

TI-99/4 HOME COMPUTER
EIA RS232C PERIPHERAL
GENERAL SOFTWARE INTERFACE AND
OPERATIONAL SPECIFICATION

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SECTION 1

INTRODUCTION

This document describes the software interface and the operational specification of the RS232 peripheral as seen by a programmer using the BASIC language contained in the Texas Instruments 99/4 Home Computer. The RS232 peripheral will process OPEN, CLOSE, LIST, INPUT, PRINT, OLD, and SAVE commands. Any other commands will generate an ILLEGAL OPERATION error code.

The RS232 peripheral has been designed to recognize a SHIFT-C on the console as an abort command. This will terminate any pending or in progress operation and return back to the BASIC program with a DEVICE ERROR code.

1.1 Functional Capabilities

All functions are programmable from a BASIC program.

The hardware programmable functions of the RS232 peripheral are:

BAUD rates: 110, 300, 600, 1200, 2400, 4800, or 9600
Number of data bits: 7 or 8
Parity: none, odd, or even
Number of stop bits: 1 or 2

The software programmable functions of the RS232 peripheral are:

- * Turn off the automatic carriage return and linefeed, or linefeed only, after each VARIABLE length DISPLAY data type record.
- * Disable the automatic echo of all read DISPLAY data type characters to the sending device.
- * Enable the checking of parity for error detection.

The RS232 peripheral also contains a handshaking protocol with retransmit capability when doing an OLD or SAVE operation.

SECTION 2

APPLICABLE DOCUMENTS

Home Computer BASIC Language Specification
(Revision 4.1, 12 April 1979)

TI-99/4 Home Computer EIA RS232C Peripheral Detailed
Software Functional Specification
(Version 2.0, Revised 28 March 1983)

SECTION 3

DEFAULT PARAMETERS

You may override any default condition by using the switch option as in the OPEN statement.

Device name RS232 is equivalent to RS232/1 and refers to port 1.

OPEN/INPUT/PRINT - 300 BAUD, 7 data bits, 1 odd parity bit, and 1 stop bit. All VARIABLE length DISPLAY data type records will automatically have carriage return and linefeed characters transmitted after them, unless this function is disabled. All characters received with DISPLAY data type will be echoed back to the sending device unless echoing is disabled. Parity will only be checked if enabled.

SAVE/OLD - 300 BAUD, 8 data bits, no parity bit, and 1 stop bit.

SECTION 4

RS232 PERIPHERAL BASIC LANGUAGE INTERFACE

The RS232 peripheral contains all the software necessary to interface the RS232 peripheral to the Home Computer file management system. The File Management subset implemented for the RS232 peripheral is comprised of the following INPUT/OUTPUT (I/O) routines:

OPEN, CLOSE, INPUT, PRINT, LIST, OLD, and SAVE.

The following sections describe actions taken by the RS232 peripheral software upon each I/O call. The RS232 peripheral will return with an ILLEGAL OPERATION error code for any other I/O call except OPEN, CLOSE, INPUT, PRINT, LIST, OLD, or SAVE.

4.1 OPEN Command

The OPEN command makes sure that all the OPEN attributes are valid, initializes the hardware to the desired conditions, and controls how the peripheral software functions.

The general format of the OPEN statement is:

OPEN #N: "<DEVICE NAME>"<FILE ATTRIBUTES>

or

OPEN #N: "<DEVICE NAME><SWITCH OPTION(S)>"<FILE ATTRIBUTES>

An OPEN statement with all default conditions looks like:

OPEN #1:XY

where X = "RS232. BAUD RATE=300. DATA BITS=7. PARITY=ODD"

or where X = "RS232. BA=300. DA=7. PA=0"

and where Y = ",UPDATE, SEQUENTIAL, DISPLAY, VARIABLE 80"

This is equivalent to: OPEN #1: "RS232"

NOTE

The character string between the two quotes (") has a maximum length of 255 characters and may be replaced by a string variable. Such as OPEN #N: A\$<FILE ATTRIBUTES>.

#N is the integer file number that is to be assigned to the OPENed device. The value of N is between 1 and 255 inclusive.

<DEVICE NAME> is the name of the device that is to respond. The device names for the RS232 peripheral are: RS232, RS232/1, and RS232/2; where "RS232" is equivalent to "RS232/1". Ports 1 and 2 on the RS232 peripheral box are referred to by "/1" and "/2" respectfully.

<SWITCH OPTIONS> are the parameters from this section which are used to initialize the hardware and control how the software functions. Only the first two characters are actually need for switch recognition. You may override any default condition with these switch options. The switch options may be in any order desired.

NOTE

An OPEN statement has access to all switch options. An OLD or SAVE command may only use .BA, .PA, .CH, or .TW switch options, an attempt to use any other switch will generate an error.

Hardware Switch Options: [Default Value]

- .BAUD RATE - 110, [300], 600, 1200, 2400, 4800, or 9600
- .DATA BITS - 7 or 8 [7 for OPEN] [8 for LOAD/SAVE]
- .PARITY - ODD, EVEN, or NONE [O for OPEN] [N for LOAD/SAVE]
(Only O, E, or N are actually needed)
- .TWO STOP BITS [1 stop bit]

Software Switch Options:

Defaults:

- .NULLS[OFF] .CHECKPARITY[OFF] .ECHO[ON] .CR
- .LF[ON] .LFC[ON]
- .NULLS ON - Enable automatic NULLs after each CR
- .CHECK PARITY ON - Enables check for parity errors

- .ECHO OFF - Disable automatic echo and edit of received data
- .CRLF OFF - Disable automatic carriage return and linefeed
- .LF OFF - Disable automatic linefeed only

<FILE ATTRIBUTES> are also mentioned in the Home Computer BASIC Language Specification. The FILE ATTRIBUTES consist of the following:

Open Mode:

- ,INPUT - OPEN file for INPUT only
- ,OUTPUT - OPEN file for OUTPUT only
- ,UPDATE - (Default) OPEN file for INPUT and OUTPUT
- ,APPEND - Same as OUTPUT for the RS232 peripheral

File Organization:

- ,SEQUENTIAL - (Default)
- ,RELATIVE - Invalid for the RS232 peripheral

Record Type:

(N is the length of the records. If not given the RS232 peripheral defaults to 80 bytes [characters]).

- ,FIXED N - (INTERNAL data type Default) Fixed length records
- ,VARIABLE N - (DISPLAY data type Default) Variable length records

Data Type:

- ,DISPLAY - (Default) Usual for terminals and printers
- ,INTERNAL - Console software internal format.
This data type is used to save record transfer time. See the Home Computer BASIC Language Specification for a description of how BASIC defines INTERNAL data type. See the TI-99/4 Home Computer EIA RS232C Peripheral Detailed Software Functional Specification for a description

of how the RS232 peripheral handles this data type.

4.2 CLOSE Command

The RS232 peripheral ignores the CLOSE command. However, BASIC does require that this command be executed so that the memory allocation for this OPENed device can be reallocated.

4.3 INPUT Command

The number of bytes (characters) that will be returned depends on the record type specified in the OPEN statement. For FIXED length or INTERNAL data type records, the RS232 peripheral will retain control until either the number of characters equals the logical record length (FIXED N where N is the logical record length), or the user types a SHIFT-C on the console and aborts the input. For VARIABLE length records with DISPLAY data type records, control will be retained until one of three conditions are met.

1. The detection of an ENTER or CARRIAGE RETURN (code decimal 13) character.
2. The logical record buffer size given in the OPEN has been filled, VARIABLE N, where N is the logical record size.
3. The user types a SHIFT-C on the console and aborts the input.

An extra degree of intelligence has been coded into the RS232 software for the case where the INPUT command is INPUTing from a terminal device using DISPLAY data type and the .ECHO OFF switch option is not given. This code recognizes the following special characters:

1. DELETE (decimal code 127) - Each time this character is received and DISPLAY data type records were OPENed, the previous character received will be deleted from the returned character buffer and echoed back to the terminal. This will mean that the characters will be displayed on the terminal in reverse order as they are deleted. If all the characters in the buffer have been

deleted a command to delete is just ignored.

2. CONTROL-R (decimal code 18) - This will cause the RS232 peripheral to echo back a carriage return, linefeed, and the current contents of the INPUT buffer. This feature would be used when some characters have been deleted and the user is not clear as to exactly what the current input line looks like.

4.4 PRINT Command

The number of bytes (characters) that will be PRINTed depends on the record type, the .CR and .LF switch options, and the data type. Carriage return and linefeed characters will be appended to all records unless either the .CR switch options is used, .LF switch option is used, or INTERNAL data type is specified. If the .CR switch option is used both the carriage return and the linefeed characters will not be appended to the output record. However, if the .LF switch option is used, the carriage return only is appended to the output record and the linefeed is not. The .LF switch should be used when exchanging text between two Texas Instruments series 99/4 Home Computers. INTERNAL data type does not output .CR or .LF characters and is treated as if it were fixed length records.

4.5 LIST Command

The way the BASIC LIST command actually functions is to automatically do an OPEN, multiple PRINTs, then a CLOSE which means that all the switch options that apply to the OPEN also apply to the LIST command.

>LIST "RS232" (Simple command: port 1, 300 BAUD, 7 data bits, 1 odd parity bit, and 1 stop bit. Automatic CR and LF will be added.)

>LIST "RS232/2.BA=9600" (Same as above, but port 2 and 9600 BAUD.)

>LIST "RS232/1.LF" (Same as LIST "RS232", but no automatic LF after CR.)

4.6 OLD Command

See section 5.0 for an operational explanation of how this command is to be used and how it functions. The switch options

.BA, .PA, .CH, and .TW described in section 3 are available to the OLD command. This command is used to load a new program image through the RS232 peripheral and is especially designed for communication with another Texas Instruments 99/4 Home Computer using the SAVE command.

4.7 SAVE Command

See section 5 for an operational explanation of how this command is to be used and how it functions. The switch options .BA, .PA, .CH, and .TW described in section 3 are available to the SAVE command. This command is used to SAVE or exchange a program image through the RS232 peripheral and is especially designed for communication with another Texas Instruments 99/4 Home Computer using the OLD command.

SECTION 5

SAMPLE PROGRAMS AND COMMANDS

EXAMPLE 1: This will OPEN the RS232 peripheral for UPDATE mode using all the default parameters: Port 1, 300 BAUD, 7 data bits, 1 odd parity bit, and 1 stop bit. a VARIABLE length record will be INPUT from port 1, then the message "ENTER TEXT NOW " will be written to port 1 followed by the actual INPUT text as received by the BASIC interpreter enclosed in single quotes "".

NOTE

DISPLAY data type will be used which means that the DELETE, BACKSPACE, and CONTROL-R features described in section 3.3 can be used during the INPUT on the remote terminal.

```
100 OPEN #1: "RS232"
200 PRINT #1: "ENTER TEXT NOW "
300 INPUT #1: A$
400 PRINT #1: "'"; A$; "'"
500 IF A$<>"" THEN 200
600 CLOSE #1
```

EXAMPLE 2: This program will OPEN port 1 and 2 and then copy one character at a time from port 1 to port 2. The parameters are: 9600 BAUD, 7 data bits, 1 odd parity bit, and 1 stop bit. Parity will be checked and a DEVICE ERROR code will be returned if an error occurs. The .EC switch option is needed to turn off the automatic edit and echo. The .CHECK PARITY switch option is needed to enable parity checking.

```
100 OPEN #1: "RS232/1. BA=9600. EC. CH", FIXED 1
200 OPEN #2: "RS232/2. BA=9600. EC. CH", FIXED 1
300 INPUT #1: A$
400 PRINT #2: A$
500 IF A$<>"" THEN 300
600 CLOSE #1
700 CLOSE #2
```

EXAMPLE 3: Variable length ASCII text messages may be communicated between two Home Computers by using the following

programs. The parameters are: 300 BAUD, 7 data bits, 1 odd parity bit, and 1 stop bit. Parity errors will be ignored. The .LF and .EC switch options are needed to turn off the automatic LF and echo.

```
(One user runs this program) [BAUD rate may be changed.]
100 OPEN #1: "RS232.EC.LF", VARIABLE 255
200 INPUT A$
300 PRINT #1:A$
400 INPUT #1:B$
500 PRINT B$
600 GOTO 200
```

```
(The other user runs this program) [BAUD rate may be changed.]
100 OPEN #1: "RS232.EC.LF", VARIABLE 255
200 INPUT #1:A$
300 PRINT A$
400 INPUT B$
500 PRINT #1:B$
600 GOTO 200
```

EXAMPLE 4: This program will OPEN file 1, 2, and 3, all on port 1. File 2 will accept variable length ASCII text input but will not echo it back to the terminal. File 3 will PRINT data and the cursor or carriage return will stay on the same line after it is printed. File 1 will automatically put a carriage return and linefeed characters after every output record. If the response to "ENTER PASSWORD " is "LEMEIN" then "PASSWORD IS OK" will be printed, otherwise "TRY AGAIN" will be printed.

```
100 OPEN #1: "RS232"
110 OPEN #2: "RS232.EC"
120 OPEN #3: "RS232.CR"
130 PRINT #3: "ENTER PASSWORD "
140 INPUT #2:A$
150 IF A$<>"PASSWORD" THEN 180
160 PRINT #1: "TRY AGAIN"
170 GOTO 130
180 PRINT #1: "PASSWORD IS OK"
190 GOTO 130
```

SECTION 6

PROCEDURE FOR PROGRAM EXCHANGE WITH OLD/SAVE COMMAND

The exchange of programs using the RS232 interface was designed for ease of program exchange through modems. All that is required to establish this program exchange link is for two users to call each other on the phone, place the phones on their respective modems, then:

The user on the SAVE side will type a minimum of:
SAVE "RS232", SAVE "RS232/1", or SAVE "RS232/2".

The user on the OLD side will type a minimum of:
OLD "RS232", OLD "RS232/1", or OLD "RS232/2".

It makes no difference who types first or how long it takes for the other user to respond once the first user has typed their part. However, establishing the link is more reliable if the SAVE command is typed before the OLD command. If the OLD command is typed first, noise on the line can be interpreted as a start of input from the SAVE which will cause the OLD side to hang up. If after both sides have typed their part and the link is not established within 15 seconds, the OLD side should type SHIFT-C on the console and retype the OLD command which should create the link immediately. There is no timeout, however typing a SHIFT-C on the console will abort the operation at any time. Once the data link is established, the exchange of the program image is completely under program control.

When either OLD or SAVE commands are executed with the RS232 peripherals, a three digit number, initially 255, will be displayed at the center of the top line on the display screen. The value will stay 255 until the program exchange link is established at which time it will change to the remaining number of 256 byte records to be transferred. Each time a good record is exchanged, the number will count down toward zero. This countdown may then be used as a visual indication of the status of the program exchange and should decrement at one of the following rates:

110 BAUD	=	23.5 seconds
300 BAUD	=	8.6 seconds
600 BAUD	=	4.3 seconds
1200 BAUD	=	2.5 seconds
2400 BAUD	=	1.1 seconds

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4800 BAUD = 0.5 seconds
9600 BAUD = 0.3 seconds

The switch options .BA, .PA, .CH, and .TW described in Section 3.1 may be used with the OLD or SAVE commands.

SAVE "RS232.BA=600.PA=0.CH"
and
OLD "RS232.BA=600.PA=0.CH"

About 8 minutes will be required to exchange a 14K program. A typical program of 3.5K will require about 2 minutes. In general each K (1024 bytes) transferred will require about 35 seconds at 300 BAUD. Under certain conditions about 7 seconds are required to establish the link after both users have typed their parts.

SECTION 7

INTERFACE RESTRICTIONS

Although both ports may be OPENed at the same time, only one port may be active. However the hardware does have the ability to buffer a single character. If a port is OPENed for INPUT and the character in the hardware buffer does not get accepted before the next data byte is received, an OVERRUN ERROR will occur, BASIC will see this as a DEVICE ERROR code on the next INPUT from the same port.

If a port is OPENed for INPUT and N characters are read, but N+2 characters were transmitted, the next time an INPUT is done from that port a DEVICE ERROR code will be generated. This is because the hardware can only buffer one character and two have come in which causes an OVERRUN ERROR.

Whenever 110 BAUD rate is selected, the number of stop bits should be set to two with the clause ".TW" or ".TWO STOP BITS".

SECTION 8

SPECIAL COMMENTS

For an INPUT command:

1. INTERNAL data type and use of the .ECHO OFF switch option will disable the remote edit feature.
2. When the .ECHO OFF switch option is not used, the .CRLF OFF and the .LF OFF determine if the echoed records are followed by automatic CR and LF characters.
3. .ECHO OFF overrides .CRLF OFF which overrides .LF OFF switch options.
4. When FIXED length DISPLAY type data records are specified, the RS232 peripheral retains control until the exact number of characters asked for are input. Carriage returns and any other control characters, except the delete character and the CONTROL-R, are treated just like any other ASCII character. The delete and CONTROL-R perform the editing functions described in section 3.3. A SHIFT-C can abort an INPUT command for more INPUT data from the RS232 peripheral.
5. The .ECHO OFF switch option disables both the automatic echo of the INPUT characters to the sending device and the interpretation of the delete and CONTROL-R characters for editing purposes.

For a PRINT command:

1. The .ECHO OFF switch option has no effect on the output data.
2. The .CRLF OFF overrides the .LF OFF switch option.
3. The .CRLF OFF and the .LF OFF switch options have no effect when fixed length records are selected. The exact number of characters asked for is output exactly as given to the peripheral.

For both INPUT and PRINT commands:

1. The .NULLS ON and the .CHECK PARITY ON switch options function independent of the .ECHO OFF, .CRLF OFF, and the .LF OFF switch options.
2. A given RS232 peripheral port can be OPENed more than once at the same time with different software switch options so long as all the hardware switch options given are the same. See EXAMPLE 5, section 4.0 and SWITCH OPTIONS, section 3.1.
3. The syntax of the OPEN statement switch option string is free form with the following conditions:
 - a. There can be no spaces between the Device Name, the period ".", and the first two characters of the first switch.
 - b. Once past the first switch XX, "RS232.XX.YY", there can be any number of spaces until the next period ".". When the period is found the next two characters must be the first two characters of the switch option name.
 - c. When a switch option has the form ".BAUD RATE = 9600" after the "BA" all characters are ignored until the "=". After the "=" spaces are ignored until the first character. After the second zero in 9600 all spaces are ignored until the next "." is found.

SECTION 9

ERRORS AND ERROR CODES

The meaning of the error codes are as follows:

X1 = BAD DEVICE NAME (Generated by BASIC interpreter)
X2 = BAD ATTRIBUTES
X3 = ILLEGAL OPERATION
X4 = OUT OF TABLE/BUFFER SPACE
X5 = DEVICE ERROR

OPEN:

CODE 02 - The switch option entry is in error. Incorrect first two characters of a switch, invalid BAUD rate, or incorrect number of data bits. RELATIVE record type specified in OPEN statement.
CODE 06 - Console peripheral frequency not compatible with RS232 peripheral frequency of 2.5 or 3.0 MHz.

CLOSE: No errors are generated during a CLOSE statement.

INPUT:

CODE 24 - INTERNAL data type record is too large to be read into the buffer space allocated.
CODE 26 - Some type of hardware error; either a framing, overrun, or parity error occurred. Abort of a pending or in progress operation with a SHIFT-C on the console keyboard.

PRINT: No errors are generated during a PRINT statement.

OLD:

CODE 52 - Attempt to use .EC, .CR, .LF, .NU, or .DA switch during OLD statement. See also CODE 02.
CODE 54 - The program is too large to be loaded.
CODE 56 - See CODE 26.

SAVE:

CODE 62 - Attempt to use .EC, .CR, .LF, .NU, or .DA switch during SAVE statement. See also CODE 02.
CODE 66 - See CODE 26.

MISC ERROR CODES:

CODE 43 - Attempt to execute a RESTORE command which is illegal.

CODE 73 - Attempt to execute a DELETE command which is illegal.
CODE 83 - Attempt to execute a SCRATCH command which is illegal.
CODE 93 - Attempt to execute a STATUS command which is illegal.

SECTION 10

DECIMAL CODED ASCII TABLE

DEC	C H A R A C T E R	DEC	CHAR	DEC	CHAR	DEC	CHAR
====	=====	====	====	====	====	====	====
0	NULL (Blank)	32	SPACE	64	@	96	`
1	SOH (Start of Header)	33	!	65	A	97	a
2	STX (Start of Text)	34	"	66	B	98	b
3	ETX (End of Text)	35	#	67	C	99	c
4	EOT (End of Transmission)	36	\$	68	D	100	d
5	ENQ (Enquiry)	37	%	69	E	101	e
6	ACK (Positive Acknowledge)	38	&	70	F	102	f
7	BEL (Bell)	39	'	71	G	103	g
8	BS (Backspace)	40	(	72	H	104	h
9	HT (Horizontal Tabulation)	41	)	73	I	105	i
10	LF (Linefeed)	42	*	74	J	106	j
11	VT (Vertical Tabulation)	43	+	75	K	107	k
12	FF (Form Feed)	44	,	76	L	108	l
13	CR (Carriage Return)	45	-	77	M	109	m
14	SO (Shift Out)	46	.	78	N	110	n
15	SI (Shift In)	47	/	79	O	111	o
16	DLE (Data Link Escape)	48	0	80	P	112	p
17	DC1 (Device Control 1)	49	1	81	Q	113	q
18	DC2 (Device Control 2)	50	2	82	R	114	r
19	DC3 (Device Control 3)	51	3	83	S	115	s
20	DC4 (Dev Ctl 4 - Stop)	52	4	84	T	116	t
21	NAK (Negative Acknowledge)	53	5	85	U	117	u
22	SYN (Synchronization)	54	6	86	V	118	v
23	ETB (End of Text Block)	55	7	87	W	119	w
24	CAN (Cancel)	56	8	88	X	120	x
25	EM (End of Medium)	57	9	89	Y	121	y
26	SUB (Substitute)	58	:	90	Z	122	z
27	ESC (Escape)	59	;	91	[	123	{
28	FS (File Separator)	60	<	92	\	124	|
29	GS (Group Separator)	61	=	93	]	125	}
30	RS (Record Separator)	62	>	94	_	126	~
31	US (Unit Separator)	63	?	95	-	127	DELETE