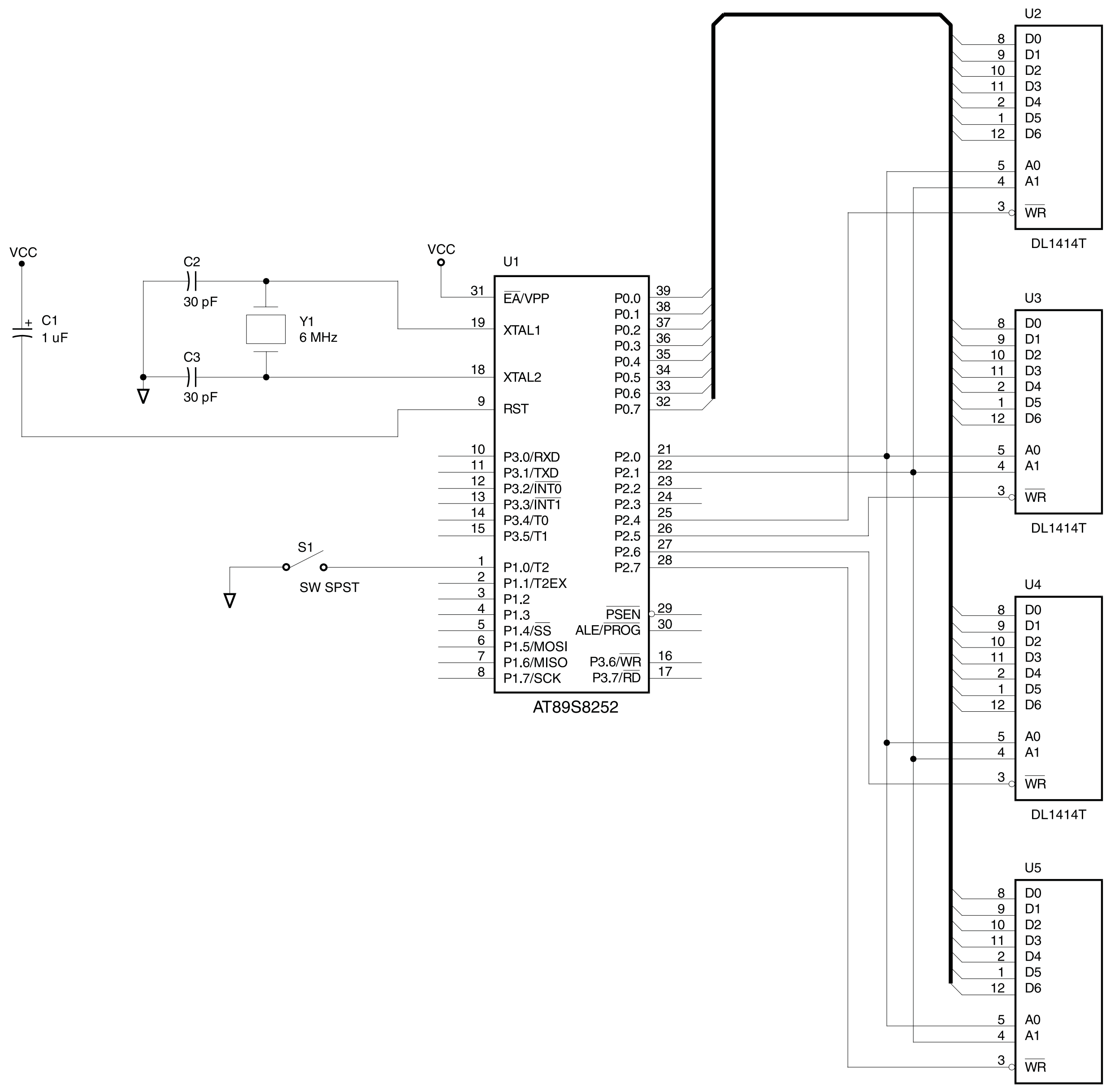
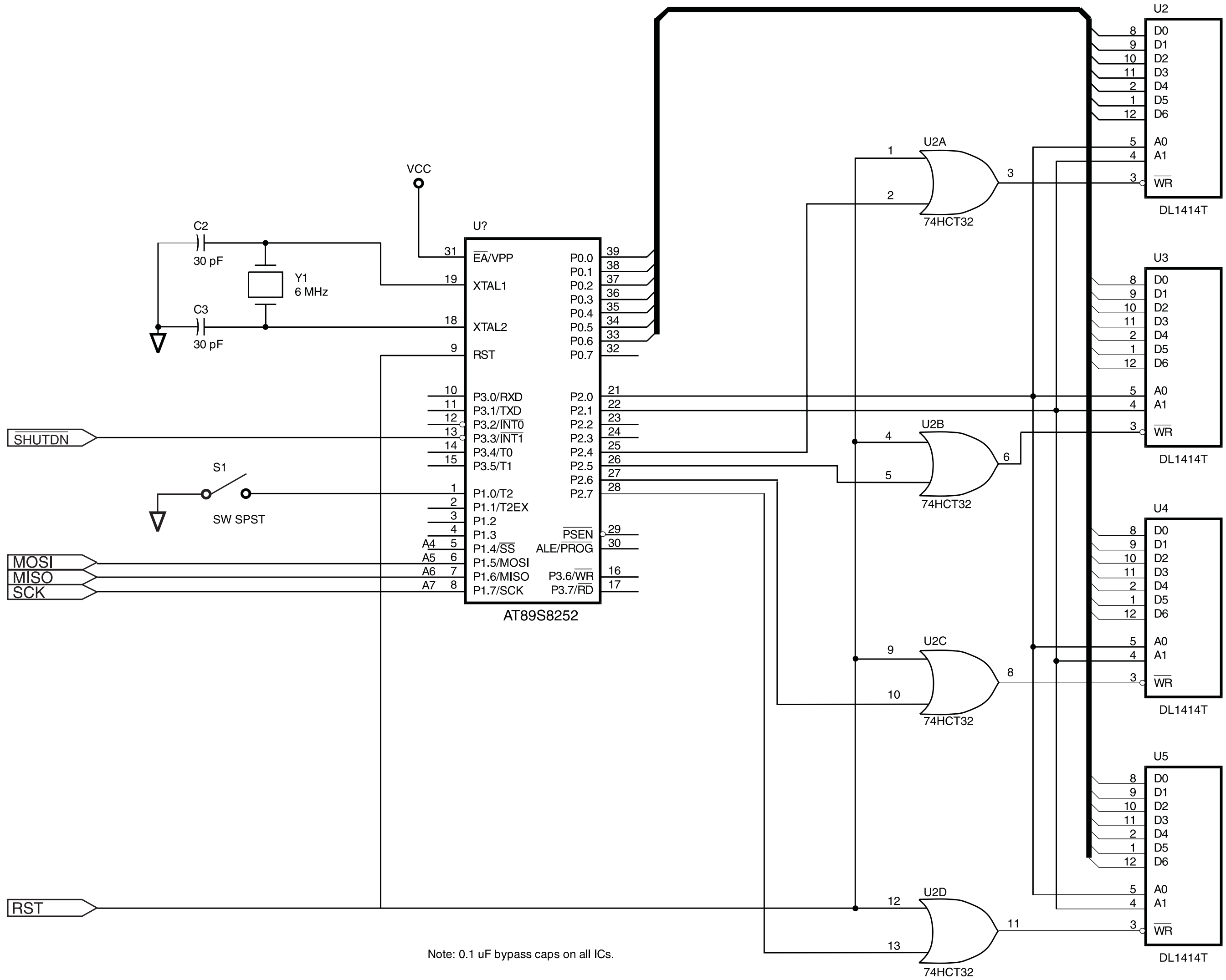


**Figure 2.** AT89S8252 Moving Display Application Modified for In-System Programming




## The Programmer

The programmer shown in Figure 3 interfaces with a modem, from which it receives packetized data. After dissecting the data packets, the programmer generates the signals required to program the data into the AT89S8252 microcontroller in the modified application. Code for the programmer is shown in Appendix 3.

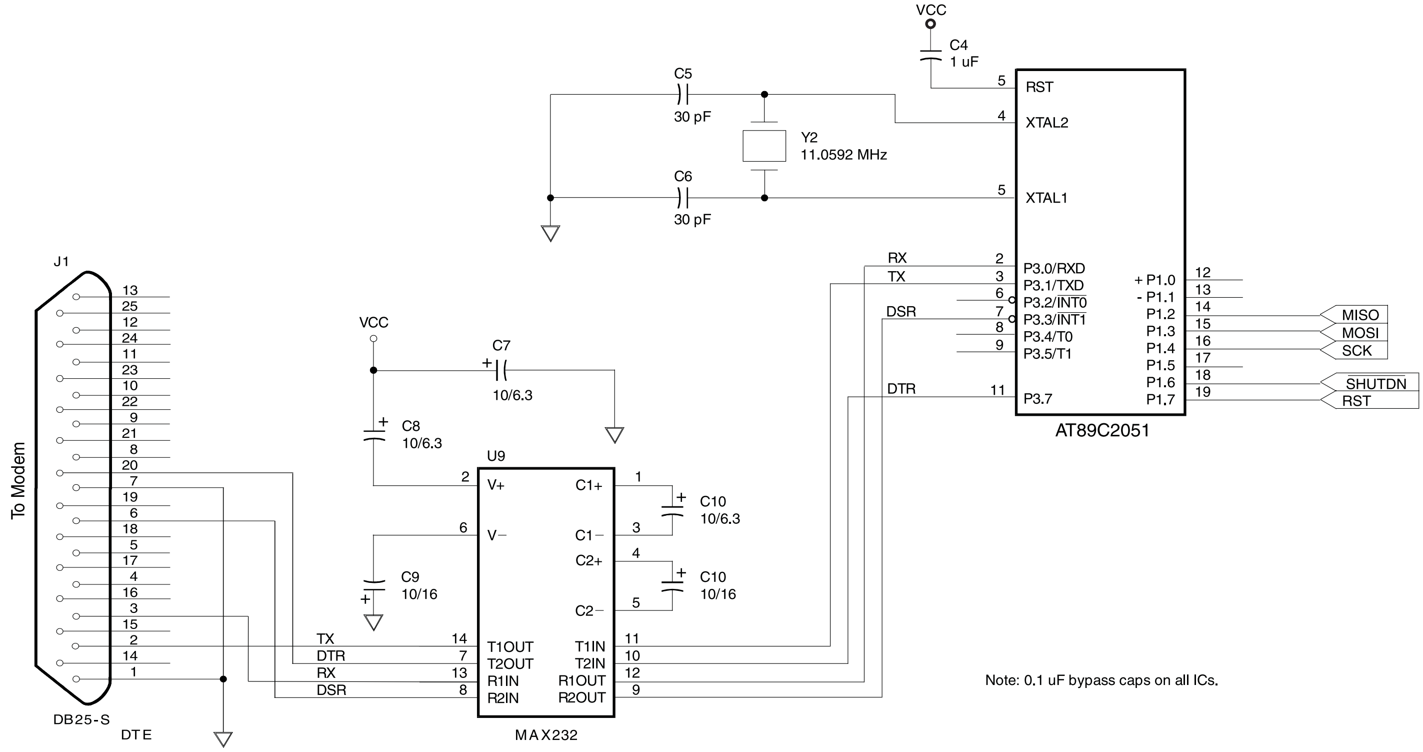
The programmer circuitry consists of little more than an Atmel 20-pin AT89C2051 microcontroller and a Maxim MAX232 line driver/receiver. The microcontroller runs at 11.0592 MHz, which allows the serial port to operate at a number of standard baud rates. The line driver/receiver produces RS-232 levels at the modem interface while requiring only a 5-V power supply. The AT89C2051 microcontroller does not support external program or data memory, which requires that program code be kept small enough to fit into on-chip memory.

The serial interface, through which the programmer connects to the modem, supports two handshaking signals, DTR and DSR. On power up, the programmer asserts DTR, to which the modem responds by asserting DSR. If the modem should fail to respond to any command, including the command to hang up, the programmer deasserts DTR, which forces the modem to hang up.

The programmer controls the modem by sending ASCII command strings over the serial interface, to which the modem responds with Hayes-style ASCII numeric codes. The programmer code is optimized for use with the U.S. Robotics Sportster 14,400 baud external modem used in the test configuration and may require modifications if used with other modems.

Since a reset circuit is absent from the modified application, the programmer provides the power-on reset function to the AT89S8252 microcontroller. The programmer powers up with RST asserted, resetting the microcontroller. Some time later, RST is deasserted under firmware control, allowing the application microcontroller to run normally. When programming is required, the programmer again asserts RST.

**Figure 3.** AT89S8252 Programmer




During programming, the programmer outputs serial data on the MOSI pin, synchronized to a software-generated clock output on the SCK pin. Serial data is input on the MISO pin, also synchronized to SCK. The maximum frequency of SCK must be less than 1/40th the crystal frequency of the AT89S8252 microcontroller being programmed, as specified in the AT89S8252 data sheet. The documented code produces a maximum SCK frequency of approximately 90 KHz, permitting a minimum AT89S8252 crystal frequency of approximately 3.6 MHz.

## Remote Programming Over a Standard Telephone Line

The programmer and modified application described previously are connected to a phone line through a modem at a remote site. Using a personal computer with a modem, a user can upload code containing a new message, which is programmed into the AT89S8252 microcontroller in the application. When programming is complete, the microcontroller executes the new firmware, which displays the new message.

### Local Station

The local station in the test configuration consists of an IBM PC AT-compatible personal computer with a Cardinal MVPV34ILC 33,600 baud internal modem. Any modem may be used, as long as it is compatible with the data communications software and matches the data rate and error correction protocols of the modem at the remote site.

Procomm Plus for Windows, version 3.0, a commercial data communications package, is used to configure the modem, set up communications parameters, and establish a link with the remote modem. Procomm Plus includes a macro language called ASPECT, which allows the user to write and compile scripts which implement custom file transfer protocols. A simple ASPECT script was written to read the contents of a code file and upload it to the remote programmer. The ASPECT script is shown in Appendix 4.

The file transfer protocol (FTP) implemented is a simple send-and-wait, packet-oriented protocol. The FTP transmit and receive modes are diagrammed in the flowcharts in figures 4 and 5, respectively. The computer sends each packet without flow control and waits for a response. The programmer may acknowledge the packet by sending an ACK or may negatively acknowledge the packet by sending a NAK. Upon receipt of an ACK, the computer sends the next packet. If the clone receives a NAK, it resends the same packet. Transmission proceeds in this manner until the entire file has been transferred.

The programmer might respond to a packet by sending a CAN, which indicates that a non-recoverable error has occurred and that the computer should immediately abort the file transfer. If the programmer fails to respond to a packet within a limited period of time, the computer will resend the same packet. The computer will continue to resend the same packet until a valid response is received or until the allowed number of attempts is exceeded, at which time the file transfer is aborted.

The send-and-wait nature of the FTP allows the time required for the programmer to program the packet data into the application microcontroller to be easily absorbed. Programming verification requires no explicit command or result codes, or additional data transfers. The programmer's response to a packet reflects the result of the programming verification operation performed by the programmer: ACK indicates success, CAN indicates failure.

Hexadecimal object file format (Intel hex) was chosen as the format of the files to be uploaded to the programmer. The records in a hex file serve, unchanged, as the packets in the FTP described above; no service fields need to be added. The fields in Intel hex file records are shown in Appendix 1. The colon which begins each record serves as the packet signature field. The load address field serves as the packet sequence number. A checksum is provided as the last field in each record. Since 7-bit ASCII coding is utilized, the eighth bit of each byte is available to be used for parity checking.

Since the AT89C2051 microcontroller in the programmer does not utilize external data memory, necessary packet buffering must be done using internal RAM. Limited memory precludes the use of conventional FTPs which utilize packets of 128 bytes or more. The hex packet format used in this application limits packet data fields to 16 or fewer entries, requiring little memory for buffering.

A disadvantage of the hex packet format is the use of ASCII, which requires each program data byte to be expressed as two hex characters. This demands that nearly twice as many bytes be transferred as might otherwise be required. This is not a severe limitation, however, since typical file transfer times are on the order of a few seconds.

### Remote Station

The remote station in the test configuration consists of the programmer and modified application, previously described, connected to a U.S. Robotics Sportster 14,400-baud external modem.

After power is applied, the programmer resets the AT89S8252 microcontroller in the application, and then sets its control outputs inactive, allowing the application to run normally. The programmer configures the modem to answer incoming calls and puts itself to sleep. While the programmer sleeps, the modem monitors the phone line, waiting for an incoming call. When a call is detected, the modem answers and attempts to establish communication with the caller. If a connection is established, the modem sends a connect code to the programmer, waking it up. The programmer verifies the connect code and begins polling for a valid packet header. Invalid connect codes are ignored.

Incoming packets must arrive fewer than 30 seconds apart, or the modem hangs up and the programmer returns to sleep, waiting for the next call. If the caller hangs up, the 30-second period must expire before another call will be answered. Calls incoming during the reset delay period are ignored.

If a valid packet header is received prior to the expiration of the reset delay period, the programmer will attempt to read and validate the incoming packet. At any time during packet reception, an invalid character, parity error or timeout during character reception will cause the partial packet to be declared invalid and discarded.

Two packet types are defined: data and end-of-file. A data packet contains five fields in addition to the packet header, one of which is a variable length data field. The data field contains program data to be written into the application microcontroller. The load address field contains the address at which the data is to be written. The end-of-file packet contains the same fields as the data packet, except that the data field is empty. This packet type has special meaning to the programmer, as explained below.

Any packet which contains an invalid record type, record length or checksum is invalid. Program data accumulated during the processing of an invalid packet is discarded. The programmer sends a NAK to the computer to signal reception of an invalid packet and resumes polling for a valid packet header.

Receipt of the first valid data packet causes the programmer to interrupt the application microcontroller. The microcontroller responds to the interrupt by abandoning its usual routine and displaying a message (“PROGRAMMING”) indicating that programming is taking place. If this is the first valid data packet since power was applied or an end-of-file packet was received, the programmer asserts the control signals necessary to place the microcontroller into programming mode.

The first and subsequent valid data packets are dissected as they are received and the data which they contain is programmed into the application microcontroller at the address indicated in the packet load address field. After programming, the data is read back from the microcontroller and verified against the received packet data. If programming was successful, the programmer sends ACK to the computer. The programmer then resumes polling for a valid packet header, subject to the thirty second reset delay.

If programming fails, the programmer sends CAN to signal the computer to abort the file transfer. The modem hangs up and the programmer returns to sleep, waiting for the next call. The application microcontroller is left in programming mode, preventing it from executing the incomplete or invalid firmware which it contains.

It is important to note that invalid packets are NEVER programmed into the application microcontroller. To do so might over-write valid program data which could not be recovered.

Upon receipt of an end-of-file packet, the programmer returns its control outputs to the inactive, power-on state, allowing the application microcontroller to begin execution of its new firmware. The programmer then resumes polling for a valid packet header, subject to the 30-second reset delay. If a valid packet is received prior to the expiration of the 30-second delay, another programming cycle begins, which can only be terminated by the reception of a valid end-of-file packet.

If the reset delay expires prior to the reception of a valid end-of-file packet, the modem will hang up and the programmer will return to sleep, waiting for the next call. In this case, the application microcontroller is left in programming mode, preventing it from executing its firmware. To return the application to normal operation, another call must be received, and a valid program file downloaded, terminated by an end-of-file packet.

## Setting Up the Hardware

### Local Station

Install the selected modem into the IBM PC AT-compatible computer and connect it to a standard analog telephone line. The modem must support a data rate of at least 9600 baud.

### Remote Station

Connect the programmer and modified display application to the U.S. Robotics Sportster 14,400 baud external modem. Connect the modem to a standard analog telephone line and set the modem switches as indicated below.

**Modem switch settings:**

| | | |
|---|---|---|
| 1 | UP | DTR normal |
| 2 | DOWN | Numeric result codes |
| 3 | DOWN | Display result codes |
| 4 | DOWN | Suppress command echo |
| 5 | UP | Auto answer |
| 6 | UP | CD normal |
| 7 | UP | Load NVRAM defaults |
| 8 | DOWN | Smart mode |

Turn the modem on and apply power to the programmer and display application. The microcontroller in the application will begin executing its firmware, if it contains any. The programmer will initialize the modem, as indicated by the activity on the modem status indicators. If it should become necessary to reinitialize the modem, briefly interrupt power to the programmer.

## Installing and Configuring Procomm Plus for Windows, Version 3.0

Install Procomm Plus as instructed in the User Manual. When prompted to specify the modem in use, select the installed modem from the list.

Put the provided ASPECT script (ATX.WAX) into the Procomm Plus ASPECT directory. If the default directories were utilized during installation, the correct directory is: \PROWIN3\ASPECT.ATX.WAX is the executable ASPECT script which results from compiling the source file ATX.WAS, shown in Appendix 4. Source files may be edited from within Procomm Plus using the ASPECT Editor, available in the Tools menu. The ASPECT Editor provides the option to compile a source file in the Editor Tools menu.

Launch Procomm Plus and create a Connection Directory entry for the remote station. Under Port Settings, set the baud rate to 9600, parity to EVEN, number of data bits to 7, number of stop bits to 1, plex to FULL.

### Creating a Hex File

The example source code for the modified display application (Appendix 2) contains a string at location “usr_msg” which is written repeatedly to the alphanumeric displays. The user may substitute a different message, as long as it is enclosed in single quotes and is null-terminated. Long messages may require that the value in the subsequent ORG directive be increased to prevent the message from being over-written by code. The message may contain only characters with ASCII codes from 20-5F (hexadecimal). The modified source code may then be assembled, linked and an Intel hex file produced.

During the development of this application note, code was assembled and hex files generated utilizing the tools in a vintage copy of the Intel MCS-51 Software Development Package for the IBM PC. The source code may require cosmetic changes for compatibility with other assemblers and software tools. It is especially important to note that variations exist in Intel hex file format. This application requires that record data fields be limited to 16 or fewer entries and that address fields contain 4 hex digits. The user must verify that the hex files produced by the selected tools conform to the format documented in Appendix 1.

### Uploading a Hex File

Launch Procomm Plus and select the correct entry from the list box in the toolbar to dial the remote site. If the line is busy and remains busy for more than 30 seconds, the programmer must be reset.

After a connection with the remote site has been established, run the ATX ASPECT script by selecting it from the list box in the toolbar. When prompted by the script, enter the path and file name (including extension) of the hex file to upload to the programmer at the remote site. The programmer must receive the first record from the file within 30 seconds of the time the connection was established or it will hang up and the user will be required to redial.

During the data transfer, data and status information is displayed in the Procomm Plus Terminal Window. If the transfer completes successfully, the message “End of File” will appear in the Terminal Window. The user has 30 seconds from the appearance of messages “End of File” or “EXCESSIVE RETRIES: UPLOAD ABORTED” to rerun the script and upload another file, if desired, before the programmer hangs up. If the message “UPLOAD ABORTED BY REMOTE” appears, the programmer has hung up and the user must redial before uploading another file.

## Appendix 1: Intel Hex File Definition

Each record in hexadecimal object file format (Intel hex) contains the following fields:

<:> <rec length> <load address> <rec type> <data> <checksum>

The colon is the record header.

The record length field consists of two hex digits, and represents the number of entries in the data field.

The load address field consists of four hex digits, and indicates the absolute address at which the data in the data field is to be loaded.

The record type field consists of two hex digits, which are always zero in data records.

The data field contains from one to 16 pairs of hex digits.

The last two hex digits are a checksum on the record length, load address, record type, and data fields. The sum of the binary equivalents of these fields and the checksum itself is zero.

Each record in the file is terminated by a carriage return (0D hex) and line feed (0A hex).

A type one record marks the end of the file. The record always contains ":00000001FF".

## Appendix 2: Code for Modified Display Application

```
NAME LEDShow1
; Displays predefined text strings on the LED display in one of two modes.
; The display mode can be changed at run time with the switch.
;
; The program may be interrupted by External Interrupt 1. This will cause the
; processor to display a string and enter a wait loop with interrupts disabled.
; Only reset will restore normal operation. This facility is provided so that
; the programmer can trigger an orderly shutdown before reprogramming the part.
;
; The LED display consists of four devices of four elements each,
; for a total display capacity of 16 characters.
; The display devices are numbered 0 to 3, from the right.
; The display elements are numbered from 0 to 3, from the right.
; Character positions are numbered 1 to 16, from the right.

NDEVS       EQU   4             ; number of devices
NELMS       EQU   4             ; number of elements in each device
SPACE       EQU   20h           ; blank
      DSEG AT 60h               ; stack origin
stack: DS  20h                  ; stack depth
SWITCH BIT p1.0                 ; display mode select input
      CSEG
      ORG 0000h                 ; power on/reset vector
      jmp init
      ORG 0003h                 ; external interrupt 0 vector
      reti                      ; undefined
      ORG 000bh                 ; timer 0 overflow vector
      reti                      ; undefined
      ORG 0013h                 ; external interrupt 1 vector
```

```
        jmp shutdown
        ORG 001bh                   ; timer 1 overflow vector
        reti                        ; undefined
        ORG 0023h                   ; serial I/O interrupt vector
        reti                        ; undefined
        ORG 30h                     ; begin constant data space

pgm_msg: DB '  PROGRAMMING', 0
usr_msg: DB ' ATMEL AT89S8252 CMOS MICROCONTROLLER'
        DB  ' WITH FLASH MEMORY AND SPI PORT', 0
        ORG 0100h                   ; begin code space
        USING 0                     ; Register bank 0 (RB0)
init:
        mov sp, #(stack-1)          ; initialize stack pointer
        setb IT1                    ; ext 1 interrupt edge triggered
        mov IE, #10000100b          ; enable ext 1 and global interrupts
  m0:
        jb    SWITCH, m1            ; check position of switch
        call rotate_msg             ; display message
        jmp m0                      ; again
  m1:
        call shift_msg              ; display message
        mov a, #3                   ; pause 3 sec between displays
        call delay_sec              ;
        jmp m0                      ; again
shutdown:
                                    ; Respond to interrupt generated by serial programmer.
        clr   ea                    ; prevent interrupts
        mov dptr, #pgm_msg          ; point to message
        call show_string            ; display message
        jmp $                       ; wait for reset

show_string:
  ; Display null-terminated string pointed to by DPTR. The string is
  ; left-justified in the display. If the length of the string exceeds
  ; the number of display positions the excess characters are ignored.
        call clear_display; begin by blanking display
        mov b, #(NDEVS*NELMS)   ; total display positions

  gs1:
        clr   a                     ; get char
        mov ca, @a+dptr;
        jz    gs2                   ; done if string terminator
        call put_char               ; display char at position in B
```

```
        inc  dptr                   ; point to next char
        djnz b, gs1                 ; done when last position is filled
   gs2:
        ret
clear_display:
                                    ; Fill display with blanks.
                                    ; All registers preserved.
        push acc
        push b
        mov b, #(NDEVS*NELMS)       ; total display positions
   c1:
        mov a, #SPACE
        call put_char               ; write space char
        djnz b, c1                  ; do all positions
        pop  b
        pop  acc
        ret

shift_msg:
   ; Display null-terminated string. Each character in the string,
   ; in turn, enters the display from the right and is moved quickly
   ; through each element of the display to its final position.
   ; The string may contain any number of characters, including none.
   ; If the length of the string exceeds the number of display
   ; positions, the excess characters are ignored.

        call    clear_display       ; begin by blanking display
        mov     r5, #(NDEVS*NELMS)  ; total display positions
        mov     dptr, #usr_msg      ; point to message
   ps1:
        mov     b, #1               ; first display position
   ps2:
        clr     a
        movc    a, @a+dptr          ; get char
        jz      ps4                 ; done if string terminator
        call    put_char            ; display char at position in B
        mov     a, #25              ; 25 ms
        call    delay_ms            ; delay so char can be seen
        mov     a, b                ; set up for compare
        clr     c                   ; ready for subtraction
        subb    a, r5               ; compare next position to final
        jnc     ps3                 ; jump if char is in final position
        mov     a, #SPACE
        call    put_char            ; blank out char
```

```
        inc     b                       ; next position
        jmp     ps2
  ps3:
        inc     dptr                    ; point to next char
        djnz    r5, ps1                 ; final position for next char
  ps4:
            ret

rotate_msg:
  ; Display null-terminated string. The string moves through the
  ; display, from right to left, with the display acting as a window
  ; onto the string. The string may contain any number of characters,
  ; including none.

        mov     dptr, #usr_msg          ; point to string
        clr     a                       ; get first char
        movc    a, @a+dptr;
        jz      dd11                    ; blank display and exit if null string
        call    clear_display           ; begin by blanking display

        ; Phase I. Shift the string into the display from the
        ; right until the first character is in the left-most
        ; display element. If the string has fewer characters than
        ; the display has elements, fill the balance with blanks.

        mov     r7, #0                  ; loop counter, one pass per element
  dd1:
        mov     dptr, #usr_msg          ; point to string
        mov     b, r7                   ; character position
        inc     b                       ; adjust
  dd2:
        clr     a                       ; get next char
        movc    a, @a+dptr;
        jz      dd3                     ; jump if string terminator
        call    put_char                ; display char at position in B
        inc     dptr                    ; point to next char
        djnz    b, dd2                  ; loop until all positions written
        jmp     dd5                     ; next pass
  dd3:                                  ; encountered end of string
        mov     a, #SPACE               ; pad balance of display with blanks
        call    put_char                ; display char at position in B
        djnz    b, dd3                  ; next position
  dd5:
        mov     a, #150                 ; 150 ms
```

```
        call    delay_ms                ; delay so string can be seen
        inc     r7                      ; next pass
        cjne    r7, #(NDEVS*NELMS), dd1  ; loop until all elements done
        ; Phase II. Shift the string THROUGH the display from
        ; the right until the last character is in the left-most
        ; display element. If the string has fewer characters than
        ; the display has elements, pad the balance with blanks.

        mov     dptr, #usr_msg          ; point to string
        inc     dptr                    ; start with the second char
    dd6:
        clr     a                       ; get char
        movc    a, @a+dptr;
        jz      dd11                    ; blank display and exit if string end
        push    dpl                     ; save string pointer
        push    dph
        mov     b, #(NDEVS*NELMS)       ; total char positions
    dd7:
        clr     a                       ; get next char
        movc    a, @a+dptr              ;
        jz      dd8                     ; jump if string terminator
        call    put_char                ; display char at position in B
        inc     dptr                    ; point to next char
        djnz    b, dd7                  ; loop until all positions written
        jmp     dd10                    ; next pass
    dd8:                                ; encountered end of string
        mov     a, #SPACE               ; pad balance of display with blanks
        call    put_char                ; display char at position in B
        djnz    b, dd8                  ; next position
    dd10:
        pop     dph                     ; restore string pointer
        pop     dpl                     ;
        inc     dptr                    ; point to next char
        mov     a, #150                 ; 150 ms
        call    delay_ms                ; delay so string can be seen
        jmp     dd6                     ; process next char
    dd11:
        call    clear_display           ; blank display
        mov     a, #150                 ; 150 ms
        call    delay_ms                ; delay
        ret

put_char:
    ; Display character in A at position indicated in B.
```

```
  ; All registers preserved.

      push   acc
      push   b
      mov    p0, a                 ; move character to output port

      ; Calculate device and element from display position.

      mov    a, b                  ; position 1..n
      dec    a                     ; convert to 0..n-1
      mov    b, #NELMS             ; elements per device
      div    ab                    ; A= device, B= element
      mov    p2, #0ffh             ; clear display control port
  s0:
      cjne   a, #0, s1             ; check device number
      mov    a, #00010000b         ; device 0 select
      jmp    s5
  s1:
      cjne   a, #1, s2
      mov    a, #00100000b         ; device 1 select
      jmp    s5
  s2:
      cjne   a, #2, s3
      mov    a, #01000000b         ; device 2 select
      jmp    s5
  s3:
      cjne   a, #3, s4
      mov    a, #10000000b         ; device 3 select
      jmp    s5
  s4:
      jmp    init                  ; undefined device, restart
  s5:
      orl    a, b                  ; add element selector
      xrl    a, #11110000b         ; invert device selector
      mov    p2, a                 ; write strobe low
      orl    a, #11110000b         ; reset device selector
      mov    p2, a                 ; write strobe high (latch data)
      pop    b
      pop    acc
      ret

delay_ms:
  ; Delay for 1 ms times the value in the accumulator.
```

```
        push    acc
        push    b
        mov     b, #0
    dd:
        djnz    b, $                    ; 500 us @ 12 MHz
        djnz    b, $                    ; 500 us @ 12 MHz
        djnz    acc, dd
        pop     b
        pop     acc
        ret

delay_sec:
    ; Delay for 1 second times the value in the accumulator.

        push    acc
        push    b
        mov     b, a
    ddd:
        mov     a, #250
        call    delay_ms                ; 250 ms
        call    delay_ms                ; 500 ms
        call    delay_ms                ; 750 ms
        call    delay_ms                ; 1000 ms
        djnz    b, ddd
        pop     b
        pop     acc
        ret

        END
```

### Appendix 3: Code for AT89S8252 Programmer

```
NAME AT89S8252_Programmer
; The programmer powers up with the control signals to the target AT89S8252
; inactive, allowing the program in the target to run normally. Upon receipt
; of the first valid data record, the programmer puts the target into write
; mode. The first and subsequent valid records are dissected as they are
; received and their data is written into the target. Receipt of a valid
; end-of-file record terminates programming and resets the target control
; signals, allowing the new program in the target to run.
;
; Each record received is checked for validity. If it is invalid,
; the receiver sends a NAK to the remote system and discards the record.
; Bad records are not programmed into the target AT89S8252. Valid records
```

```
; are programmed into the target AT89S8252 and verified. If verification
; succeeds, an ACK is sent to the remote system. If verification fails,
; the receiver sends CAN to abort the upload. Failure to verify is a fatal
; error. The target AT89S8252 will be left in program mode (held reset) so
; that the incomplete or invalid code which it contains cannot be executed.
;
; Incoming records must appear less than 30 seconds apart, or the line
; is dropped in preparation for the next call. If the remote system drops
; the line, the programmer will wait 30 seconds before resetting. Calls
; incoming during this time are ignored.
;
; The programmer manages five lines (SHUTDN, RST, SCK, MOSI, MISO)
; which control the target AT89S8252 and 4 lines which handle the modem
; interface. The AT89S8252 control lines occupy bits of port 1 and the
; modem interface lines bits of port 3, as defined in the EQUates.
;
; Procedures SHOUT (SHift OUT) and SHIN (SHift IN) manage the serial transfer
; of data between the programmer and the target AT89S8252. The serial clock
; is generated and timed by software. The code meets timing requirements
; when executed by an AT89Cx051 microcontroller with a 12-MHz clock.
; Code modifications may be required if a faster clock is substituted.
;
; Two long period timers are implemented utilizing Timer Zero and members of
; register bank one. Timer Zero is configured in 16-bit mode and is loaded
; with an initial count of zero, which yields the maximum delay of 65.5 ms
; (at 12 MHz). The timer is allowed to free-run, generating an interrupt
; each time the count rolls over from FFFF to 0000. At each interrupt, the
; counts in each of the long period timers are decremented if their respective
; overflow flags are not set. If the new count in either long timer is zero,
; the corresponding overflow flag is set. It is not necessary to stop Timer
; 0 or to disable interrupts to reload the long timers, because they will
; not be disturbed by the Timer 0 interrupt service routine whenever their
; overflow flags are set. Because Timer 0 free-runs, it is not possible to
; know where in a period timing of an event begins. Therefore, one additional
; count should be added to the calculated long timer count to guarantee that
; the timed interval is not short.
;
; Long timer 0 is 16 bits, allowing a maximum timed interval of
; over one hour. Long timer 1 is 8 bits, allowing a maximum timed
; interval of 16 seconds.
;
; The programmer software is compatible with the U.S. Robotics Sportster
; 14,400-baud external modem and may require modifications if used with other
; modems. The switches on the modem are set as follows:
```

```
;
;  1    UP  DTR normal
;  2    DOWNNumeric result codes
;  3    DOWNDisplay result codes
;  4    DOWNSuppress command echo
;  5    UP  Auto answer
;  6    UP  CD normal
;  7    UP  Load NVRAM defaults
;  8    DOWNSmart mode
;
; Modem switch 7 specifies that the power on and reset configuration be
; loaded from NVRAM profile zero, which must contain the factory default
; hardware flow control template. Other switch settings then override the
; loaded configuration. If NVRAM profile zero does not contain the hardware
; flow control template, it may be restored with the following command
; sequence:
;
;  AT&F1&W0<ENTER>
;
; Some of the switch functions can be controlled by software, but making
; use of the switches simplifies the code required to initialize the modem.
; The only additional commands which must be issued to the modem are:
;
;  &R1Ignore RTS,
;  &A0Disable ARQ result codes.
;
; "&R1" causes the modem to forward incoming data to the programmer regardless
; of the state of RTS. "&A0" suppresses the extended protocol result codes.
; Note that suppression of the codes does not affect the connection. If it is
; desired to disable Error Control, issue the command "&M0".

CR              EQU     0dh         ; carriage return
LF              EQU     0ah         ; line feed
ACK             EQU     6h          ; responses to remote system
NAK             EQU     15h         ;
CAN             EQU     18h         ;
BAUD_1200       EQU     0e8h        ; 1200 baud timer reload values
BAUD_2400       EQU     0f4h        ; 2400 baud
BAUD_9600       EQU     0fdh        ; 9600 baud
OK              EQU     '0'         ; modem status codes
RINGING         EQU     '2'         ;
CONNECT_1200    EQU     '5'         ;
CONNECT_2400    EQU     '10'        ;
CONNECT_9600    EQU     '13'        ;
```

```
MTRIES          EQU     5           ; max attempts to access modem
ERASE_1         EQU     0ach        ; erase chip function, first byte
ERASE_2         EQU     04h         ; second byte
ENABLE_1        EQU     0ach        ; enable write function, first byte
ENABLE_2        EQU     53h         ; second byte
DUMMY           EQU     55h         ; function third byte
WRITE_CODE      EQU     02h         ; write code memory function (Flash)
READ_CODE       EQU     01h         ; read code memory function
WRITE_DATA      EQU     06h         ; write data memory function (EEPROM)
READ_DATA       EQU     05h         ; read data memory function
lt0_lo          EQU     r2          ; long timer one low byte
lt0_hi          EQU     r3          ; long timer one high byte
lt1             EQU     r4          ; long timer two only byte
index           EQU     r0          ; general purpose index register
chksum          EQU     r5          ; running checksum on record
temp            EQU     r6          ; temporary storage
kount           EQU     r7          ; loop counter
DSR_            BIT     p3.3        ; modem control signals
DTR_            BIT     p3.7        ;
RST             BIT     p1.7        ; target control signals
SHUTDN_         BIT     p1.6        ;
SCK             BIT     p1.4        ;   serial clock
MOSI            BIT     p1.3        ;   serial data out
MISO            BIT     p1.2        ;   serial data in

                DSEG AT 20h

flags           DATA    20h         ; misc flags
LT0F            BIT     flags.0     ; long timer 0 overflow flag
LT1F            BIT     flags.1     ; long timer 1 overflow flag

                ORG30h
rec_type:       DS      1           ; record type
laddr_lo:       DS      1           ; record load address, low byte
laddr_hi:       DS      1           ; record load address, high byte
data_len:       DS      1           ; record data byte count
data_buf:       DS      32          ; storage for record data field
                ORG     60h         ; stack origin
stack:          DS      20h         ; stack depth
PCON            DATA    87h         ; address of Power Control register
                                    ;   (added to enlighten the assembler)
                CSEG
                ORG     0000h       ; power on/reset vector
                jmp     init
```

```
            ORG     0003h               ; external interrupt 0 vector
            reti                        ; undefined
            ORG     000Bh               ; timer 0 overflow vector
            jmp     timer_int
            ORG     0013h               ; external interrupt 1 vector
            reti                        ; undefined
            ORG     001Bh               ; timer 1 overflow vector
            reti                        ; undefined
            ORG     0023h               ; serial I/O interrupt vector
            jmp     serial_int
            ORG     40h                 ; begin constant data space
attn_cmd:   DB      '+++', 0            ; modem return to command mode
reset_cmd:  DB      'ATZ', CR, 0        ; modem reset string
                                        ;   must be last command on line and
                                        ;   modem returns code before executing
init_cmd:   DB      'AT&R1&A0', CR, 0       ; modem init string
hangup_cmd: DB      'ATH', CR, 0        ; modem on-hook string
            ORG     0080h               ; begin code space
            USING   0                   ; register bank 0
init:
            mov     sp, #(stack-1)      ; initialize stack pointer
            call    initialize          ; initialize controller registers
            setb    LT0F                ; disable long timer 0
            setb    LT1F                ; disable long timer 1
                                        ; Initialize the modem.
            setb    TI                  ; set transmit interrupt flag
                                        ;   (kludge for first use)
            setb    ET0                 ; enable timer 0 interrupt
            call    modem_init          ; initialize modem
            clr     ET0                 ; disable timer 0 interrupt
            jnc     m1                  ; jump if modem init passes
            clr     EA                  ; global interrupt disable
            orl     PCON, #1            ; idle the controller, reset exits
 m1:
    ; Clear pending interrupts before enabling serial interrupts.
            jnb     TI, $               ; wait for transmitter to clear
            clr     TI                  ; clear transmit interrupt flag
            clr     RI                  ; clear receive interrupt flag
            setb    ES                  ; enable serial ints to wake controller
            clr     F0                  ; clear connect flag / PSW.5 bit
 idle:
            orl     PCON, #1            ; idle the controller, serial int exits
            jnb     F0, idle            ; return to idle if not connected
            ; Connection has been established.
```

```
                ; Begin polling for valid record header.
                clr     ES                  ; disable serial interrupts
                setb    TI                  ; set transmit interrupt flag
                                            ;   (kludge for first use)
                clr     F0                  ; clear program mode flag
                setb    ET0                 ; enable timer 0 interrupt
 m2:
                call    init_longtimer0     ; start 30-second timer
 m3:
                call    get_char            ; get char, 1-second timeout
                jc      m8                  ; try again if parity error or timeout
                cjne    a, #':', m8         ; try again if not record header
                                            ; Found header, process hex record.
                call    get_record          ; load and dissect record
                jnc     m4                  ; jump if record is good
                mov     a, #NAK             ; tell sender record is bad
                call    send_char;
                jmp     m2                  ; next record
 m4:
                cjne    a, #0, m6           ; jump if record is not type zero
                ; Process record type zero (data).
                jb      F0, m5              ; jump if target is in write mode
                call    shutdown            ; notify target of impending doom
;               call    erase_chip          ; erase target
                call    set_pgm             ; place target in write mode
                setb    F0                  ; flag target in write mode
 m5:
                call    write_record        ; program data into target
                call    verify_record       ; verify program data
                jnc     m7                  ; jump if verify OK
                mov     a, #CAN             ; tell sender to abort
                call    send_char;
                jmp     m9                  ; hang up and reset for next call
 m6:
        ; Process record type one (end-of-file).
                call    clear_pgm           ; take target out of write mode
                clr     F0                  ; flag target not in write mode
 m7:
                mov     a, #ACK             ; tell sender record OK
                call    send_char           ;
                jmp     m2                  ; next record
 m8:
                jnb     LT0F, m3            ; poll until timer times out
 m9:                                        ; timer timed out or upload cancelled
```

```
                call    hang_up                 ; break the connection
                clr     ET0                     ; disable timer 0 interrupt
                jmp     m1                      ; return controller to idle
serial_int:
  ; Process serial interrupt. Interrupts due to transmit done are
  ; cleared and ignored. If interrupt is due to receive data ready,
  ; check for a modem connect code, and set the connect flag.
  ; The procedure includes code for identifying both single- and
  ; double-character connect codes, but both may not be active
  ; simultaneously. The code for identifying double-character
  ; connect codes is dependent on the receive baud rate.
  ; Serial interrupts are enabled elsewhere.

                clr     F0                      ; clear connect flag
                clr     TI                      ; clear transmit interrupt flag
                jnb     RI, si2                 ; exit if not receive data ready
                mov     a, SBUF                 ; get character into accumulator
                mov     c, p                    ; carry set for odd parity (error)
                jc      si1                     ; ignore char if parity error
                ; Test for single-character 1200-baud connect code.
;;              anl     a, #7fh                 ; strip off parity (eighth) bit
;;              cjne    a, #CONNECT_1200, si1                   ; ignore char if wrong code
                ; Test for double-character 9600-baud connect code.
                anl     a, #7fh                 ; strip off parity (eighth) bit
                cjne    a, #(HIGH CONNECT_9600), si1; ignore wrong char
                clr     RI                      ; reset receive flag
                mov     a, #2                   ; expect next char in about 1 ms
                call    delay_ms                ; wait for next char
                jnb     RI, si2                 ; exit if not receive data ready
                mov     a, SBUF                 ; get character into accumulator
                mov     c, p                    ; carry set for odd parity (error)
                jc      si1                     ; ignore char if parity error
                anl     a, #7fh                 ; strip off parity (eighth) bit
                cjne    a, #(LOW CONNECT_9600), si1; ignore wrong char
                setb    F0                      ; set connect flag
  si1:
                clr     RI                      ; reset receive flag
  si2:
                reti

timer_int:
  ; Process Timer Zero interrupt, which occurs about every 65.5 ms.
  ; Each long timer count is decremented if its overflow flag is clear.
  ; When a long timer count reaches zero, its overflow flag is set.
```

```
  ; Counts are reloaded and overflow flags are reset elsewhere.

                push    psw                 ; save flags
                setb    RS0                 ; select register bank one
                jb      LT0F, ti2           ; skip if long timer 0 overflow set
                cjne    lt0_lo, #0, ti1     ; test low byte
                dec     lt0_hi              ; low byte is zero, borrow from high
  ti1:
                djnz    lt0_lo, ti2         ; dec low byte, skip if not zero
                cjne    lt0_hi, #0, ti2     ; low byte is zero, test high byte
                                            ; both bytes equal zero
                setb    LT0F                ; set overflow flag
  ti2:
                jb      LT1F, ti3           ; skip if long timer 1 overflow set
                djnz    lt1, TI3            ; decrement count and skip if not zero
                setb    LT1F                ; count is zero, set overflow flag
  ti3:
                pop     psw                 ; restore flags and reg bank zero
                reti

initialize:
  ; Initialize controller registers and I/O lines.

                mov     PCON, #0            ; initialize power control register
                mov     IE, #0              ; deactivate all interrupts
                mov     SCON, #01000000b; serial port mode 1
                mov     TMOD, #00100001b; timer 1 8-bit auto-reload,
                                            ;   timer 0 16-bit
;;              mov     TH1, #BAUD_1200     ; timer 1 reload value
                mov     TH1, #BAUD_9600     ; timer 1 reload value
                mov     TCON, #01000000b; start timer 1
                mov     TL0, #0             ; set timer 0 to max count
                mov     TH0, #0             ;
                setb    TR0                 ; start timer 0
                setb    REN                 ; enable serial reception
                setb    EA                  ; global interrupt enable
                ; Initialize I/O lines.
                setb    DTR_
                setb    SHUTDN_
                setb    MISO
                setb    MOSI
                clr     SCK
                clr     RST                 ; remove reset from target
                ret
```

```
modem_init:
  ; Reset and initialize the modem.
  ; Return with carry set if modem fails to respond as expected.
                  clr     DTR_                ; assert DTR to talk to modem

      ; First must ensure that the modem is in command mode.
                  mov     a, #1               ; wait 1 second
                  call    delay_sec           ;
                  mov     dptr, #attn_cmd     ; point to attention string
                  call    send_string         ; transmit string
                  mov     a, #1               ; wait 1 second
                  call    delay_sec           ;
                  ; Reset modem, causing the switches to be read.
                  mov     dptr, #reset_cmd    ; point to reset string
                  call    modem_cmd           ; transmit string
                  jc      nn1                 ; jump on fail
                  mov     a, #1               ; wait 1 second before next command
                  call    delay_sec           ;
      ; Modem is powered up and on-line.
      ; Send required software parameters.
                  mov     dptr, #init_cmd     ; point to init string
                  call    modem_cmd           ; transmit string
                  jnc     nn2                 ; jump on pass
  nn1:
                  ; Modem is misbehaving, so deactivate it.
                  ; The controller must be reset to exit this state.
                  setb    DTR_                ; deassert DTR to deactivate modem
  nn2:
                  ret
  hang_up:
          ; Force the modem to drop the line.
                  ; First must return the modem to command mode.
                  mov     a, #1               ; wait 1 second
                  call    delay_sec           ;
                  mov     dptr, #attn_cmd     ; point to attention string
                  call    send_string         ; transmit string
                  mov     a, #1               ; wait 1 second
                  call    delay_sec           ;
                  ; Issue command to hang up.
                  mov     dptr, #hangup_cmd   ; point to hang up string
                  call    modem_cmd           ; transmit string
                  jnc     hh                  ; jump on pass
                  ; The polite way didn't work, so drop DTR.
```

```
            ; The controller must be reset to exit this state.
            setb    DTR_                ; force modem to drop the line
  hh:
            ret

modem_cmd:
  ; Transmit command string to modem and validate the response.
  ; Return with carry set if modem fails to respond as expected,
  ; or if excessive parity errors or receive timeouts occur.
  ; Valid responses consist of a byte code followed by a carriage
  ; return. Parity errors and timeouts cause the command to be
  ; resent. Expected delays for command responses are absorbed
  ; by GET_CHAR. On entry, DPTR must point to a null-terminated
  ; command string.

            push    b
            mov     b, #MTRIES          ; number of attempts
  mm1:
            call    send_string         ; transmit command string
            clr     RI                  ; discard any waiting character
  mm2:
            call    get_char            ; receive result code
            jc      mm3                 ; jump on parity error or timeout
            cjne    a, #OK, mm2         ; loop if response is not valid
            call    get_char            ; receive carriage return
            jc      mm3                 ; jump on parity error or timeout
            cjne    a, #CR, mm2         ; loop if response is not valid
                                        ; valid response complete
            clr     c                   ; clear error flag
            jmp     mm4                 ; return
  mm3:
            djnzb,  mm1                 ; resend command
            setb    c                   ; out of retries, set error flag
  mm4:
            pop     b
            ret

send_string:
  ; Transmit string pointed to by DPTR.
  ; String may be of any length, but must be null-terminated.

            push    acc
            push    dpl
            push    dph
```

```
ss1:
                clr     a
                movc    a, @a+dptr          ; get character
                jz      ss2                 ; check for terminator
                call    send_char           ; send character
                inc     dptr                ; point to next character
                jmp     ss1
ss2:
                pop     dph
                pop     dpl
                pop     acc
                ret

send_char:
  ; Wait for transmitter to clear, add even parity bit to character
  ; in accumulator and transmit it. Does not wait for transmitter
  ; to clear before returning.

                jnb     TI, $               ; wait here for transmitter to clear
                clr     TI                  ; clear transmit flag
                push    acc                 ; save char
                movc,    p                  ; get parity bit
                mov     acc.7, c            ; add parity bit to data
                mov     SBUF, a             ; load character into transmitter
                pop     acc                 ; restore char
                ret

get_char:
  ; Read a character from the serial port and check for even parity.
  ; Return the character in the accumulator with parity stripped off.
  ; The routine will wait for approximately 1 second before timing
  ; out. Return with carry set on parity error or timeout.

                jb      RI, gc2             ; jump if char is waiting
                call    init_longtimer1     ; start 1-second timer
gc1:
                jb      RI, gc2             ; exit loop when char received
                jnb     LT1F, gc1           ; loop until timer times out
                setbc                       ; set error flag
                jmp     gc3                 ; return
gc2:
                mov     a, SBUF             ; get character into accumulator
                mov     c, p                ; carry set for odd parity (error)
                anl     a, #7fh             ; strip off parity (eighth) bit
```

```
            clr     RI                  ; reset receive flag
gc3:
            ret

get_byte:
  ; Read two hexadecimal ASCII characters from the serial port
  ; and return their binary equivalent in the accumulator.
  ; Return with carry set if either character was invalid or
  ; contained a parity error.

            call    get_char            ; get first char from serial port
            jc      gb                  ; exit on parity error
            call    ascii2bin           ; convert hex to binary
            jc      gb                  ; exit on invalid char
            swap    a                   ; first hex digit times 16
            mov     b, a                ; save value
            call    get_char            ; get second char from serial port
            jc      gb                  ; exit on parity error
            call    ascii2bin           ; convert hex to binary
            jc      gb                  ; exit on invalid char
            orl     a, b                ; combined binary equivalent
gb:
            ret

ascii2bin:
  ; Convert hexadecimal digit in the accumulator to its binary
  ; equivalent and return it in the accumulator. Valid hex digits
  ; are 0..9 and A..F (upper case only). Return with carry set
  ; if the character received is not a valid hex digit.

            mov     temp, a             ; save char
            clr     c                   ; prepare for subtraction
            subb    a, #('9'+1)         ; compare to '9'
            jnc     a1                  ; jump if char above '9'
            mov     a, temp             ; get original char
            clr     c                   ; prepare for subtraction
            subb    a, #'0'             ; compare to '0'
            jmp     a4                  ; return error if char below '0'
                                        ;   else binary value in accumulator
a1:
            mov     a, temp             ; get original char
            subb    a, #('F'+1)         ; compare to 'F'
            cpl     c                   ; invert error flag
            jc      a4                  ; return error if char is above 'F'
```

```
a2:
        mov     a, temp             ; get original char
        subb    a, #'A'             ; compare to 'A'
        jc      a4                  ; return error if char is below 'A'
a3:
        add     a, #10              ; adjust binary value
a4:
        ret

get_record:
  ; Read and dissect record. Two record types are accepted: data and
  ; end-of-file. If the record type is data, the appropriate values
  ; are extracted and stored. If the record type and checksum are
  ; valid, the carry bit is cleared and the record type is returned
  ; in the accumulator. Return with carry set to signal an invalid
  ; record type, checksum error, or other problem. Errors returned
  ; by routine GET_BYTE (invalid char or parity) cause an immediate
  ; return with carry set.

        mov     chksum, #0          ; clear running checksum
        call    get_byte            ; get record data length field
        jc      rr4                 ; jump on error
        mov     data_len, a         ; save data length
        clr     c                   ; prepare for subtraction
        subb    a, #(16+1)          ; data length limited to 16 bytes
        jnc     rr4                 ; jump if max size exceeded
        call    get_byte            ; get high byte of load address field
        jc      rr4                 ; jump on error
        mov     laddr_hi, a         ; save it
        call    get_byte            ; get low byte of load address field
        jc      rr4                 ; jump on error
        mov     laddr_lo, a         ; save it
        call    get_byte            ; get record type field
        jc      rr4                 ; jump on error
        mov     rec_type, a         ; save type
        cjne    a, #0, rr2          ; jump if not type zero (data)
        ; Process data in data type record.
        mov     index, #data_buf    ; pointer to data buffer
        mov     kount, data_len     ; byte counter
rr1:
        call    get_byte            ; get data from serial port
        jc      rr4                 ; jump on error
        mov     @index, a           ; save data in buffer
        add     a, chksum           ; update checksum
```

```
                 mov     chksum, a           ;
                 inc     index               ; point to next location
                 djnz    kount, rr1          ; decrement byte count and loop
                 jmp     rr3                 ; done with data, do checksum
  rr2:
                 mov     a, rec_type         ; get record type
                 cjne    a, #1, rr4          ; jump if not type one (end-of-file)
  rr3:
                 ; Process checksum.
                 call    get_byte            ; get record checksum
                 jc      rr4                 ; jump on error
                 add     a, chksum           ; update running checksum
                 add     a, data_len         ;
                 add     a, laddr_lo         ;
                 add     a, laddr_hi         ;
                 add     a, rec_type         ;
                 jnz     rr4                 ; jump if record checksum is not zero
                                             ; Discard CR/LF which terminates record.
;                call    get_byte
;                jc      rr4                 ; jump on error
;                call    get_byte
;                jc      rr4                 ; jump on error
                 mov     a, rec_type         ; return record type in accumulator
                 clr     c                   ; no errors
                 jmp     rr5                 ; return
  rr4:
                                             ; Error: data field too large, invalid type or bad checksum.
                 setb    c                   ; set error flag
  rr5:
                 ret

write_record:
        ; Write the data extracted from the most recently received record
        ; into the target AT89S8252. Timing delays are enforced by software.
        ; This routine assumes that the target has already been prepared
        ; for programming. Returns nothing.

                 mov     r2, laddr_lo        ; save low byte of load address
                 mov     r3, laddr_hi        ; save high byte of load address
                 mov     a, r3               ; get high byte of load address
                 anl     a, #00011111b       ; isolate 5 bits
                 rl      a                   ; move 5 bits to top
                 rl      a                   ;
                 rl      a                   ;
```

```
              orl     a, #WRITE_CODE  ; specify code write function
              mov     temp, a         ; save adjusted high byte
              mov     index, #data_buf ; pointer to data buffer
              mov     kount, data_len ; byte counter
  pp1:
              mov     a, temp         ; send adjusted high byte of address
              call    shout           ;
              mov     a, r2           ; send low byte of address
              call    shout           ;
              mov     a, @index       ; send data from buffer
              call    shout           ;
              mov     a, #3           ; wait 3 ms
              call    delay_ms
              ; Next address.
              mov     a, r2           ; get low byte of address
              add     a, #1           ; increment low byte
              movr2, a                ; save incremented value
              jnc     pp2             ; jump if no carry out of low byte
              ; carry out of low byte
              mov     a, r3           ; get high byte of address
              add     a, #1           ; increment high byte
              mov     r3, a           ; save incremented value
              anl     a, #00011111b   ; isolate 5 bits
              rl      a               ; move 5 bits to top
              rl      a               ;
              rl      a               ;
              orl     a, #WRITE_CODE  ; specify code write function
              mov     temp, a         ; save adjusted high byte
  pp2:
              ; Next data.
              inc     index           ; point to next buffer location
              djnz    kount, pp1      ; decrement byte count and loop
              ret

verify_record:
  ; Verify the data extracted from the latest record against that
  ; written into the target AT89S8252. Timing delays are enforced by
  ; software. This routine assumes that the target has already been
  ; prepared for programming. Return with carry set if verify fails.

              mov     r2, laddr_lo    ; save low byte of load address
              mov     r3, laddr_hi    ; save high byte of load address
              mov     a, r3           ; get high byte of load address
              anl     a, #00011111b   ; isolate 5 bits
```

```
        rl      a               ; move 5 bits to top
        rl      a               ;
        rl      a               ;
        orl     a, #READ_CODE   ; specify code read function
        mov     temp, a         ; save adjusted high byte
        mov     index, #data_buf ; pointer to data buffer
        mov     kount, data_len ; byte counter
vv1:
        mov     a, temp         ; send adjusted high byte of address
        call    shout           ;
        mov     a, r2           ; send low byte of address
        call    shout           ;
        ; Read data and verify.
        call    shin            ; read data
        mov     b, @index       ; get record data
        cjne    a, b, vv2       ; jump on verify fail
        jmp     vv3             ; verify OK, do next address
vv2:
        setb    c               ; set error flag
        jmp     vv5             ; return
vv3:
        ; Next address.
        mov     a, r2           ; get low byte of address
        add     a, #1           ; increment low byte
        mov     r2, a           ; save incremented value
        jnc     vv4             ; jump if no carry out of low byte
        ; carry out of low byte
        mov     a, r3           ; get high byte of address
        add     a, #1           ; increment high byte
        mov     r3, a           ; save incremented value
        anl     a, #00011111b   ; isolate 5 bits
        rl      a               ; move 5 bits to top
        rl      a               ;
        rl      a               ;
        orl     a, #READ_CODE   ; specify code write function
        mov     temp, a         ; save adjusted high byte
vv4:
        ; Next data.
        inc     index           ; point to next buffer location
        djnz    kount, vv1      ; decrement byte count and loop
        clr     c               ; clear error flag
vv5:
        ret
```

shout:
```
; Shift out a byte, most significant bit first.
; SCK expected low on entry. Return with SCK low.
; Called with data to send in A.

                push    b
                mov     b, #8           ; bit counter
x42:
                rlc     a               ; move bit into CY
                mov     MOSI, c         ; output bit
                nop                     ; enforce data setup
                nop                     ;
                setb    SCK             ; raise clock
                nop                     ; enforce SCK high
                nop                     ;
                nop                     ;
                nop                     ;
                clr     SCK             ; drop clock
                djnz    b, x42          ; next bit
                pop     b
                ret
```

shin:
```
; Shift in a byte, most significant bit first.
; SCK expected low on entry. Return with SCK low.
; Returns received data byte in A.

                push    b
                mov     b, #8           ; bit counter
x43:
                setb    SCK             ; raise clock
                mov     c, MISO         ; input bit
                rlc     a               ; move bit into byte
                nop                     ; enforce SCK high
                nop                     ;
                clr     SCK             ; drop clock
                nop                     ; enforce SCK low
                nop                     ;
                djnz    b, x43          ; next bit
                pop     b
                ret
```

erase_chip:
```
; Erase target AT89S8252.
```

```
        setb    RST             ; force target into reset
        mov     a, #ERASE_1     ; send first byte of erase function
        call    shout           ;
        mov     a, #ERASE_2     ; send second byte
        call    shout           ;
        mov     a, #DUMMY       ; send third byte
        call    shout           ;
        mov     a, #10          ; wait 10 milliseconds
        call    delay_ms        ;
        clr     RST             ; remove reset from target
        ret

shutdown:
  ; Force target to abandon execution of its internal program.

        clr     SHUTDN_         ; notify target of impending reset
        mov     a, #5           ; give target 5 ms to shut down
        call    delay_ms        ;
        setb    SHUTDN_         ; deassert interrupt
        ret

set_pgm:
  ; Prepare the target AT89S8252 for programming.

        setb    RST             ; force target into reset
        mov     a, #1           ; wait 1 ms (arbitrary)
        call    delay_ms        ;
        ; Enable writes to code and data memory.
        mov     a, #ENABLE_1    ; send first byte of enable code
        call    shout           ;
        mov     a, #ENABLE_2    ; send second byte
        call    shout           ;
        mov     a, #DUMMY       ; send third byte
        call    shout           ;
        ret
clear_pgm:
        ; Allow target AT89S8252 to resume execution of its own program.

        clr     RST             ; remove reset from target
        ret

init_longtimer0:
  ; Load and start long timer 0.
```

```
; System Timer 0 count loaded and interrupt enabled elsewhere.

        setb    LT0F            ; disable counter
        setb    RS0             ; select register bank one
        mov     lt0_lo, #0c8h   ; load 30-second count
        mov     lt0_hi, #1      ;
        clr     RS0             ; back to bank zero
        clr     LT0F            ; enable counter
        ret

init_longtimer1:
  ; Load and start long timer 1.
  ; System Timer Zero count loaded and interrupt enabled elsewhere.

        setb    LT1F            ; disable counter
        setb    RS0             ; select register bank one
        mov     lt1, #17        ; load 1-second count
        clr     RS0             ; back to bank zero
        clr     LT1F            ; enable counter
        ret

delay_ms:
  ; Delay for 1 ms times the value in the accumulator.

        push    acc
        push    b
        mov     b, #0
  dd:
        djnz    b, $            ; 500 us @ 12 MHz
        djnz    b, $            ; 500 us @ 12 MHz
        djnz    acc, dd
        pop     b
        pop     acc
        ret

delay_sec:
  ; Delay for 1 s times the value in the accumulator.

        push    acc
        push    b
        mov     b, a
  ddd:
        mov     a, #250
        call    delay_ms; 250 ms
        call    delay_ms; 500 ms
```

```
call    delay_ms; 750 ms
call    delay_ms; 1000 ms
djnz    b, ddd
pop     b
pop     acc
ret

END
```

## Appendix 4: ASPECT Script for Procomm Plus

```
; PROCOMM ASPECT script to read and transmit an Intel hex file.
; The script does not set up communications parameters, initialize the
; modem, dial out or establish a connection with the receiver; this is
; done manually via the PROCOMM Connection Directory.
; Each record in the hex file is terminated by a CR/LF. The receiver is
; expected to respond with an ACK after each record is validated and
; programmed into the target processor. If the receiver cannot validate
; the record, it responds with a NAK. If the receiver cannot verify the
; record data after programming the target processor, it responds with
; a CAN, which tells the transmitter to abort the upload. The transmitter
; waits 2 seconds between records for a response. If a response is not
; received in the allowed interval, or if the response is other than an
; ACK or a CAN, the record is retransmitted.
  #define ACK          6       ; ^F
  #define NAK          21      ; ^U
  #define CAN          24      ; ^X
  #define MAXRETRIES   4
  proc main
  string filename, record
  integer retry, rxcode
  sdlgfopen "Select HEX File" "*.hex" single filename; get file name
  if failure          ; get file name failed
      exit
  endif
  if filename   ; validate path and file name
      if fopen 0 filename read; open file for read
          fgets 0 record; read record
      else
          errormsg "FILE OPEN FAILED"
          exit
      endif
  else
      errormsg "FILE DOES NOT EXIST"
      exit
  endif
  set aspect rxdata on               ; script processes receive data
  while not feof 0                   ; check for EOF
      termwrites record              ; show record
      rxflush                        ; purge pending receive data
      transmit record raw            ; send record including CR/LF
      comgetc rxcode 2               ; wait max 2 seconds for answer
      call show_rxcode with rxcode   ; show received code
      retry = 0                      ; initialize counter
```

```
        while (rxcode != ACK) && (retry < MAXRETRIES)
            if (rxcode == CAN); abort ordered by remote
                errormsg "UPLOAD ABORTED BY REMOTE"
                fclose 0; close file
                set aspect rxdata off
                exit
            endif
            termwrites "Resending record^M^J"
            termwrites record; show record
            rxflush                     ; purge pending receive data
            transmit record raw         ; send record
            comgetc rxcode 2            ; get response
            call show_rxcode with rxcode; show received code
            ++retry                     ; advance counter and try again
        endwhile
        if (rxcode != ACK)
            errormsg "EXCESSIVE RETRIES: UPLOAD ABORTED"
            fclose 0 ; close file
            set aspect rxdata off
            exit
        endif
        fgets 0 record; read next record
    endwhile
    termwrites "End of file^M^J"
    fclose 0        ; close file
    set aspect rxdata off
    exit
endproc
proc show_rxcode
    param integer rxcode
;   termmsg "%#X`r`n", rxcode
    switch rxcode
        case -1
            termwrites "Timed out^M^J"
        endcase
        case ACK
            termwrites "Received ACK^M^J"
        endcase
        case NAK
            termwrites "Received NAK^M^J"
        endcase
        case CAN
            termwrites "Received CAN^M^J"
        endcase
```

```
        default
              termwrites "Received garbage^M^J"
        endcase
   endswitch
endproc
```

**Figure 4.** FTP Transmit Mode

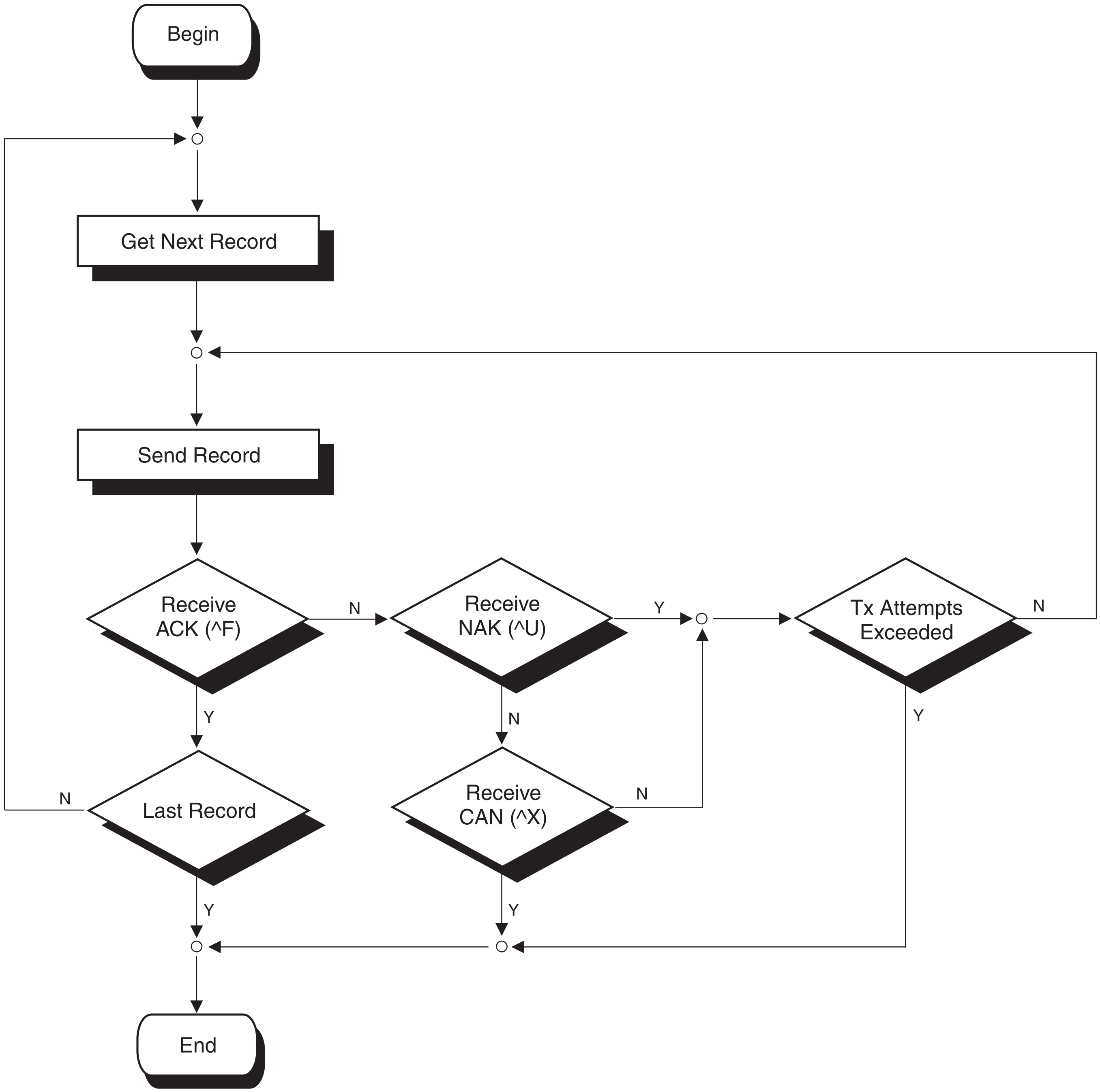


**Figure 5.** FTP Receive Mode