# SECTION 1

# TI-99/8 KEYBOARD SCAN ROUTINE

## 1.1 Introduction

The TI-99/8 has a 54-key typewriter style keyboard. In order to support this new device and maintain compatibility with existing software, a rather complex keyboard scan routine was written. The following sections explain the various aspects of this routine.

## 1.2 State of the Keyboard

The TI-99/8 keyboard has three possible states. They are:

1. TI-99/4 Emulator keyboard
2. Pascal keyboard
3. BASIC keyboard

Also, to maintain compatibility with existing software, the scan routine supports a split keyboard configuration.

The console software maintains an internal flag which determines the state of the keyboard. This flag can be controlled by any application by means of the keyboard number parameter in the GPL status block. The keyboard number parameter is in CPU RAM location >8374. The value 0 is used to scan the keyboard in whatever state it happens to be. The values 3, 4, and 5 are used to change keyboard states. The following paragraphs describe each state of the keyboard and the use of the keyboard number parameter to select that state.

### 1.2.1 TI-99/4 Emulator Keyboard.

The TI-99/8 powers up with the keyboard in this state. The keyboard number is set to zero. If an application needs to return to this state from some other state, the keyboard is scanned with keyboard number set to 3. Scanning keyboard number

three sets the internal state flag to "99/4 Emulator", resets the keyboard number parameter to zero, and performs a keyboard scan in that state. Thereafter, the keyboard may be scanned with keyboard number set to 0.

In this state only 99/4 keyboard values are returned. There are three exceptions: [, \, and ]. These characters were built into the 99/4 console but were not implemented on the keyboard. All other key codes are ignored and a no key condition is returned. For example, "CONTROL 1", which returns the value >81, is not a legal 99/4 key. Therefore, the scan would return "No Key" for "CONTROL 1". Another result is that in this state the keyboard is "alpha-locked" regardless of the state of the ALPHA LOCK key.

### 1.2.2 Pascal Keyboard.

The keyboard is placed in this state by scanning with keyboard number set to 4. The internal state flag is set to "Pascal", the keyboard number is reset to 0, and the keyboard is scanned in this state. Thereafter, the keyboard may be scanned with keyboard number set to 0.

This is the state used by the UCSD P-System (Registered trademark of the Regents of the University of California). The complete ASCII range from 0 to >7F is returned. This includes standard control codes and the complete ASCII printable character set. In addition, codes from >81 through >8C, >8E and >8F, and >B0 through >C6 are returned for use as special function keys as follows:

>81 - AID
>82 - CLEAR
>83 - DELETE
>84 - INSERT
>85 - QUIT
>86 - REDO
>87 - ERASE
>88 - LEFT ARROW
>89 - RIGHT ARROW
>8A - DOWN ARROW
>8B - UP ARROW
>8C - PROCEED
>8E - BEGIN
>8F - BACK
>B0 through >C6 - application definable

### 1.2.3 BASIC Keyboard.

This state is selected by scanning with keyboard number set to 5. The internal state flag is set to "BASIC", the keyboard number is reset to 0, and the keyboard is scanned in this state. Thereafter, the keyboard may be scanned with keyboard number set to 0.

This state is used by BASIC, Terminal Emulator II and text editors. The differences between the keyboards are as follows:

1. ASCII control codes have the most significant bit set, i.e. >00 through >1F on the Pascal keyboard become >80 through >9F on the BASIC keyboard.

2. The defined application special function keys do not have the most significant bit set, i.e. >81 through >8C, >8E and >8F on the Pascal keyboard become >01 through >0C, >0E and >0F on the BASIC keyboard.

## 1.3 Keyboard Levels

Within each of the keyboard states there are five levels controlled by the four modifier keys: CONTROL, FUNCTION, SHIFT, and ALPHA LOCK. The precedence of the modifier keys is the order listed. For example, if CONTROL and any other modifier are down simultaneously, CONTROL will take precedence. The following three tables show the key codes returned by each of the states of the keyboard on each of the levels. The ENTER and SPACE keys are not included because they return >0D and >20 respectively, regardless of the state or level of the keyboard. NK is used to indicate the "no key" condition. This consists of returning a >FF key code and a reset condition bit.

Table 1-1 TI-99/4 Emulator Keyboard - Keycodes

| KEY | UNMODIFIED | ALPHA LOCK | CONTROL | FUNCTION | SHIFT |
|---|---|---|---|---|---|
| 1 | >31 | | NK | >03 | >21 |
| 2 | >32 | | NK | >04 | >40 |
| 3 | >33 | A | NK | >07 | >23 |
| 4 | >34 | L | NK | >02 | >24 |
| 5 | >35 | P | NK | >0E | >25 |
| 6 | >36 | H | NK | >0C | >5E |
| 7 | >37 | A | NK | >01 | >26 |
| 8 | >38 | | NK | >06 | >2A |
| 9 | >39 | L | NK | >0F | >28 |
| 0 | >30 | O | NK | NK | >29 |
| = | >3D | C | NK | >05 | >2B |
| - | >2D | K | NK | NK | >5F |
| \ | >5C | | NK | NK | NK |
| Q | >51 | H | NK | NK | >51 |
| W | >57 | A | NK | NK | >57 |
| E | >45 | S | NK | >0B | >45 |
| R | >52 | N | NK | NK | >52 |
| T | >54 | O | NK | NK | >54 |
| Y | >59 | | NK | NK | >59 |
| U | >55 | E | NK | NK | >55 |
| I | >49 | F | NK | NK | >49 |
| O | >4F | F | NK | NK | >4F |
| P | >50 | E | NK | NK | >50 |
| [ | >5B | C | NK | NK | NK |
| ] | >5D | T | NK | NK | NK |
| ` | NK | I | NK | NK | NK |
| A | >41 | N | NK | NK | >41 |
| S | >53 | | NK | >08 | >53 |
| D | >44 | T | NK | >09 | >44 |
| F | >46 | H | NK | NK | >46 |
| G | >47 | I | NK | NK | >47 |
| H | >48 | S | NK | NK | >48 |
| J | >4A | S | NK | NK | >4A |
| K | >4B | T | NK | NK | >4B |
| L | >4C | A | NK | NK | >4C |
| ; | >3B | T | NK | NK | >3A |
| ' | >27 | E | NK | NK | >22 |
| ENTER | >0D | | >0D | >0D | >0D |
| Z | >5A | | NK | NK | >5A |
| X | >58 | | NK | >0A | >58 |
| C | >43 | | NK | NK | >43 |

| | | | | | | |
|---|---|---|---|---|---|---|
| V | >56 | | NK | NK | >56 | |
| B | >42 | | NK | NK | >42 | |
| N | >4E | | NK | NK | >4E | |
| M | >4D | | NK | NK | >4D | |
| , | >2C | | NK | NK | >3C | |
| . | >2E | | NK | NK | >3E | |
| / | >2F | | NK | NK | >3F | |
| SPACE | >20 | | >20 | >20 | >20 | |

Table 1-2 Pascal Keyboard - Keycodes

| KEY | UNMODIFIED | ALPHA LOCK | CONTROL | FUNCTION | SHIFT |
|---|---|---|---|---|---|
| 1 | >31 | >31 | >B1 | >83 | >21 |
| 2 | >32 | >32 | >B2 | >84 | >40 |
| 3 | >33 | >33 | >B3 | >87 | >23 |
| 4 | >34 | >34 | >B4 | >82 | >24 |
| 5 | >35 | >35 | >B5 | >8E | >25 |
| 6 | >36 | >36 | >B6 | >8C | >5E |
| 7 | >37 | >37 | >B7 | >81 | >26 |
| 8 | >38 | >38 | >1E | >86 | >2A |
| 9 | >39 | >39 | >1F | >8F | >28 |
| 0 | >30 | >30 | >B0 | >BC | >29 |
| = | >3D | >3D | >1D | >85 | >2B |
| - | >2D | >2D | NK | NK | >5F |
| \ | >5C | >5C | NK | NK | >7C |
| Q | >71 | >51 | >11 | >C5 | >51 |
| W | >77 | >57 | >17 | NK | >57 |
| E | >65 | >45 | >05 | >8B | >45 |
| R | >72 | >52 | >12 | NK | >52 |
| T | >74 | >54 | >14 | NK | >54 |
| Y | >79 | >59 | >19 | >C6 | >59 |
| U | >75 | >55 | >15 | NK | >55 |
| I | >69 | >49 | >09 | NK | >49 |
| O | >6F | >4F | >0F | NK | >4F |
| P | >70 | >50 | >10 | NK | >50 |
| [ | >5B | >5B | NK | NK | >7B |
| ] | >5D | >5D | NK | NK | >7D |
| ` | >60 | >60 | NK | NK | >7E |
| A | >61 | >41 | >01 | NK | >41 |
| S | >73 | >53 | >13 | >88 | >53 |
| D | >64 | >44 | >04 | >89 | >44 |
| F | >66 | >46 | >06 | NK | >46 |
| G | >67 | >47 | >07 | NK | >47 |
| H | >68 | >48 | >08 | >BF | >48 |
| J | >6A | >4A | >0A | >C0 | >4A |
| K | >6B | >4B | >0B | >C1 | >4B |
| L | >6C | >4C | >0C | >C2 | >4C |
| ; | >3B | >3B | >1C | >BD | >3A |
| ' | >27 | >27 | NK | NK | >22 |
| ENTER | >0D | >0D | >0D | >0D | >0D |
| Z | >7A | >5A | >1A | NK | >5A |
| X | >78 | >58 | >18 | >8A | >58 |
| C | >63 | >43 | >03 | NK | >43 |

| | | | | | | |
|---|---|---|---|---|---|---|
| V | >76 | >56 | >16 | >7F | >56 |
| B | >62 | >42 | >02 | >BE | >42 |
| N | >6E | >4E | >0E | >C4 | >4E |
| M | >6D | >4D | >0D | >C3 | >4D |
| , | >2C | >2C | >00 | >B8 | >3C |
| . | >2E | >2E | >1B | >B9 | >3E |
| / | >2F | >2F | >BB | >BA | >3F |
| SPACE | >20 | >20 | >20 | >20 | >20 |

Table 1-3 BASIC Keyboard - Keycodes

| KEY | UNMODIFIED | ALPHA LOCK | CONTROL | FUNCTION | SHIFT |
|---|---|---|---|---|---|
| 1 | >31 | >31 | >B1 | >03 | >21 |
| 2 | >32 | >32 | >B2 | >04 | >40 |
| 3 | >33 | >33 | >B3 | >07 | >23 |
| 4 | >34 | >34 | >B4 | >02 | >24 |
| 5 | >35 | >35 | >B5 | >0E | >25 |
| 6 | >36 | >36 | >B6 | >0C | >5E |
| 7 | >37 | >37 | >B7 | >01 | >26 |
| 8 | >38 | >38 | >9E | >06 | >2A |
| 9 | >39 | >39 | >9F | >0F | >28 |
| 0 | >30 | >30 | >B0 | >BC | >29 |
| = | >3D | >3D | >9D | >05 | >2B |
| - | >2D | >2D | NK | NK | >5F |
| \ | >5C | >5C | NK | NK | >7C |
| Q | >71 | >51 | >91 | >C5 | >51 |
| W | >77 | >57 | >97 | NK | >57 |
| E | >65 | >45 | >85 | >0B | >45 |
| R | >72 | >52 | >92 | NK | >52 |
| T | >74 | >54 | >94 | NK | >54 |
| Y | >79 | >59 | >99 | >C6 | >59 |
| U | >75 | >55 | >95 | NK | >55 |
| I | >69 | >49 | >89 | NK | >49 |
| O | >6F | >4F | >8F | NK | >4F |
| P | >70 | >50 | >90 | NK | >50 |
| [ | >5B | >5B | NK | NK | >7B |
| ] | >5D | >5D | NK | NK | >7D |
| ` | >60 | >60 | NK | NK | >7E |
| A | >61 | >41 | >81 | NK | >41 |
| S | >73 | >53 | >93 | >08 | >53 |
| D | >64 | >44 | >84 | >09 | >44 |
| F | >66 | >46 | >86 | NK | >46 |
| G | >67 | >47 | >87 | NK | >47 |
| H | >68 | >48 | >88 | >BF | >48 |
| J | >6A | >4A | >8A | >C0 | >4A |
| K | >6B | >4B | >8B | >C1 | >4B |
| L | >6C | >4C | >8C | >C2 | >4C |
| ; | >3B | >3B | >9C | >BD | >3A |
| ' | >27 | >27 | NK | NK | >22 |
| ENTER | >0D | >0D | >0D | >0D | >0D |
| Z | >7A | >5A | >9A | NK | >5A |
| X | >78 | >58 | >98 | >0A | >58 |
| C | >63 | >43 | >83 | NK | >43 |

| | | | | | | |
|---|---|---|---|---|---|---|
| V | >76 | >56 | >96 | >7F | >56 |
| B | >62 | >42 | >82 | >BE | >42 |
| N | >6E | >4E | >8E | >C4 | >4E |
| M | >6D | >4D | >8D | >C3 | >4D |
| , | >2C | >2C | >80 | >B8 | >3C |
| . | >2E | >2E | >9B | >B9 | >3E |
| / | >2F | >2F | >8B | >BA | >3F |
| SPACE | >20 | >20 | >20 | >20 | >20 |

## 1.4 Returned Information and Debounce

The 99/8 keyboard scan returns three bytes of information. The first of these is modification of the keyboard number parameter (CPU RAM >8374). When keyboard numbers 3, 4, and 5 are scanned, the 99/8 resets the keyboard number to 0. This fact can be used by an application to determine whether it is running on a 99/4 or a 99/8. The second piece of information is the keycode of the current key. >FF is used to indicate "No Key Down". The keycode value is returned in CPU RAM >8375. The final bit of information is the key status which is returned in the GPL STATUS byte (CPU RAM >837C). If the key is a new key, bit 5 (GPL condition bit) is set. If the key is an old key, this bit is reset.

Debounce is done by key station, not by keycode value. As a result when a key is held down, changes in the level of the keyboard (with the exception of ALPHA LOCK) do not affect the keycode returned. Thus if "CONTROL 1" is held down, >B1 is repeatedly returned. If just the CONTROL key is released, the scan will still return >B1. If the FUNCTION key is now pressed, the scan will still return >B1. In other words >B1 will be returned until either the "1" key is released or a key with higher precedence is pressed.

The 99/8 keyboard routine stops scanning as soon as it finds a key. As a result the keyboard has a fixed hierarchy, and the key stations assume the following order of precedence:

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Z | Q | A | 1 | O | P | ; | / | B | T | G | 5 | 6 | Y | H | N | V |
| R | F | 4 | 7 | U | J | M | C | E | D | 3 | 8 | I | K | , | X | W |
| S | 2 | 9 | 0 | L | . | ENTER | | SPACE | | = | | | | | | |

Thus in the previous example where the "1" key is being held down, if the "Z", "Q", or "A" key is now pressed, they will take precedence over the "1" key, and the returned code will change.

In addition a time-delay debounce was added to the 99/8 keyboard routine. Each time a new key is found, the routine delays for 10 milliseconds. This delay is to avoid multiple entries from one keypush, an existing problem on the 99/4. Since keys bounce when released as well as when pressed, the routine also performs the delay when it finds a "No Key" condition immediately following a "Key Down" condition.

## 1.5 Split Keyboard and Joystick Scans

These two features are combined as on the 99/4. Executing the routine with keyboard number set to 1 scans joystick unit 1 and the left side split keyboard. If the keyboard number is set to 2, the routine scans joystick unit 2 and the right side split keyboard. Scanning the split keyboard does not affect the internal flag which determines the state of the console keyboard. In this respect the console keyboard and the split keyboard are separate devices. However, because the 99/4 did not treat them as separate devices and because of compatibility issues with existing software, they are not treated as separate devices with respect to debounce.

### 1.5.1 Returned Information.

Scanning a joystick/split-keyboard returns the following information:

>8375 - Returned keycode; the fire button on the joystick unit takes precedence over any key on the split keyboard

>8376 - Y joystick parameter;
4 = pushed forward, 0 = centered, -4 = pulled back

>8377 - X joystick parameter;
4 = pushed right, 0 = centered, -4 = pushed left

>837C - Status of returned keycode

### 1.5.2 Split Keyboard 1.

The following table shows the key station assignments for split keyboard 1 and the corresponding return values.

Table 1-4 Split Keyboard 1 - Keycodes

| KEY | KEYCODE | KEY | KEYCODE | KEY | KEYCODE | KEY | KEYCODE |
|---|---|---|---|---|---|---|---|
| 1 | >13 | Q | >12 | A | >01 | Z | >0F |
| 2 | >07 | W | >04 | S | >02 | X | >00 |
| 3 | >08 | E | >05 | D | >03 | C | >0E |
| 4 | >09 | R | >06 | F | >0C | V | >0D |
| 5 | >0A | T | >0B | G | >11 | B | >10 |

All other keys return a "No Key" condition.

The fire button on joystick unit one is logically identical to the "Q" key with one exception, the fire button takes precedence over all the other keys, the "Q" key does not.

### 1.5.3 Split Keyboard 2.

The following table shows the key station assignments for split keyboard 2 and the corresponding return values.

Table 1-5 Split Keyboard 2 - Keycodes

| KEY | KEYCODE | KEY | KEYCODE | KEY | KEYCODE | KEY | KEYCODE |
|---|---|---|---|---|---|---|---|
| 6 | >13 | Y | >12 | H | >01 | N | >0F |
| 7 | >07 | U | >04 | J | >02 | M | >00 |
| 8 | >08 | I | >05 | K | >03 | , | >0E |
| 9 | >09 | O | >06 | L | >0C | . | >0D |
| 0 | >0A | P | >0B | ; | >11 | / | >10 |

All other keys return a "No Key" condition.

The fire button on joystick unit two is logically identical to the "Y" key with one exception, the fire button takes precedence over all the other keys, the "Y" key does not.

## 1.6 Assembly Language Interface

The 99/8 keyboard routine may be used from 9900 assembly language. Entry is accomplished by a BL @>0E instruction. The following inputs are required:

1. The proper keyboard number in CPU RAM >8374.
2. CPU RAM >83D4 must contain the current value of VDP register 1.
3. The GPL workspace (>83E0) must be used when a BL @>0E instruction is executed.
4. All interrupts must be disabled before a BL @>0E instruction. (LWPI 0)
5. CPU RAM >8373 must contain a one-byte pointer into CPU RAM, i.e. the least significant byte of a CPU RAM address. This pointer is the GPL subroutine stack pointer. The scan routine pushes the current GROM address (2 bytes) on this stack, then pops it off after the scan. The stack is a pre-incrementing one.
6. CPU RAM >83C6 through >83CA must contain the information stored there by the previous keyboard scan. This is keyboard state and debounce information and must be maintained.
7. CPU RAM >8314 must contain a copy of VDP RAM Register 1. It is used to turn on the screen when a key is pressed.

Execution of the scan routine modifies the following CPU RAM locations:

1. The word located two bytes higher than the address indicated by the pointer in CPU RAM >8373
2. >8374 - Keyboard number; reset from 3, 4, or 5 to 0
3. >8375 - Returned keycode
4. >8376 - Y joystick parameter; modified when keyboard number 1 or 2 is scanned
5. >8377 - X joystick parameter; modified when keyboard number 1 or 2 is scanned
6. >837C - Key status; cleared for old keys; >20 for new

keys

7. >83C6 through >83CA - Debounce and internal flags; these values must be maintained between scans for the routine to function properly

8. >83D6 and >83D7 - Screen timeout; cleared after each new key

9. >83D8 and >83D9 - Save return address during scan routine

10. R0 through R7, R11, and R12 of the GPL workspace