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FAA TECHNICAL CENTER LETTER REPORT

THE USE OF AUTO DIAL/AUTO ANSWER

MODEMS IN REMOTE MAINTENANCE MONITORING

by

David Wainland

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U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
TECHNICAL CENTER
Atlantic City Airport, N.J. 08405

INTRODUCTION

PURPOSE.

The purpose of this activity was to investigate the integration of an intelligent serial auto-dial/auto-answer modem to remote maintenance monitoring hardware and software. This work was performed as part of Task 9 of 9550-AAF-501-78-002.

BACKGROUND.

Auto-dial/auto-answer modems have several potential applications in the Remote Maintenance Monitoring System (RMMS). One potential application would be when dial-up lines are used as a back-up to a leased line. If the leased line has failed, a remote monitor or a higher level computer (such as a concentrator or Maintenance Processor Subsystem (MPS)), can be accessed through auto-dial/ auto-answer modems.

Dial-up lines can also be used as the only data link between a remote monitor and a higher level computer. A study, conducted at the FAA Technical Center and discussed in letter report CT-81-100/9-LR, indicates that between remote monitors and a higher level computer, dial-up lines would be less expensive than leased lines.

Another potential application for auto-dial/auto-answer modems would be in remotely accessing an MPS's or concentrator's data base. For example, a technician with a portable terminal and a dial-up modem or acoustic coupler can obtain information from an MPS over ordinary dial-up lines (provided the MPS is equipped with an auto-answer modem).

Since a need for auto-dial/auto-answer modems exists in the RMMS, the next question is how can auto-dial/auto-answer modems be integrated into the RMM system.

With dedicated TELCO lines, asynchronous modems typically interface to computers or terminals, over three signal lines, receive, transmit, and ground (all other signal connections are functional enhancements). In the past, auto-dial modems required additional interfaces and a considerable amount of software. Within the last year, auto-dial/auto-answer modems using only three wires and a minimum of software have become available. One such modem is the Model 1022 Intelligent Modem from the Business Computer Corporation (BIZCOMP).

The remainder of this report will discuss the capabilities of the BIZCOMP Model 1022 modem and discuss the interfacing of these modems to RMMS hardware.

DISCUSSION

Model 1022 Intelligent Modem.

The Model 1022 is an intelligent auto-dial/auto-answer modem. The modem accesses the computer or terminal through an EIA Standard RS-232C interface and accesses the telephone network through a telephone company standard RJ11 jack.

The modem operates in one of two modes: Command Mode or Data Mode. In the Command Mode, the Model 1022 is programmed to perform a desired task (such as dialing a number). In the Data Mode, the Model 1022 operates like an ordinary modem, passing data between the telephone network and the computer or terminal.

Upon applying power, the modem enters the Command Mode and initializes itself as an auto-answer modem. The modem can be programmed to be an auto-dial modem by entering in ASCII, at the RS-232C interface, a start-of-text character (STX), D, the number, and a carriage return character (CR). Once the modem receives a telephone number, it can be re-dialed by entering a STX, D, and CR.

In the auto-dial operation, when a dial tone is detected, the modem sends the terminal (or computer) a 7, CR. If the line is busy or after 40 seconds there is no answer, the modem outputs a 2, CR. If a connection is obtained, the modem outputs a 1, CR and then enters the Data Mode. The modem will institute disconnect procedures upon receiving the DLE, EOT ASCII character sequence from the terminal or computer. After the disconnection, the modem sends the terminal (or computer) a 2, CR. Disconnections can also take place by placing the data terminal ready (DTR) pin on the RS-232C interface in an "off" state or when the modem fails to receive a tone from the answering modem.

As an auto-answer modem, when a connection is established, the 1022 modem sends its terminal or computer a 1, CR. The link disconnect procedures used by Model 1022 when it acts as an auto-answer modem are identical to those used when it acts as an auto-dial modem. Therefore, either the originating or answering modem may institute disconnect procedures.

In addition to being programmed as an auto-answer or auto-dial modem, other options can be programmed. For example, the modem can be commanded to be either a pulse dialer or tone dialer. The modem baud rates can be changed from 110 baud through 300 baud (110, 134.5, 150, 200, and 300 baud are available). All communication is asynchronous. The modem can be placed in a transparent Data Mode. In this instance, the receipt of DLE, EOT characters will not cause a link disconnect. This allows the transmission of non-ASCII data. The modem also has a remote control capability. By sending the modem a STX, U and then the dialing sequence, the answering modem will toggle pin 25 of its RS-232C interface. This output could be used to remotely reset a computer. Detailed descriptions of all of the Model 1022's capabilities are provided in the Model 1022 Intelligent Modem Reference Manual from BIZCOMP.

The cost of a Model 1022 modem is less than $600. Other models are now available for less than half this price.

The Model 1022 requires 117 VAc 60 Hertz. It weighs two pounds and its dimensions are 8" x 4.5" x 1.875".

Interfacing the Model 1022 to RMMS Type Hardware.

For test purposes, one modem was interfaced directly to a terminal, while a second modem was interfaced to a computer. The interface to a terminal demonstrates how a computer, such as an MPS, can be accessed remotely. The interface to the computer demonstrates how the modem could be used by either a remote monitor or higher level RMMS computer. The computer hardware used in the interface is identical to the hardware used in the FAA Technical Center's concentrator. However, since these modems require only a serial RS-232C port, they can easily be interfaced to any RMMS computer.

The test configuration is shown in figure 1. One modem is interfaced directly to a Computer Devices Inc. Miniterm portable terminal. The other modem is interfaced to a serial port of a microprocessor-based computer. The computer serial port is contained on a B1018 eight channel serial communications board from Central Data Corporation. The computer is on an SBC-86/12A board from the Intel Corporation and uses an 8086 microprocessor. The SBC-86/12A is also interfaced to a Hazeltine 1520 CRT terminal. The B1018 and SBC-86/12A boards are housed in an Intel ICS-80 chassis. For these tests, use was made of two commercial telephone lines terminating in the RMMS laboratory at the Technical Center. These lines provide direct access to the telephone network without going through the PBX at the Center. Thus both modems are in the laboratory, but the telephone circuit is routed off the Center, through the TELCO network, and back to the Center (a loop distance of about 20 miles). The telephone number used for the terminal modem is 645-2215. The telephone number used for the computer is 645-3632. All communication was at 300 baud and asynchronous.

The computer is programmed to respond to user inputs from the Hazeltine terminal and to use those inputs to generate commands to the modem. When the modem enters the Data Mode, entries made at the Hazeltine terminal are sent to the CDI Miniterm via the modems. However, the data is not sent until an ASCII end-of-text (ETX) character is entered at the Hazeltine. The computer then sends all the Hazeltine entries as a single block. It also sends an "OK" to the Hazeltine terminal. While the modems are in the command mode, the computer enhances the modem replies. For example, if the computer receives a 7, CR from the modem, it will send to the Hazeltine terminal "Dial Tone". While the modems are in the Data Mode, all entries made at the Miniterm are sent through the modems to the computer. The computer then sends this data directly to the Hazeltine terminal.

The computer software for this test was written in PLM-86, a high level language for the 8086. It uses less than 2K bytes of EPROM and about 1K bytes of RAM (only about 200 bytes of code would be required, if these modems were interfaced to the existing concentrator program.) It consists of an initialization routine, a main routine, a modem receive interrupt routine.

The initialization routine programs all the devices needed to operate the serial port to the modem, and the serial port to the Hazeltine. It also sets flags used in the main routine and interrupt routines. After execution of the initialization routine, program execution jumps to the main routine.

A simplified flowchart of the main routine is shown in figure 2. The first routine called by the main routine is MODXMT. If there is data in the terminal receive buffer, this routine transfers data from the terminal receive buffer to the modem transmit buffer. (Data is placed in the terminal receive buffer during the terminal receive interrupt routine). If the modem is in the Data Mode, this routine will not transfer data to the modem transmit buffer unless the last character received from the terminal is an ETX.

The next routine called is XMIT. If there is data in the modem transmit buffer and the serial port to the modem is ready to transmit, a character is sent to the modem. If the modem is in the Data Mode, the character will be passed on to the Miniterm. If the modem is in the Command Mode, the character will be accepted by the modem as a program command.

The next routine is LTX. This routine outputs data from the terminal transmit buffer to the Hazeltine terminal. In the Data Mode, this routine also transfers every character received from the modem receive buffer to the terminal transmit buffer.

After LTX execution is completed, the process described above of calling MODXMT, XMIT, and LTX is continually repeated. Execution of these routines is temporarily halted when either a modem receive interrupt or terminal receive interrupt occurs.

Every time a character is received from the modem, the modem receive interrupt routine is entered. If the modem is in the Data Mode, the received character is stored in the modem receive buffer. If the modem is in the Command Mode, this routine determines what type of character was received (such as a 7 to signify a dial tone). It then places an appropriate message in the terminal transmit buffer. For example, if it receives a 7 and then a CR, this routine will place "Dial Tone" in the terminal transmit buffer.

Every time the Hazeltine keyboard is depressed, the terminal interrupt routine is entered. This routine stores the incoming characters in a terminal receive buffer. The characters are sent to the modem transmit buffer during execution of the MODXMT routine. This routine also determines if a response to the Hazeltine is required. If a response is required, it is placed in the terminal transmit buffer. For example, if a D is received, (a request to a dial a number), the response "Enter Number Followed by Carriage Return" is placed in the terminal transmit buffer. During execution of LTX, this response is sent to the Hazeltine.

Test Examples.

In general, the Model 1022 Intelligent Modem performed exactly as specified in the reference manual. The only exception was that the DTR pin (pin 20) on the RS-232C connector had to be tied to the "on" state if it was not going to be used to generate link disconnects. The reference manual indicated that the DTR

pin was internally tied to the "on" state, however, the DTR pin was actually left floating. As a result, the modems tended to suddenly disconnect in the middle of data transfers.

After the problem with the DTR pin was resolved, a series of dial-up procedures were conducted. Some of these procedures will now be described.

Figure 3 shows a typical auto-dial procedure generated by the computer. The information presented in figure 3 is what appeared on the Hazeltine 1520 CRT display. Dialing was instituted by typing a D at the Hazeltine terminal, and by typing the number after receiving the prompt message from the computer. The computer receives a 7, CR from the modem, recognizes this as a dial tone message and so prints "Dial Tone" on the terminal. When the receiving modem answers, the dialing modem sends the computer a 1, CR indicating a connection. The computer then prints "Connection". The user then types a message at the terminal. Upon completing the message, the user simultaneously depresses the Control and C keys to generate an ETX character (ETX is a non-printable character). The computer acknowledges receipt by sending "OK" to the terminal. It also sends the user's entries through the modems to the remote miniterm terminal. Each character entered at the Miniterm is immediately transmitted through the modems to the computer. The computer immediately transmits these characters to the Hazeltine terminal. The connection is terminated when the user enters a DLE (Control and @ keys) and EOT (Control and D keys) at the Hazeltine terminal. When the modem receives the DLE and EOT characters, it disconnects the link and sends a 2, CR to the computer. The computer recognizes this as the disconnect message and sends to the Hazeltine terminal "Good-Bye". The modem then automatically goes into the Command Mode and programs itself as an auto-answer modem.

Once a number is given to the modem, it remains stored until the modem receives a different number. In figure 4, the number stored in the modem is requested by typing "N" at the Hazeltine terminal. The computer sends the "N" to the modem. The modem replies by sending the computer the stored number. The computer then displays this number on the terminal. If a number is stored in the modem, it need not be re-entered at the terminal. In figure 4, the number 645-2215 is dialed by typing "D" and then a carriage return.

Figure 5 shows two additional functions that can be performed by the Model 1022 modem. When the modem receives a "V" it automatically performs tone dialing instead of pulse dialing. In this way, the modem can be used on either tone or pulse dial lines.

All the examples thus far have used the modem at the computer to initiate calls. In figure 6a, the CDI miniterm is used to originate a call. The user types a D, the number, and a carriage return. The modem sends the terminal a 7 and carriage return when a dial tone is obtained and then a 1 and a carriage return when a connection is made. When a connection is made, both modems are in the Data Mode and data can be exchanged between the CDI Miniterm terminal and the computer via the modems. When a DLE and EOT are entered at the CDI Miniterm, the modem disconnects the link. The modem indicates the disconnect by sending to the miniterm a 2 and a carriage return. Figure 6b shows what this operation looks like at the answering end (at the computer terminal).

CONCLUSIONS AND RECOMMENDATIONS

The tests performed indicated that a serial auto-dial/auto-answer modem can be readily integrated with RMM equipment, without requiring the additional interfaces needed with older auto-dial modems. The tests also demonstrated that auto-dial and auto-answer operations can be accomplished without requiring a large increase in RMM software.

It is therefore recommended that for all RMM dial-up applications intelligent serial auto-dial modems be used.

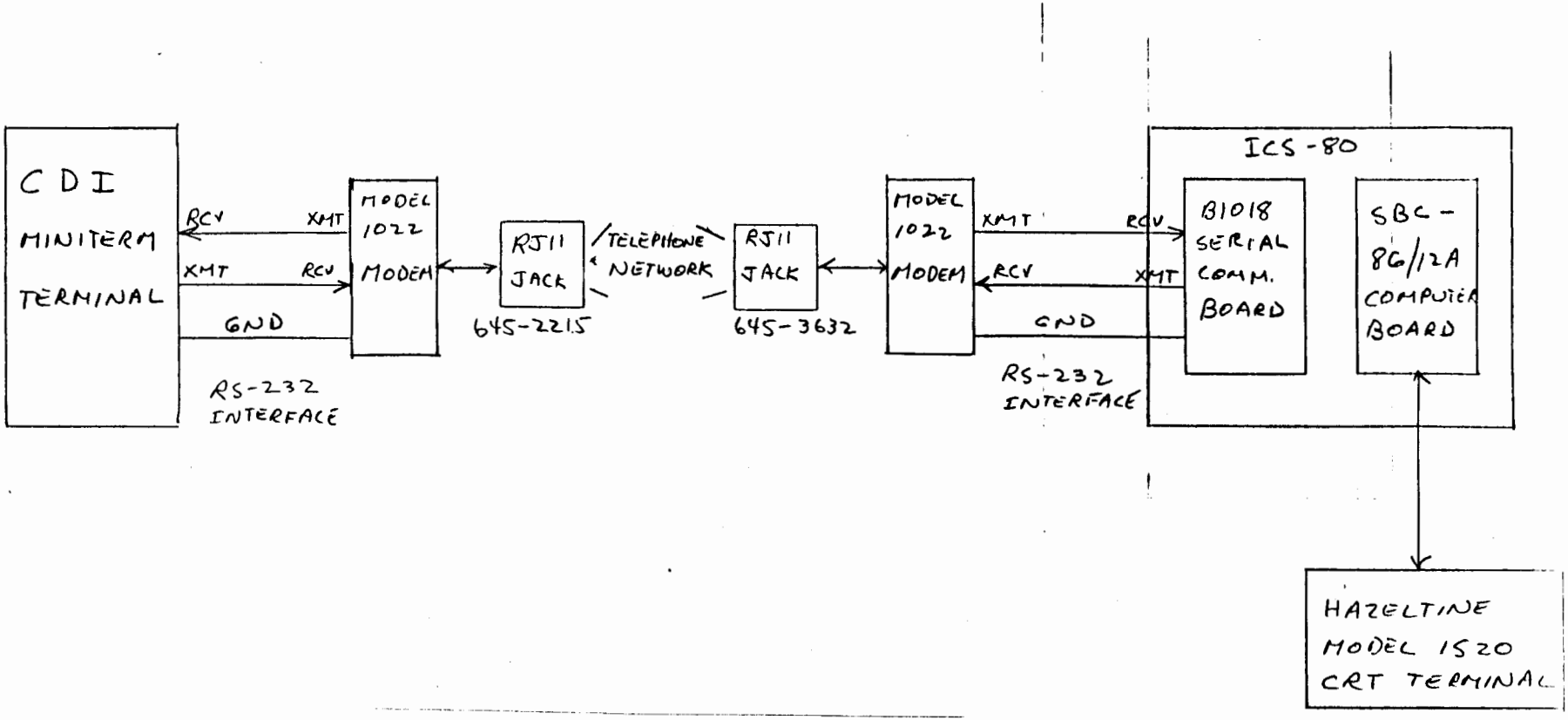

FIGURE 1. MODEM TEST CONFIGURATION

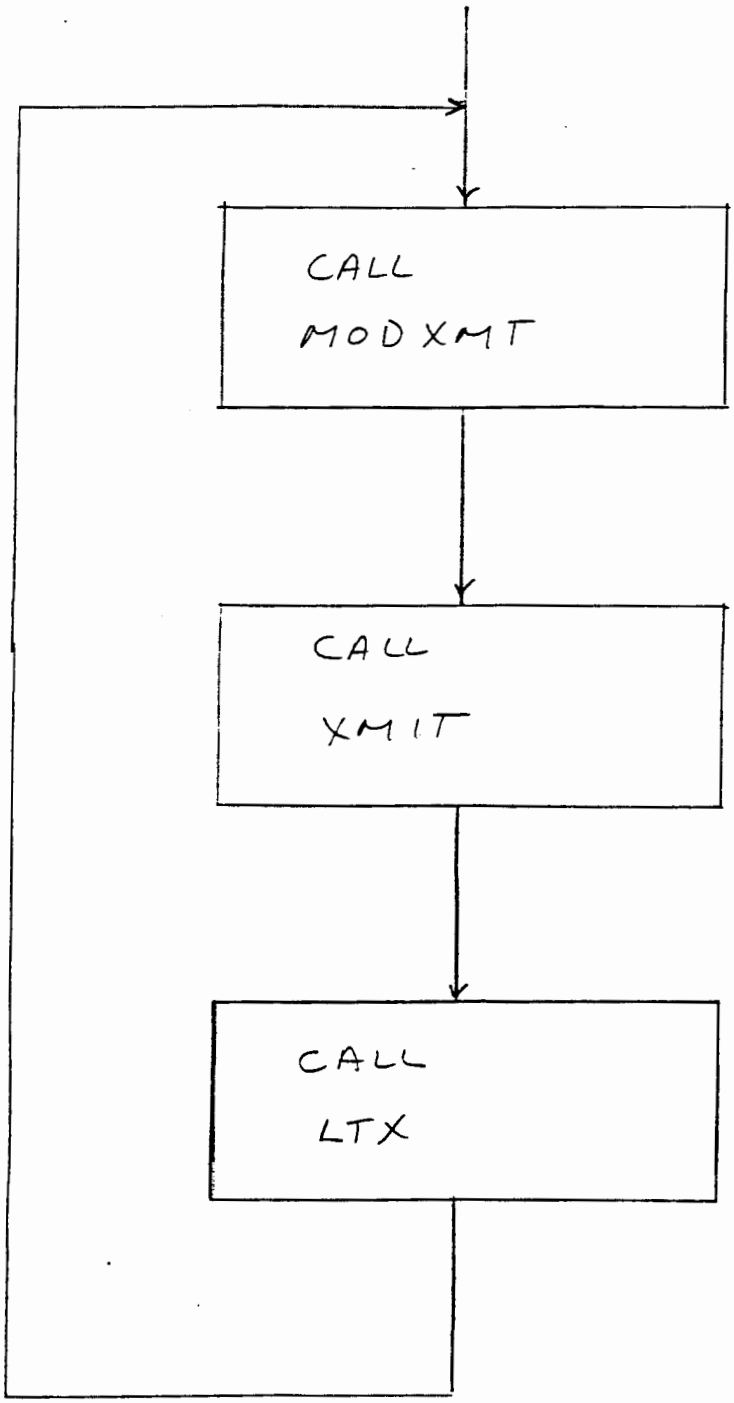

FIGURE 2. MAIN ROUTINE FLOWCHART

D ENTER NUMBER FOLLOWED BY CARRIAGE RETURN
6452215
DIAL TONE
CONNECTION
HELLO. THIS IS 645-3632.

OK
this is 645-2215.

GOOD-BYE 2215.
OK
GOOD-BYE

FIGURE 3. TYPICAL AUTO-DIAL PROCEDURE AT COMPUTER

(Underlined characters are user entries, lower cased characters are data from the remote miniterm terminal)

N 6452215
D ENTER NUMBER FOLLOWED BY CARRIAGE RETURN

DIAL TONE

CONNECTION

HELLO AGAIN 2215.

OK

hello again 3632.

GOOD-BYE 2215.

OK

GOOD-BYE

FIGURE 4. RE-DIALING 645-2215

(Underlined characters are user entries, lower cased characters are data from the remote miniterm terminal)

```
I

Self Test--fully functional
N 6452215
V
D ENTER NUMBER FOLLOWED BY CARRIAGE RETURN

DIAL TONE

CONNECTION

HELLO & GOOD-BYE.
 OK

GOOD-BYE
```

FIGURE 5. PERFORMING A SELF-TEST AND TONE DIALING

(Underlined characters are user entries)

```
D6453632
?
1

THIS IS 645-8215 CALLING 645-3632.

THIS IS 3632.

GOOD-BYE 3632.

2
```

FIGURE 6a. AUTO-DIAL PROCEDURE AT THE CDI MINITERM

(Underlined characters are entries made by the user)

CONNECTION

This is 645-2215 calling 645-3632.

THIS IS 3632.

OK

good-bye 3632.

GOOD-BYE

FIGURE 6b. AUTO-ANSWER PROCEDURE

(Underlined characters are user entries, lower case characters are from the CDI Miniterm)