

An Answer/Originate Modem

Ronald G Parsons
9001 Laurel Grove Dr
Austin TX 78758

One of the few and nearly universal methods of exchanging data between diverse microprocessors is by means of data transmission over switched telephone facilities. Most other means of data exchange such as floppy disk or cassette tape are specific to one or a few microcomputers. But data transmission over phone lines is nearly independent of the microprocessors involved and the method or speed of the mass data storage used by either processor.

To transmit data at reasonable speeds over a telephone line, a *modem* is used to convert digital signals to an analog form for transmission over the telephone network. "Modem" is a hybrid of the words modulator and demodulator. A modem must be used because the telephone network was designed for analog voice transmission and not for digital data. The telephone network has an audio bandwidth of approximately 3000 Hz, so the modem must condition the signals to fit within this bandwidth.

Since communication usually involves data transmission in both directions, a convention has been established so that two sets of data traveling in opposite directions do not interfere with each other. The Bell 103 type of modem uses designated audio frequencies for binary 0 and 1. One of the pair of communicating entities is arbitrarily designated as the originating end and the other the answering end. As the words imply, the originating end usually originates

the telephone call and the answering end usually answers, but this is not necessary. All that is necessary is for one of the pair to agree to call itself the answerer and the other the originator.

The originating end transmits a binary 0 (sometimes called a space) as

The telephone network was designed for analog voice transmission, not digital data.

a tone of 1070 Hz and a binary 1 (sometimes called a mark) as a tone of 1270 Hz. The originating end also receives spaces and marks as tones of 2025 Hz and 2225 Hz, respectively. The answering end has the transmit and receive frequencies interchanged. The Bell 103 modem translates serial data from voltage levels to these audio tones capable of being transmitted over standard telephone lines at a data rate from 0 to 300 bps.

A data bit is usually translated first by a terminal or microcomputer to standard voltage levels defined by an Electronic Industries Association (EIA) standard known as RS-232C. This standard defines a space as a voltage level between +5 V and +15 V and a mark as a voltage level between -5 V and -15 V. Voltages between -5 V and +5 V have undefined meaning. These signals are capable of being transmitted over

wire cable for distances of several hundred feet at speeds up to several thousand bits per second.

The modem described in this article uses RS-232C levels between the processor or terminal and the telephone line; it connects to the telephone line through a device called a data access arrangement (DAA). This device has two common types: the CBS data coupler, which uses RS-232C levels to interface with the modem; and the simpler CBT data coupler, which uses contact closures (ie: switches or relays) for the modem interface. The CBT type is used in this design for simplicity. Motorola's *Application Note AN-747* entitled "Low-Speed-Modem System Design using the MC6860" discusses the interface to either coupler.

The most complicated and troublesome parts of a modem are usually the filters used to separate and purify the transmitted and received audio tones. It is not uncommon for filters for the transmit and receive frequencies each to contain several operational amplifiers and many precision resistors and capacitors. The filters used in this design, however, are available as "miniModem" building blocks from Cermetek Microelectronics, 660 National Ave, Mountain View CA 94043. They require no adjustments and few external components.

Two filters are used. One, the CH1262, is a switchable, dual-channel, transmit filter and line hybrid. The center frequency of the filter is

chosen to be 1170 Hz or 2125 Hz by changing the DC voltage on the channel-select pins. The other, the CH1267, is a switchable, dual-channel, receive filter and limiter. It is necessary for us to be able to switch the center frequencies of the filters so the modem can be used as an originate or an answer modem.

The functions of modulation, demodulation, and control are performed by a Motorola MC6860 metal-oxide semiconductor/large-scale integration (MOS/LSI) modem chip. After conversion to transistor-

transistor logic (TTL) levels, the modulator section of the 6860 converts serial digital data into analog frequencies. It does this by digitally synthesizing a sine wave at one of the space and mark frequencies. This signal is filtered and amplified by the transmit filter. The demodulator section of the 6860 detects the presence of a mark or space frequency and presents a digital 0 or 1 output to the terminal or computer. The receive-signal input to the 6860 must be a 50% duty-cycle, TTL signal that is filtered and limited (ie: amplified and

clipped).

Several supervisory control functions are provided by the 6860. The 6860 places the modem into answer mode (if a ring indication is detected) or into originate mode (if a handset-off-hook condition is detected). If the data terminal is ready, the detection of the ring creates an answer phone signal to the DAA. A mode-signal output from the 6860 is used to control the switchable filters to ensure that the correct set of signal pairs are used. A clear-to-send (CTS) signal is also created to indicate to the terminal or computer the establishment of a communication link.

Constructing the Modem

Figure 1 shows the schematic diagram for the modem. The signals from the terminal or computer to and from the modem are first converted from RS-232C levels to TTL levels by the 1488 and 1489A integrated circuits. The request-to-send (RTS) signal is not used by the 6860, but is used by the support circuitry to control pulse dialing and setting the answer/originate mode. The 1458 dual operational amplifier is used to convert the TTL-level mode signal, as possibly modified by the test/normal switch, to a +12 V or -12 V signal sent to switch the filters between originate and answer. The 301A operational amplifier is used to limit the received signal. The 3.9 V zener diode causes the output of the operational amplifier to be TTL compatible and the TTL gate helps square up the limited signal. The 200 k-ohm variable resistor on the CH1262 is used to set the transmit level to 0 dBm (ie: 1 mW at 600 ohms or 0.7 V RMS).

If the modem is powered up with the ready-to-send line active (ie: at +5 V to +12 V), the modem is in originate mode and the answer-phone signal from the 6860 commands the DAA telephone interface to take the phone line off hook. The telephone may then be dialed by pulsing the ready-to-send line off and on under software control. An assembly-language program for an 8080 to do automatic dialing is shown in listing 1.

If the modem is powered up and the ready-to-send line is off (ie: -5 V to -12 V), the modem will wait for a ring indication from the DAA

Text continued on page 34



Eliminate The Data Comm Hassles of Outmoded "DUMB" Modems

BIZCOMP's Intelligent Modem is new. Brand new. It teams a Bell 103-type "dumb" modem with a custom BIZ-080 microcomputer in an attractive desk-top enclosure. RESULT: Incredibly simple data comm for professional users. No more mad dash to get a handset into coupler muffs before being disconnected by the remote. No more exclusion-key telephone needed to do the dialing. No more outboard coupler boxes. And for computer sites, communications software written in high level language like BASIC or COBOL. How's that for simplicity!

The 1030 gives you automatic dial, automatic answer and, unique to the industry, automatic REPEAT dial. The top-of-the-line 1031 adds command-selectable tone or dial pulse dialing for TWX net applications and self-test for ensuring full functionality. Both models are FCC registered for direct connection and feature comm rates from 110, 134.5, 150, 200 to 300 baud. BIZCOMP's innovative Code-Multiplexed Design enables complete control using a simple 3-wire RS-232 interface. Don't burden your customers with data comm hassles. Install a BIZCOMP Intelligent Modem today.

BIZCOMP Communications...
Why not start with the best?

BIZCOMP

P.O. Box 7498 • Menlo Park CA 94025 • 415/854-5434

Suggested prices from \$395.00

Patent Pending

Number	Type	+ 5 V	GND	- 12 V	+ 12 V
IC1	1488		7	1	14
IC2	1409A	14	7		
IC3	6860	12	1		
IC4	7407	14	7		
IC5	LM301			4	7
IC6	1458				8
IC7	7485	14	7		
IC8	7404	14	7		
IC9	7400	14	7		
IC10	CH1282		5	13	12
IC11	CH1257		18	9	7

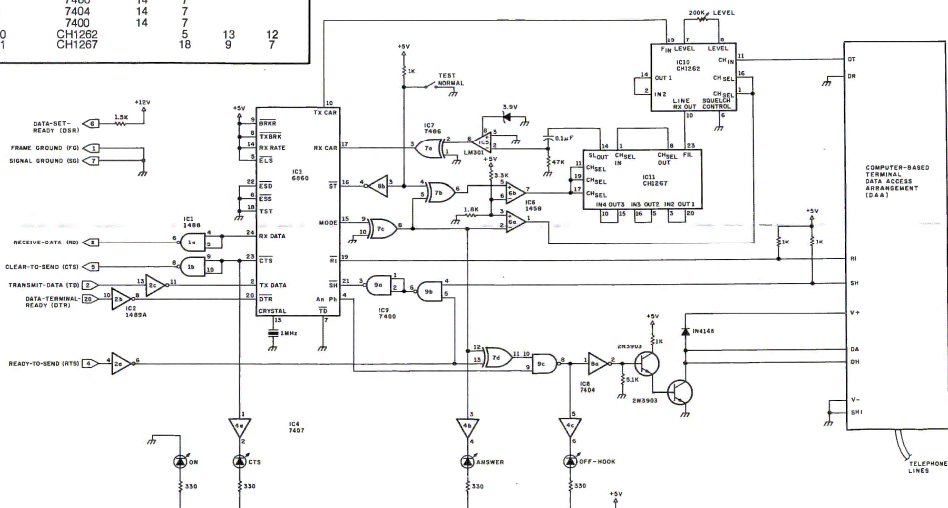


Figure 1: Schematic diagram of the answer/ originate modem. IC1 and IC2 convert the modem RS-232C signal to a digital transistor-transistor logic (TTL) level and back. IC3 is the Motorola 6860 modem integrated circuit. IC10 and IC11 are the transmit and receive filters, respectively, used to interface the modem and the telephone line.

Listing 1: DIAL routine to perform automatic dialing by the computer. This listing, which is designed to run as part of a CP/M-based 8080 or Z80 system, performs automatic dialing of a telephone number with the command DIAL <phone number>. If a modem answers, this program causes its computer to act as a "dumb" terminal for the computer connected to the answering modem.

```

; Auto-dial program
; Syntax: DIAL <phone-number>[:<signon-character>]
; <signon-character> sent when CTS is asserted.
;
0005 = BDOS EQU 5 ;BDOS entry point
E00C = TERM EQU 0E00CH ;Terminal simulation subroutine
0020 = SCTS EQU 32 ;serial CTS
0010 = SRTS EQU 16 ;serial RTS
00F8 = SERST EQU 0F8H ;serial status port
;
0100 ; ORG 100H
;
0100 31FFCB START: LXI SP,0CBFFH
0103 CDA101 CALL OFFHOOK
0106 0E64 MVI C,100 ;wait 2 seconds for dialtone
0108 CD5C01 CALL DELAY
010B 0E64 MVI C,100
010D CD5C01 CALL DELAY
0110 218100 LXI H,81H ;use default buffer area
0113 7E NEXT: MOV A,M ;get digit
0114 23 INX H
0115 B7 ORA A
0116 CA3301 JZ TERMINAL
0119 FE3A CPI ':' ;signon-character?
011B CA2901 JZ GETSIGNON
011E F5 PUSH PSW
011F CD5301 CALL SOUT ;echo number
0122 F1 POP PSW
0123 CD6A01 CALL DIGIT
0126 C31301 JMP NEXT
;
GETSIGNON:
0129 7E MOV A,M
012A B7 ORA A
012B C23001 JNZ NOTCR
012E 3E0D MVI A,13 ;CR if character zero
NOTCR:
0130 32AC01 STA SIGNON
;
TERMINAL:
0133 DBF8 IN SERST
0135 E620 ANI SCTS
0137 C23301 JNZ TERMINAL ;wait for clear-to-send
013A CD4A01 CALL SETIO ;set I/O parameters for serial port
013D 3AAC01 LDA SIGNON
0140 B7 ORA A
0141 C45301 CNZ SOUT
0144 CD0CE0 TRANS: CALL TERM
0147 C34401 JMP TRANS
;
014A 3E01 SETIO: MVI A,1 ;set Sol/SOLoS I/O parameters serial
C806 = IPORT: EQU 0C806H
C807 = OPORT: EQU 0C807H
014C 3206C8 STA IPORT
014F 3207C8 STA OPORT
0152 C9 RET

```

Listing 1 continued on page 32

Listing 1 continued:

```

0153 5F      ;SOUT:  MOV     E,A      ;write character to console
0154 0E02    MVI     C,2
0156 E5      PUSH    H
0157 CD0500  CALL    BDOS
015A E1      POP     H
015B C9      RET

015C 115403  ;DELAY: LXI     D,852    ;.01 times (C) seconds
;Adjust DE for different clock periods
015F 0D      DCR     C
0160 F8      RM
0161 1B      DELA1: DCX     D
0162 7A      MOV     A,D
0163 B3      ORA     E
0164 C26101  JNZ     DELA1
0167 C35C01  JMP     DELAY

016A FE2D    ;DIGIT: CPI     '-'    ;Call with ASCII digit in A
016C C8      RZ          ;skip '-'
016D FE20    CPI     ' '
016F C8      RZ          ;skip blanks
0170 FE30    CPI     '0'
0172 DAA601  JC      DIGERR
0175 FE3A    CPI     '9'+1
0177 D2A601  JNC     DIGERR ;not an ASCII digit
017A E60F    ANI     0FH    ;subtract ASCII Bias
017C C28101  JNZ     NOTZERO
017F C60A    ADI     10     ;zero is ten

NOTZERO:
0181 47      MOV     B,A
PULSE: ;each digit is onhook for 60 ms and offhook for 40 ms
0182 0E06    MVI     C,6
0184 CD9C01  CALL    ONHOOK
0187 CD5C01  CALL    DELAY
018A 0E04    MVI     C,4
018C CDA101  CALL    OFFHOOK
018F CD5C01  CALL    DELAY
0192 05      DCR     B
0193 C28201  JNZ     PULSE
0196 0E64    MVI     C,100
0198 CD5C01  CALL    DELAY ;inter-digit delay
019B C9      RET

019C 3E00    ;ONHOOK: MVI     A,0    ;put line on-hook
019E D3F8    OUT     SERST
01A0 C9      RET

;OFFHOOK:
01A1 3E10    MVI     A,SRTS ;take line off-hook
01A3 D3F8    OUT     SERST
01A5 C9      RET

;DIGERR:
01A6 CD9C01  CALL    ONHOOK ;not a digit - go on-hook and reboot
01A9 C30000  JMP     0 ;boot

;SIGNON DB 0 ;store for sign-on character
01AC 00

```

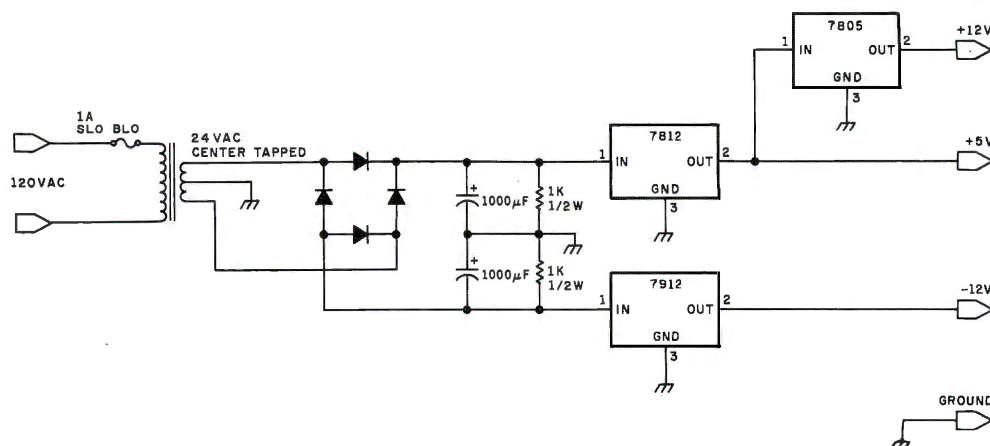


Figure 2: Schematic diagram of the optional power supply. This regulated power supply can be eliminated if the required voltages are available from a nearby computer or terminal.

Text continued from page 26:

telephone interface. On receipt of the ring, the 6860 will bring the answer-phone line high and begin sending the transmit carrier, which is at 2225 Hz. If the modem on the other end of the

line responds with its carrier, which is at 1270 Hz, the 6860 will turn clear-to-send on about a half second later. The terminal or computer can detect this and initiate whatever procedure is necessary to communicate with the

originator.

Figure 1 shows four light-emitting diodes (LEDs) that can be used by the operator to monitor the operation of the modem. The functions displayed are power-on, clear-to-send, mode (with the LED on in answer mode), and off-hook.

A power-supply schematic is shown in figure 2; it supplies +5 V, +12 V, and -12 V, regulated. These voltages may be obtained from the terminal or computer if they are available. I chose to make the modem an independent device: it was wire-wrapped on a small perforated board and enclosed in a cabinet.

Modem Software

Listing 1 shows a CP/M-based, assembly-language program for an 8080 processor to perform automatic dialing to an answer modem and to initiate communication. The CP/M syntax of the program is:

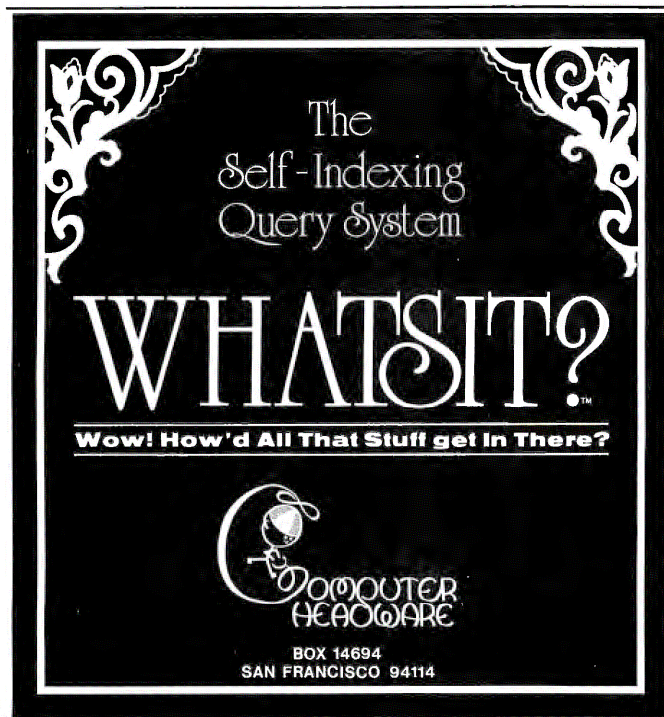
DIAL <phone number>

or

DIAL <phone number>:
<logon character>

The phone number may contain blanks and hyphens that are ignored. If an invalid character is found in the phone number, the program hangs up the telephone and reboots.

Text continued on page 40



Listing 2: Remote-access computer routine. This is the software needed by the computer that is connected to the answering modem of figure 1. This routine allows its computer to be controlled by a remote terminal, with the connections made by two modems and a telephone line. This routine runs on a CP/M system.

```

; Remote Access to CP/M
; using a Sol and SOLOS
;
BFE0 = IOCODE EQU 0BFE0H ;Temporary storage for I/O code
C01C = AOUT EQU 0C01CH ;Write to logical output unit (A)
C022 = AINP EQU 0C022H ;Read logical input unit (A)
C800 = UIPRT EQU 0C800H ;User defined input routine address
C802 = UOPRT EQU 0C802H ;User defined output routine address
C806 = IPORT EQU 0C806H ;Standard input unit number
C807 = OPORT EQU 0C807H ;Standard output unit number
00F8 = SERST EQU 0F8H ;Serial status port
00D4 = DCCMD EQU 0D4H ;Tarbell command port
;
0100 = ORG 100H
;
0100 31FFCB START LXI SP,0CBFFH
0103 3E00 MVI A,0
0105 D3F8 OUT SERST ;set modem for answer - RTS off
0107 3E06 MVI A,6 ;turn disk motor off
0109 D3D4 OUT DCCMD
010B DBF8 NOTCTS IN SERST ;CTS?
010D E620 ANI 20H ;wait for modem to answer and get response
010F C20B01 JNZ NOTCTS ;no
0112 3E05 MVI A,5 ;turn disk motor on
0114 D3D4 OUT DCCMD
0116 CD4001 CALL DELAY ;wait one second
0119 3E03 MVI A,3 ;set up SOLOS for
; user defined I/O routines
011B 3206C8 STA IPORT
011E 3207C8 STA OPORT
0121 21E0BF LXI H,IOCODE ;store user defined I/O addresses
0124 2202C8 SHLD UOPRT
0127 21EBBF LXI H,IOCODE+XIPRT-XOPRT
012A 2200C8 SHLD UIPRT
; Transfer I/O code to IOCODE
012D 21E0BF LXI H,IOCODE
0130 0E11 MVI C,XEND-XOPRT
0132 114A01 LXI D,XOPRT
TRANLOOP:
0135 1A LDAX D
0136 77 MOV M,A
0137 0D DCR C
0138 23 INX H
0139 13 INX D
013A C23501 JNZ TRANLOOP
013D C30000 JMP 0 ;boot
;
0140 = DELAY EQU $
0140 110000 LXI D,0
0143 1B DLOP1 DCX D
0144 7A MOV A,D
0145 B3 ORA E
0146 C24301 JNZ DLOP1
0149 C9 RET
;
;Relocatable user defined I/O routines
;
;Output routine - output to serial and screen
XOPRT MVI A,1
014C CD1CC0 CALL AOUT ;put on serial
014F 3E00 MVI A,0

```

Listing 2 continued on page 38

Listing 2 continued:

```

0151 CD1CC0      CALL    AOUT    ;put on screen
0154 C9          RET
;
;Input routine - input from serial port
0155 3E01      XIPRT    MVI      A,1
0157 CD22C0      CALL    AINP    ;get serial
015A C9          RET
;
015B 00      XEND:    DB      0
;

```

Listing 3: Remote-user routine. This routine allows a remote user to communicate with the operator of the host computer tied to the answering modem.

```

; Write to operator
;Syntax: WTO <message text>
0100      ORG      100H
0100 210000    LXI      H,0
0103 2B      BELOOP: DCX      H
0104 7D      MOV      A,L
0105 B4      ORA      H
0106 D3FC      OUT      0FCH    ;sound alarm port
0108 C20301    JNZ      BELOOP
010B C9      RET      ;return to CP/M
;

```

Listing 4: Remote-user routine. This routine allows a remote user to communicate with the host computer's operator; it also allows the operator to send a reply to the remote terminal.

```

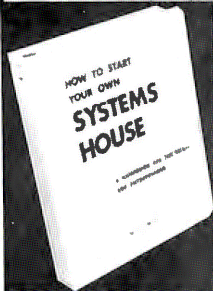
; Write to operator with reply
;Syntax: WTOR <message text>
;
0100      ORG      100H
;
C019 =      SOUT    EQU      0C019H
C01C =      AOUT    EQU      0C01CH
C022 =      AINP    EQU      0C022H
;
0100 210000    START: LXI      H,0
BELL00P:
0103 2B      DCX      H
0104 7D      MOV      A,L
0105 B4      ORA      H
0106 D3FC      OUT      0FCH    ;sound alarm port
0108 C20301    JNZ      BELL00P
REPL00P:
010B 3E00      MVI      A,0
010D CD22C0      CALL    AINP    ;get keyboard character
0110 CA0B01      JZ      REPL00P
0113 FE0D      CPI      13      ;done?
0115 C8      RZ      ;return to CP/M
0116 47      MOV      B,A
0117 CD19C0      CALL    SOUT    ;send to standard output port
; may be user defined port
; such as serial and display
011A C30B01      JMP      REPL00P
;

```


ENTREPRENEURS NEEDED

MORE THAN EVER IN THE MICRO-COMPUTER INDUSTRY.

The shortage of knowledgeable dealers/distributors is the #1 problem of microcomputer manufacturers. Over 300 new systems houses will go into business this year, but the number falls short of the 1200 needed. It is estimated that the nationwide shortage of consultants will be over 3000 by 1981. The HOW TO manuals by Essex Publishing are your best guide to start participating in the continued microcomputer boom.



\$36. No. 10

Documentation • Solutions to the Service Problem • How to Write a Good Business Plan • Raising Capital

HOW TO START YOUR OWN SYSTEMS HOUSE

6th edition, March 1980

Written by the founder of a successful systems house, this fact-filled 220-page manual covers virtually all aspects of starting and operating a small systems company. It is abundant with useful, real-life samples: contracts, proposals, agreements and a complete business plan are included in full, and may be used immediately by the reader.

Proven, field-tested solutions to the many problems facing the small systems house are presented.

From the contents:

- New Generation of Systems Houses • The SBC Marketplace • Marketing Strategies • Vertical Markets & IAPs • Competitive Position/Plans of Major Vendors • Market Segment Selection & Evaluation • Selection of Equipment & Manufacturer • Make or Buy Decision • Becoming a Distributor • Getting Your Advertising Dollar's Worth • Your Salesmen: Where to Find Them • Product Pricing • The Selling Cycle • Handling the 12 Most Frequent Objections Raised by Prospects • Financing for the Customer • Leasing • Questions You Will Have to Answer Before the Prospect Buys • Producing the System • Installation, Acceptance, Collection • Protecting Your Product • Should You Start Now? • How to Write a Good Business Plan • Raising Capital



\$28. No. 16

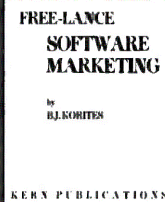
pitfalls • How consultants' associations can help you • How others did it: real-life sample cases • and much more.

HOW TO BECOME A SUCCESSFUL COMPUTER CONSULTANT

by Leslie Nelson, May 1980

Independent consultants are becoming a vitally important factor in the microcomputer field, filling the gap between the computer vendors and commercial/industrial users. The rewards of the consultant can be high: freedom, more satisfying work and doubled or tripled income. HOW TO BECOME A SUCCESSFUL COMPUTER CONSULTANT provides comprehensive background information and step-by-step directions for those interested to explore this lucrative field:

- Established consulting markets • How to get started • Itemized start-up costs • Are you qualified? • Beginning on a part-time basis • The Marketing Kit • Should you advertise? • Five marketing tips • Getting free publicity • How much to charge • When do you need a contract? • Sample proposals • Which jobs should be declined • Future markets • The way to real big money • Avoiding the legal pitfalls • How consultants' associations can help you • The National Register of Computer Consultants • How others did it: real-life sample cases • and much more.



\$30. No. 32

training users and providing maintenance and support. It also contains sample software contracts that have been used in actual software transactions. Also included are tips on how to negotiate with a large corporation, ways of avoiding personal liability, techniques for obtaining free computer time and hints on how to run a free-lance software business while holding a full-time job.

FREE-LANCE SOFTWARE MARKETING

3rd edition, June 1980

Writing and selling computer programs as an independent is a business where • you can get started quickly, with little capital investment • you can do it full time or part time • the potential profits are almost limitless. Since the demand for computer software of all kinds is growing at an explosive rate, the conditions for the small entrepreneur are outstanding.

This manual will show you how to sell your own computer programs using these proven techniques: • direct to industries • through consulting firms • through manufacturers of computer hardware • in book form • mail order • through computer stores. It will show you how to profitably sell and license all types of software ranging from sophisticated analytical programs selling for thousands of dollars, down to simple accounting routines and games for personal computers.

The book will guide you step by step through the process of marketing, advertising, negotiating a contract, installing software, training users and providing maintenance and support. It also contains sample software contracts that have been used in actual software transactions. Also included are tips on how to negotiate with a large corporation, ways of avoiding personal liability, techniques for obtaining free computer time and hints on how to run a free-lance software business while holding a full-time job.

ESSEX PUBLISHING CO. Dept. 2
285 Bloomfield Avenue • Caldwell, N.J. 07006

Order books by number. Send check, money order (U.S.\$), VISA or Master Charge #. Publisher pays 4th class shipping. For rush Air Mail shipping add \$2.50 per book in USA and Canada, \$5.00 in Europe, \$8.00 elsewhere. N.J. residents add 5% sales tax.

☐ No. 10 ☐ No. 16 ☐ NO. 32 ☐ Check enclosed ☐ Credit card

Name _____

Address _____

City _____ State _____ Zip _____

Card # _____ Exp. _____

For immediate shipment on credit card orders call (201) 783-6940 between 9 and 5 Eastern time.

Text continued from page 34:

CP/M. If a colon follows the phone number, the next character is sent in ASCII form to the answering modem after the clear-to-send signal is received from the answering modem. Such a logon character is often required by timesharing services. After communication is established and any logon character is sent, the program calls a terminal-simulation subroutine (TERM) that will listen for a character which was the serial line, display it on the CP/M display, and send a character of input to the CP/M console. The serial status port and bit configuration is that of a Processor Technology Sol. The subroutine SETIO must configure CP/M to send output to the serial port and receive input from the serial port. The subroutine shown is also for the Sol.

Listing 2 shows a program that will configure the operating system to be remotely accessed. The program, after starting, will wait for the telephone to ring and the modem to answer. If the caller is an originating modem, the program will configure CP/M to use the terminal on the other end of the telephone line as the display console. All data output to the remote terminal and input to CP/M from the remote terminal is echoed to the local display.

Listings 3 and 4 show small programs that can be used by the remote user to communicate with the local operator. The programs can be used only to send a message or to send a message and get a reply from the local operator. These programs are thus named Write To Operator (WTO) and Write To Operator and Reply (WTOR).

Conclusion

Once the modem is constructed and tested, a protocol is still needed to establish two-way communications between processors. Commercial timesharing services set this protocol for their customers. Personal computer users do not have a standard file and message exchange protocol, but groups such as PCNET in the San Francisco Bay area (280 Polaris Ave, Mountain View CA 94303) are working on the problem. The PCNET protocol is based on the use of modems similar to the type described in this article. ■