<table>
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<th>DECUS NO.</th>
<th>8-285</th>
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<tr>
<td>TITLE</td>
<td>TELETYPE INPUT-OUTPUT PACKAGE</td>
</tr>
<tr>
<td>AUTHOR</td>
<td>Garth Peterson</td>
</tr>
</tbody>
</table>
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|           | South Dakota School of Mines and Technology  
|           | Rapid City, South Dakota |
| DATE      | December 9, 1969 |
| SOURCE LANGUAGE | PALD |

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Title: Teletype Input-Output Package

Author: Garth Peterson

Date: 2 December 1969

Name: TTYP

Programming language: PALD

Core usage: One page, plus location 0.

Abstract:

This is a teletype control package containing subroutines for single-character input and output and for output of packed and open text. These subroutines are single-field oriented, but provide for interrupt-enabled and disabled operation.
Description:

There are nine subroutines:

<table>
<thead>
<tr>
<th>Name</th>
<th>Function</th>
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<tbody>
<tr>
<td>KTREAD</td>
<td>Read one input character unconditionally.</td>
</tr>
<tr>
<td>KTGET</td>
<td>Get contents of keyboard buffer (conditional input).</td>
</tr>
<tr>
<td>KTKCL</td>
<td>Clear keyboard buffer.</td>
</tr>
<tr>
<td>KTKSV</td>
<td>Service keyboard flag interrupt.</td>
</tr>
<tr>
<td>KTWRTE</td>
<td>Write one output character.</td>
</tr>
<tr>
<td>KTTSV</td>
<td>Service teletype output flag interrupt.</td>
</tr>
<tr>
<td>KTACPT</td>
<td>Accept keyboard input character and echo it.</td>
</tr>
<tr>
<td>TYPON</td>
<td>Type open text.</td>
</tr>
<tr>
<td>TYPACK</td>
<td>Type packed text.</td>
</tr>
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</table>

KTREAD, KTGET, and KTACPT return to the calling program with data in the accumulator; all others return with the accumulator cleared to zero. KTWRTE takes data from the accumulator upon entry; all others clear the accumulator at the start.

The design of these subroutines is based on the following interrupt philosophy: Under interrupt-disabled operation the user's program consists of a single process which includes all calculations, decision branches, and peripheral device service. The operation of peripherals simultaneously with one another and with the calculating and branching parts of the program is thus limited to the inherent buffering capabilities of the peripheral hardware. Under interrupt-enabled operation the user's program contains first a main process, which makes calculations and decisions and which initiates peripheral operations, and second an interrupt service process, which clears flags and issues such commands as are required by the current states of the peripheral devices [8]. Whenever the interrupt service determines that no more devices currently require service, execution of the main process must resume at the point of interruption. The main process runs primarily with the interrupt facility enabled but with it disabled when instructions are executed which are common to both processes. Thus this teletype package is unsuitable for time-sharing systems, but it can run only one teletype anyway. Interrupt-enabled operation is made to resemble interrupt-disabled operation as closely as possible; therefore buffering of the teletype is actually or virtually limited to hardware buffering, and multiple entry points for the individual subroutines are avoided. Other peripherals can run simultaneously with the teletype as permitted by program logic and the interrupt facility.
If the calling program enables the interrupt facility, the interrupt flag identification routine should contain some coding sequence such as:

```
KSF
SKP
JMS KTKSV
TSF
SKP
JMS KTTSV
```

KTKSV and KTTSV should be called only while the interrupt facility is disabled and only in response to interrupts. No references in the calling program to these two subroutines are needed if the interrupt facility is always disabled. All the remaining subroutines may be called with the interrupt facility enabled or disabled, but only as part of the main process.

The text output subroutines have calling sequences as follows:

```
JMS TYPOPN
AREA

JMS TYPPAK
AREA
```

"AREA" is the address of the first word of the text. The separation of the character string from the subroutine call allows more efficient use of PDP-8 memory pages. TYPOPN outputs open text consisting of 8-bit ASCII with one right-justified character per memory word. The text string is terminated by a zero word; however, blank tape can still be punched by means of a non-zero word which is zero in the low-order 8 bits.

When writing a program, certain characters, such as carriage return, line feed, rubout, and back arrow, must be written in octal to avoid problems with the Editor program. Most printing characters can be written explicitly, using the single-character assembly facility of PALD or MACRO-8 [2,5]. For example:

```
MESG, 215;212;"M;"E;"S;"S;"A;"G;"E;0
```

At least three characters in the source program are needed for each character in the text, so that open text is inefficient in both the source program and object program. However, open text is more convenient as program-generated text, such as numerical output.

TYPPAK outputs 6-bit stripped ASCII, packed two characters per word, as assembled by PALD or MACRO-8 when the pseudo-op "TEXT" is used [3,6]. Permissible output characters are space, carriage return, line feed, and all the graphics except the at (@), per cent (%), and pound (#) signs. The text is terminated by 00 (octal), which is generated by the assembler, and which is what "@" in the text will compress to. The at sign is therefore a logical choice for a text delimiter. The
per cent and pound signs are compressed in the usual way by the assembler but then converted by TYPPAK to carriage return and line feed respectively [1]. The back arrow is excluded by the Editor, rather than by TYPPAK or the assembler. In addition, if the Editor converts successive spaces in the text to a single tabulate character, the final result in the output will be "I".

Both text subroutines call KTWRTE, which the calling program may also access directly. KTWRTE loops until the teletype flag rises, or until enough time has elapsed to assure that no flag is pending, and then issues the output command [7]. The entry point KTWRTE is immediately followed by a skip and return:

```
KTWRTE, 00
SKP
JMP I KTWRTE

This allows the output of TYPPAK to be diverted to another device when the skip is replaced by a call to the subroutine for that device. For example, suppose "PTWRTE" is the name of a fast punch subroutine. Then output can be diverted and restored thus:

TAD (JMS I [PTWRTE])
DCA KTWRTE+1

TAD (SKP)
DCA KTWRTE+1

Note that "PTWRTE" must return to KTWRTE+2 with the accumulator cleared.
```

KTWRTE must be in its normal condition whenever KTACPT is called. For the PDP-8/S the supplied version of KTWRTE should be replaced by:

```
00
00
00
KTWRTE, 00
SKP
JMP I KTWRTE
DCA KTWRTE-2
DCA KTWRTE-3
ISZ KTWRTE-3
TAD KTWRTE-1
SNA CLA
JMP .+3
TSF
JMP -.5
TAD KTWRTE-2
TLS
STA
DCA KTWRTE-1
JMP I KTWRTE
```
The input subroutines KTREAD, KTGET, and KTKCL provide access to the "keyboard buffer," which is an abstraction but which has these properties from the viewpoint of the calling program: The buffer is cleared, or voided, by a program command; keyboard input data loads the buffer, which then remains loaded with this input character until cleared by the program or until reloaded by new input data. KTKCL clears the buffer and should be called before data is read from the teletype to avoid inputting spurious characters. KTREAD provides unconditional input; after entry KTREAD loops until the keyboard buffer contains data, then clears the buffer, and returns with the input data in the accumulator and also in core location KTNEXT. KTGET is a conditional input subroutine which shows the current contents of the keyboard buffer in the accumulator but which does not clear the buffer. If the buffer is void, it sets the accumulator to -1. KTGET is called by KTREAD and may be called directly by the user's program to determine whether or not a teletype key has been pressed. In order to determine the status of the interrupt facility, KTGET accesses location 0; the calling program must therefore avoid this location even if the interrupt facility is never used. The interrelation of KTKCL, KTGET, and KTREAD may be made clearer by the following examples of how these subroutines would be written if the interrupt facility were always disabled. Here the "keyboard buffer" is in fact the hardware buffer, provided that a keyboard flag must be present for the buffer to be considered loaded.

```
KTKCL, 00
KCC
JMP I KTKCL
/
KTGET, 00
CLA
KCS
KSF
STA
JMP I KTGET
/
KTREAD, 00
JMS KTGET
SPA
JMP , -2
DCA KTNEXT
KCC
TAD KTNEXT
JMP I KTREAD
KTNEXT, 00
```

Interrupt-enabled operation and teletype paper tape input are not fully compatible. This is a hardware characteristic and cannot readily be offset in programming; a fairly large input buffer in memory is usually required. If KTREAD is used for paper tape input with the interrupt facility enabled, successive calls must occur within 100 milliseconds.
to avoid loss of data; if the teletype reader is ready, the tape will advance continuously even when input is not requested. Under interrupt-disabled operation the tape advances by one character for each call to KTREAD.

KTACPT inputs characters from the keyboard and echoes them on the teleprinter. It first clears the keyboard buffer, then reads one character, echoes it, and returns with the character in the accumulator and in KTNEXT. All characters are typed as read except carriage return, which is echoed as carriage return plus line feed. KTACPT is not suitable for paper tape input because of this double echo and because KTKCL should be called only once at the beginning of a paper tape, not repeatedly while the tape is read. Paper tape input with teletype echo is performed by this coding sequence:

```
JMS KTREAD
JMS KTWRTE
TAD KTNEXT
```

This teletype control package is intended for use by programs which run entirely within 4096 words of memory or which use extended memory only as fast-access auxiliary data storage. Its use on a multiple-field PDP-8 is subject to these restrictions: Each subroutine must be called with the data field matching the instruction field, and it will return only to locations in the field where it resides. Location 0 must be avoided in any field where KTGET is called. Interrupt-enabled operation is limited to field 0. Text for TYPOPN or TYPOPAK must not "wrap around" from location 7777 to location 0.

It can be useful to patch the input and output functions of the PDP-8 floating-point interpreter \cite{4} into the teletype package, allowing floating-point input and output with the interrupt facility enabled. The following patches will do this:

```
*7344+1 /OUTPUT PATCH
JMS I .+2
JMP I 7344
KTWRTE

*7142+1 /INPUT PATCH
JMS I [KTKCL] /OMIT IF PT INPUT
*7142+2
SKP
KTREAD
JMS I .-1
```

These patches should be assembled along with the main program, which must be loaded into core after the floating-point interpreter.

This subroutine package is supplied in ASCII, both with and without comments, and can be assembled as one page of core in the user's program. The first line has the pseudo-op "PAGE", which is the only exception to PAL III, and the last line is a dollar sign. There are 11 labels and no references to auto-index registers.
References:


3. ibidem, p. 2-2.


6. ibidem, pp. 6-3, 6-4.

7. Fichtenbaum, Matthew L., to Mrs. Angela J. Cossette (DECUS Executive Secretary), June 7, 1967, distributed to members of Digital Equipment Computer Users Society.

// JOB T 0002 0002 0002 13670

LOG DRIVE CART SPEC CART AVAIL PHY DRIVE
0000 0001 0001 0000
0001 0002 0002 0001

V2M6 16K SDSMT COMP CNTR 05DEC69

// * GARTH PETERSON 50120

// XEQ PTTCD

KTACPT 0274
KTGET 0213
KTKCL 0225
KTKSV 0232
KTNEXT 0211
KTPA 0351
KTREAD 0200
KTTSV. 0265
KTWRE 0242
TYPOPN 0311
TYPPAK 0325
*
PAGE
/TTY I/O PACKAGE
/11MR68, 30NV69
/
0200 0000 KTREAD, 00 /SUBR, READ KEYBOARD UNCONDITIONALLY
0201 4213 JMS KTGET /GET INPUT CHARACTER, IF ANY
0202 7510 SPA /
0203 5201 JMP .-2 /IF NONE, TRY AGAIN
0204 3211 DCA KTNEXT /DEPOSIT INPUT CHARACTER
0205 7240 STA /
0206 3212 DCA KTNEXT+1 /MARK BUFFER IN CORE EMPTY
0207 1211 TAD KTNEXT /
0210 5600 JMP I KTREAD /RETURN WITH INPUT IN AC
0211 0000 KTNEXT, 00 /+0 TELETYPING INPUT WORD
0212 0000 00 /+1 TELETYPING INPUT BUFFER
/
0213 0000 KTGET, 00 /SUBR, GET TELETYPING INPUT CHARACTER IF
0214 7200 CLA / ANY
0215 3000 DCA 0 /LOCATION 0 HOLDS RETURN ADDRESSES OF
0216 6031 KSF // INTERRUPTS
0217 5223 JMP .+4 /BRANCH IF NO FLAG, LOOK FOR CHARACTER
0220 1000 TAD 0 / IN CORE
0221 7650 SNA CLA /SKIP IF FLAG CAUSED INTERRUPT
0222 4232 JMS KTKSV /READ HARDWARE BUFFER INTO CORE
0223 1212 TAD KTKSV+1 /GET BUFFER CHARACTER, AC= -1 IF NONE
0224 5613 JMP I KTGET /
/
0225 0000 KTKCL, 00 /SUBR, CLEAR OUT PREVIOUS KEYBOARD INPUT
0226 6032 KCC /CLEAR HARDWARE FLAG WHEN INTERRUPT
0227 7240 STA /DISABLED
0230 3212 DCA KTNEXT+1 /MARK BUFFER IN CORE EMPTY
0231 5625 JMP I KTKCL /
/
0232 0000 KTKSV, 00 /KEYBOARD INPUT INTERRUPT & FLAG SER'CE
0233 6036 KRB /CLEAR FLAG, READ BUFFER, ALLOW NEW 'AR
0234 3212 DCA KTNEXT+1 /SAVE CHARACTER
0235 5632 JMP I KTKSV /
/
0236 0000 00 /-4 HIGH-ORDER TIME COUNT
0237 0000 00 /-3 LOW-ORDER TIME COUNT
0240 0000 00 /-2 OUTPUT CHARACTER
0241 0000 00 /-1 BUSY LATCH, -1 = BUSY, 0 = NOT BUSY
0242 0000 KTWWRTE, 00 /SUBR, TELETYPING OUTPUT
0243 7410 SKP /PATCH HERE TO DIVERT TO ANOTHER DEVICE
0244 5642 JMP I KTWWRTE /SAVE CHARACTER
0245 3240 DCA KTWWRTE-2 /AC = -3
0246 7346 CLL STA RTL /INITIALIZE TIME COUNT (140 MS MIN)
0247 3236 DCA KTWWRTE-4 /BEGIN LOOP
0248 2237 ISZ KTWWRTE-3 /BEGIN LOOP
0249 7410 SKP /
0250 2236 ISZ KTWWRTE-4 /SKIP IF TIME COUNT DONE, EXPECT NO FLAG
0251 1241 TAD KTWWRTE-1 /CHECK BUSY LATCH
0252 2236 TAD KTWWRTE-1 /CHECK BUSY LATCH
0253 1241 TAD KTWWRTE-1 /CHECK BUSY LATCH
0254 7650 SNA CLA /SKIP IF LATCH ON AND COUNT NOT DONE
0255 5260 JMP .+3 /BRANCH IF NOT BUSY
0256 6041 TSF /SKIP IF FLAG, INTERRUPT MAY BE DISABLED
0257 5250 JMP .-7 /PREVIOUS CHARACTER NOT DONE, TRY AGAIN
0258 1240 TAD KTWWRTE-2 /GET CHARACTER
0259 6046 TLS /START TELETYPING
0260 7240 STA /
0261 3241 DCA KTWWRTE-1 /MARK BUSY

9
JMP I KTWRT  / 0264 5642   
/ 0265 0000   KTTSV, 00   /TELETYPES OUTPUT INTERRUPT SERVICE   
0266 6042   TCF   /CLEAR FLAG   
0267 7200   CLA   
0270 3241   DCA KTWRT-1   /MARK NOT BUSY   
0271 5665   JMP I KTTSV   /   
0272 0212   212   
0273 7563  -215   
0274 0000   KTACPT, 00   /ACCEPT (AND ECHO) KEYBOARD INPUT   
0275 4225   JMS KTKCL   /CLEAR KEYBOARD BUFFER   
0276 4200   JMS KTREAD   /READ KEYBOARD   
0277 4242   JMS KTWRT   /ECHO ON TELEPRINTER   
0300 1211   TAD KTNEXT   
0301 1273   TAD KTACPT-1   /CHECK FOR CARRIAGE RETURN   
0302 7640   SZA CLA   
0303 5306   JMP +3   
0304 1272   TAD KTACPT-2   /IF CARRIAGE RETURN, SUPPLY LINE FEED   
0305 4242   JMS KTWRT   
0306 1211   TAD KTNEXT   /GET CHARACTER   
0307 5674   JMP I KTACPT   /RETURN   /   
0310 0000  00   
0311 0000   TYPPAK, 00   /TYPE MESSAGE OF OPEN TEXT   
0312 7200   CLA   / JMS TYPPAK (EFFECTIVE)   
0313 1711   TAD I TYPPAK   / ADDRESS-OF-MESSAGE   
0314 3310   DCA TYPPAK-1   / (NEXT INSTRUCTION)   
0315 2311   ISZ TYPOPN   
0316 1710   TAD I TYPPAK-1   
0317 2310   ISZ TYPPAK-1   
0320 7450   SNA   
0321 5711   JMP I TYPPAK   /ZERO WORD TERMINATES MESSAGE   
0322 4242   JMS KTWRT   /WRITE CHARACTER   
0323 5316   JMP -. 5   /   
0324 0000  00   / TEXT POINTER   
0325 0000   TYPPAK, 00   /TYPE PACKED TEXT   
0326 7200   CLA   / JMS TYPPAK (EFFECTIVE)   
0327 1725   TAD I TYPPAK   / AREA   
0330 3324   DCA TYPPAK-1   / (NEXT INSTRUCTION)   
0331 2325   ISZ TYPPAK   
0332 1724   TAD I TYPPAK-1   /GET FIRST CHAR IN WORD   
0333 4351   JMS KTPA   
0334 1724   TAD I TYPPAK-1   /GET SECOND CHAR IN WORD   
0335 7006   RTL   
0336 7006   RTL   /LEFT-JUSTIFY   
0337 7006   RTL   
0340 4351   JMS KTPA   
0341 2324   ISZ TYPPAK-1   /INCREMENT POINTER   
0342 5332   JMP TYPPAK+5   
0343 0245  245   /PER CENT   
0344 7750  215-245   /CR - PER CENT   
0345 7776  243-245   /POUND - PER CENT   
0346 7747  212-243   /LF - POUND   
0347 7535  -243   /-POUND   
0350 7700  7700   
0351 0000   KTPA, 00   /SUBR, PRINT 6-BIT ASCII LEFT   
0352 0350   AND KTPA-1   /CLEAR RIGHT 6 BITS   
0353 7450   SNA   

10
0354 5725 JMP I TYPPAK /RETURN IF 00 CHAR (NO AT SIGN)
0355 7101 CLL IAC /AC BIT 11 WILL GO TO CHANNEL 8
0356 7500 SMA /LINK WILL GO TO CH 7 (= COMPLEMENT OF
0357 7120 STL / CH 6)
0360 7012 RTR /AC 0-5 GO TO CHS 6-1
0361 7012 RTR /AC HOLDS 8-BIT ASCII
0362 7012 RTR
0363 1347 TAD KTPA-2
0364 7450 SNA /CHANGE POUND SIGN TO LINE FEED
0365 1346 TAD KTPA-3
0366 1345 TAD KTPA-4
0367 7450 SNA /CHANGE PER CENT TO CARRIAGE RETURN
0370 1344 TAD KTPA-5
0371 1343 TAD KTPA-6
0372 4242 JMS KTWRTEn /WRITE CHARACTER
0373 5751 JMP I KTPA /END, TTY PKG

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