
Section 5. Keyboard

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Description

The IBM PS/1 computer keyboard has 101 keys for the U.S. and Canada (English) models. For other countries' models, it has 102 keys.

At system power-on, the keyboard monitors the signals on the "clock" and "data" lines and establishes its line protocol. A bidirectional serial interface in the keyboard converts the clock and data signals and sends this information to and from the keyboard through the keyboard cable.

Keyboard Charts

The 101-/102-key keyboard is shown in the following charts:

- Belgium (Dutch)
- Canada (French)
- Denmark
- Finland and Sweden
- France and Belgium (French)
- Germany
- Italy
- Netherlands
- Norway
- Portugal
- Spain
- Switzerland (French)
- Switzerland (German)
- U.K.
- U.S. and Canada (English).

The charts are shown in alphabetical order on the following pages. On the actual keyboard, nomenclature is on the top and the front of the keybuttons. In this manual, nomenclature for the front of the key is shown on the top of the key, in the lower right corner.

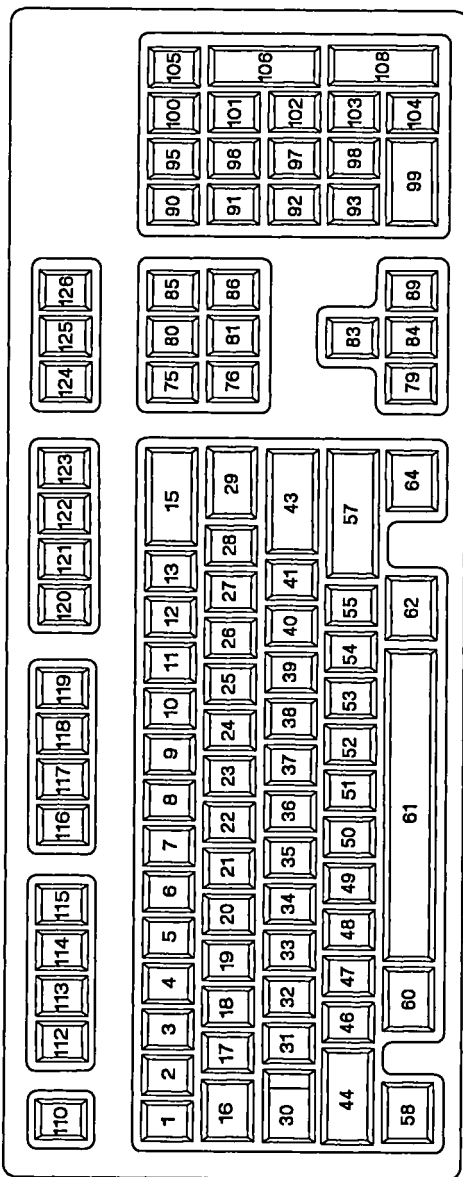


Figure 5-1. Key Numbering for the 101-Key Keyboard

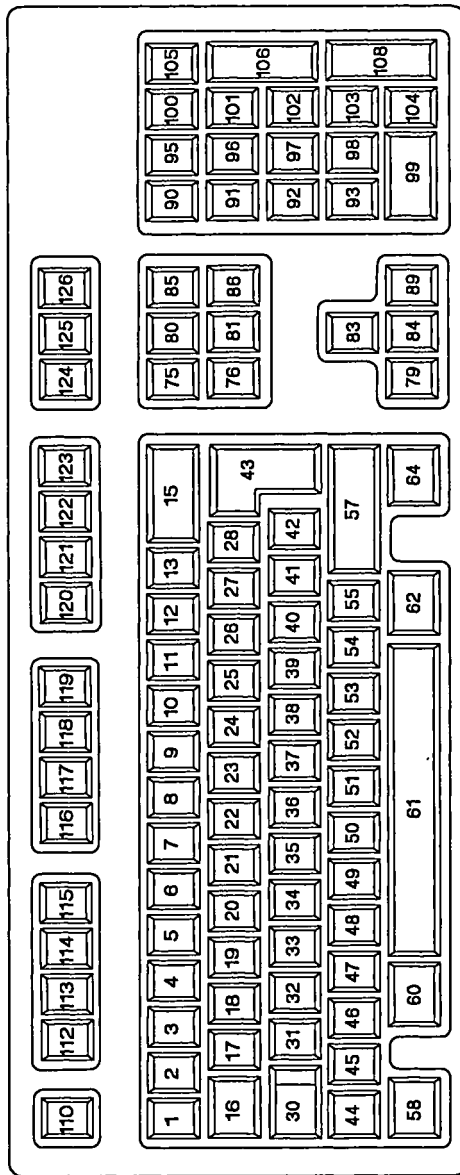
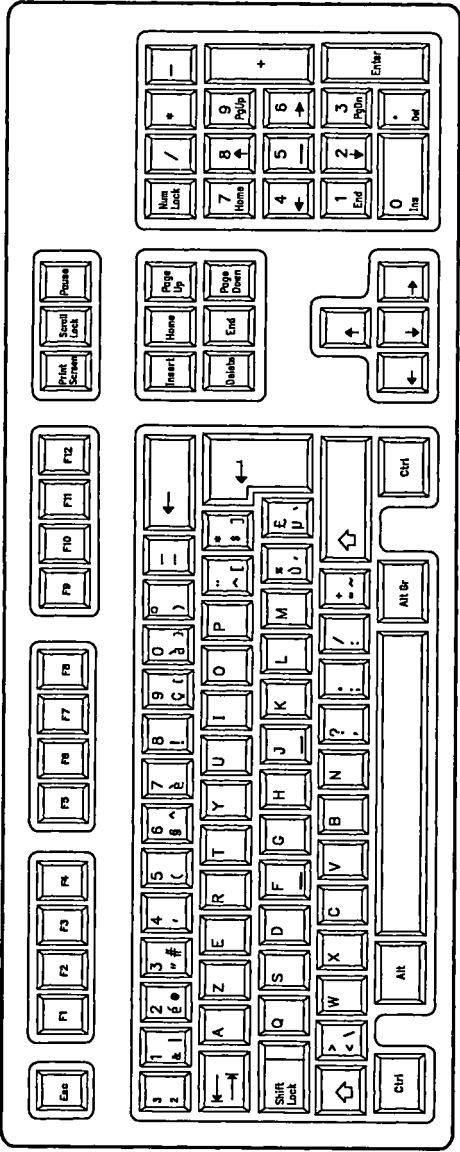
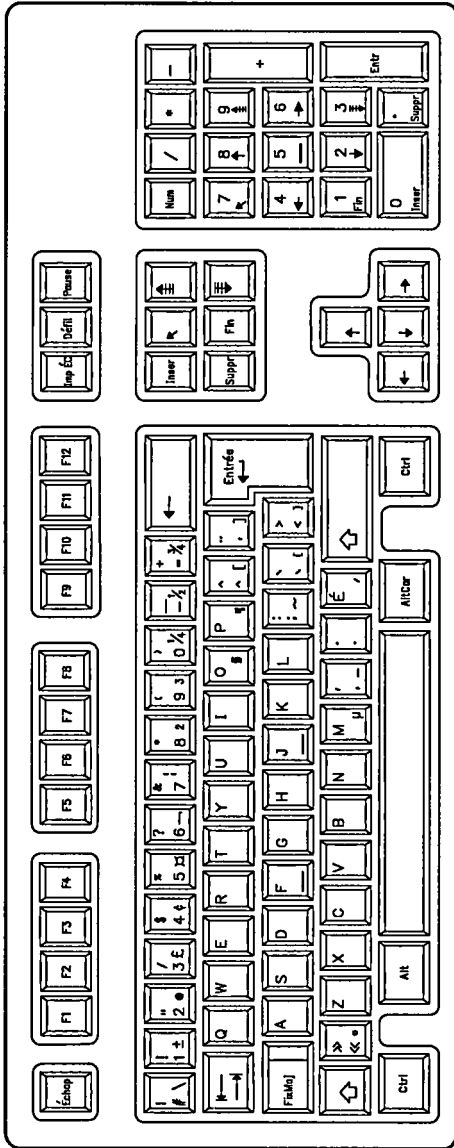


Figure 5-2. Key Numbering for the 102-Key Keyboard

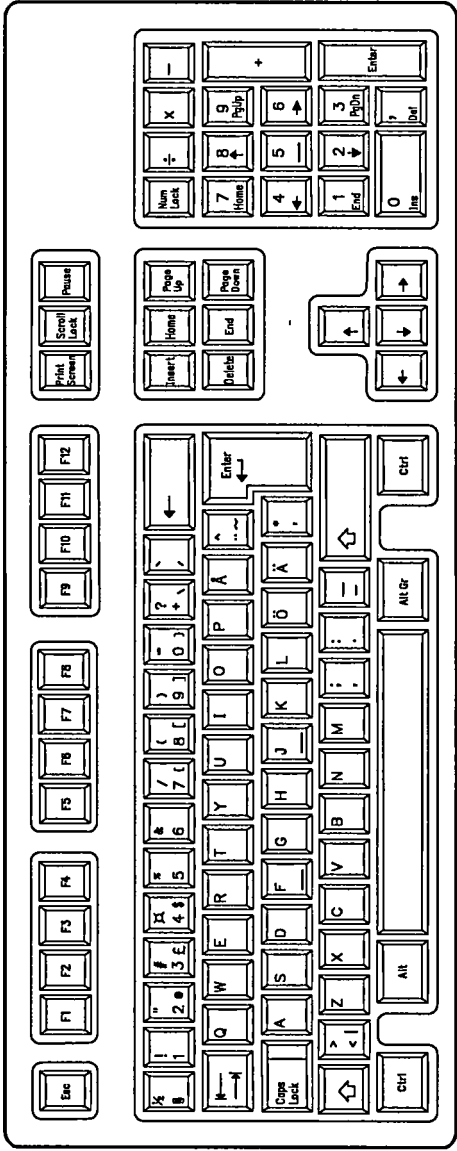
Belgium (Dutch) Keyboard



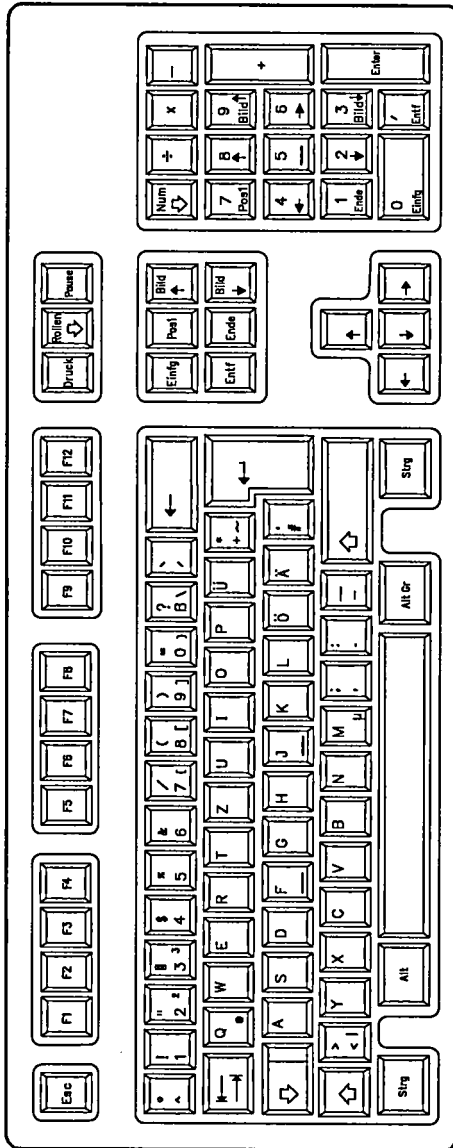
Canada (French) Keyboard



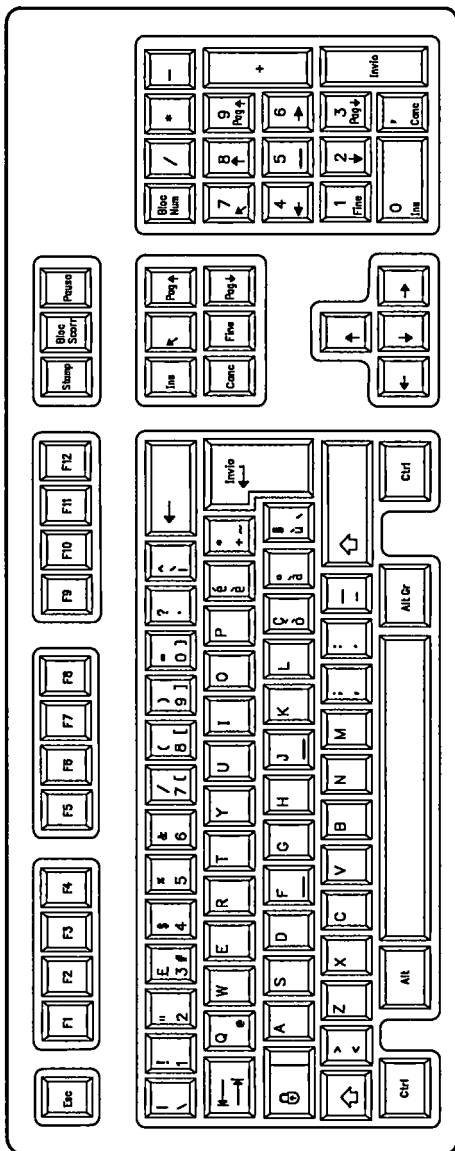
Finland and Sweden Keyboard



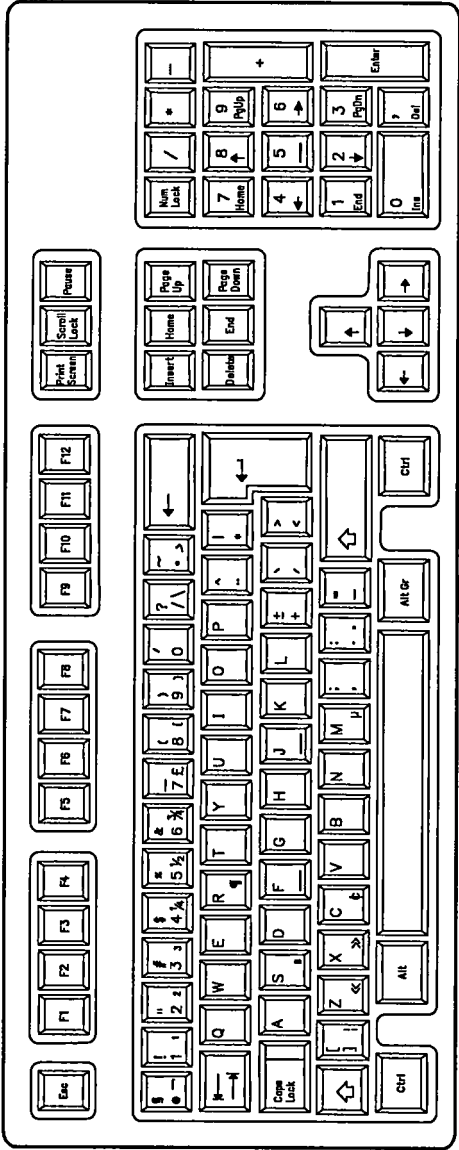
Germany Keyboard



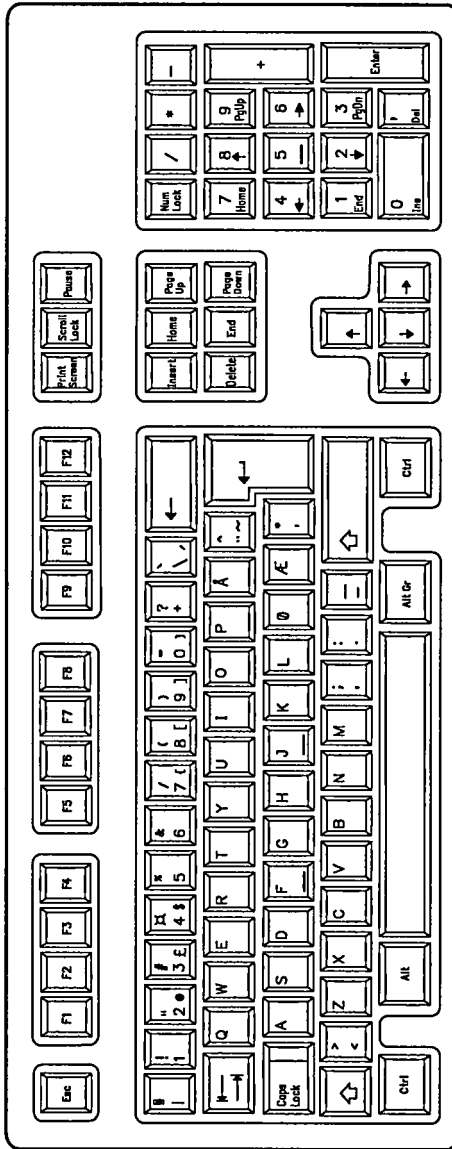
Italy Keyboard



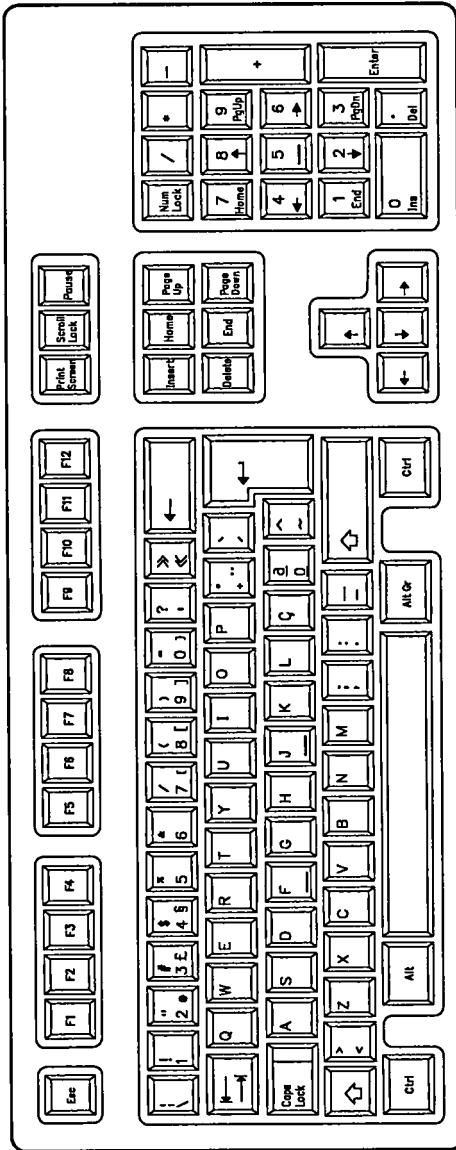
Netherlands Keyboard



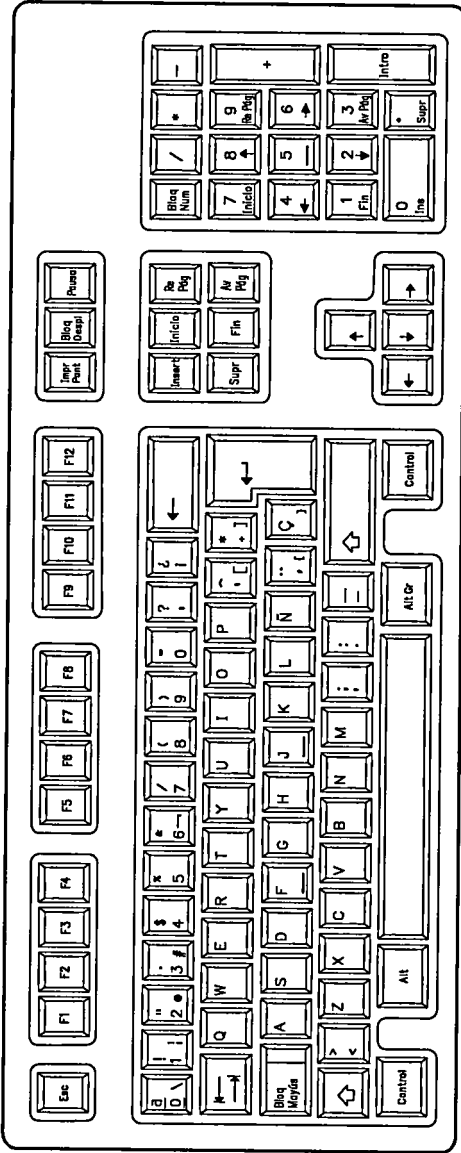
Norway Keyboard



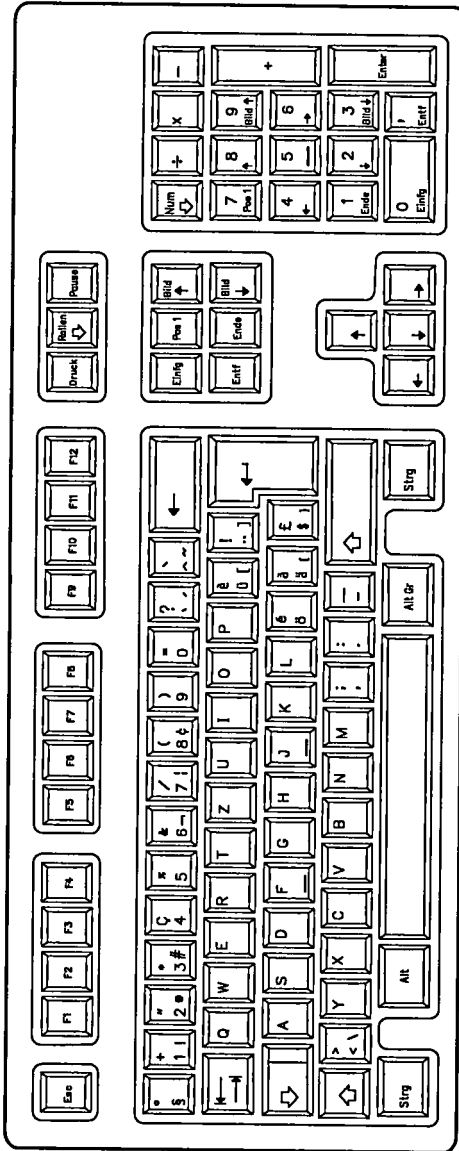
Portugal Keyboard



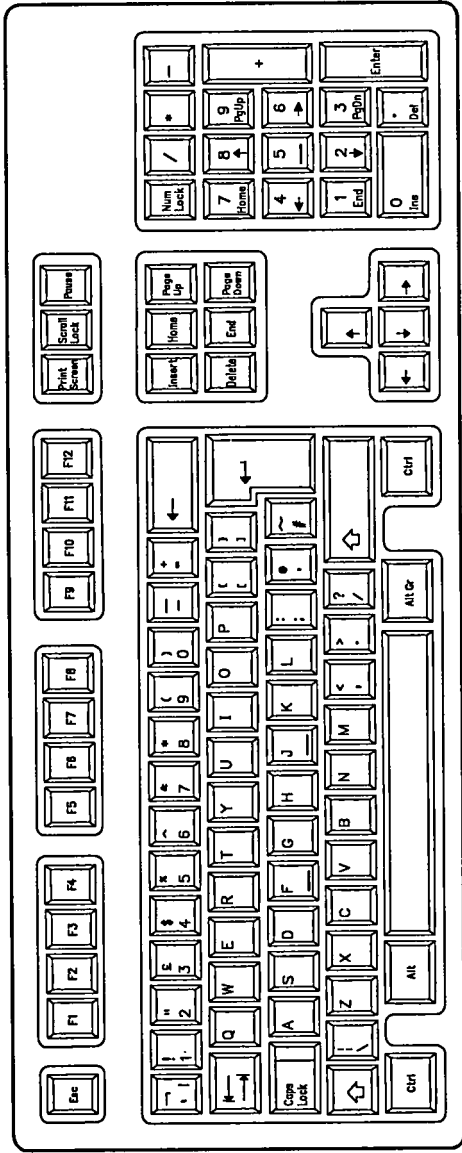
Spain Keyboard



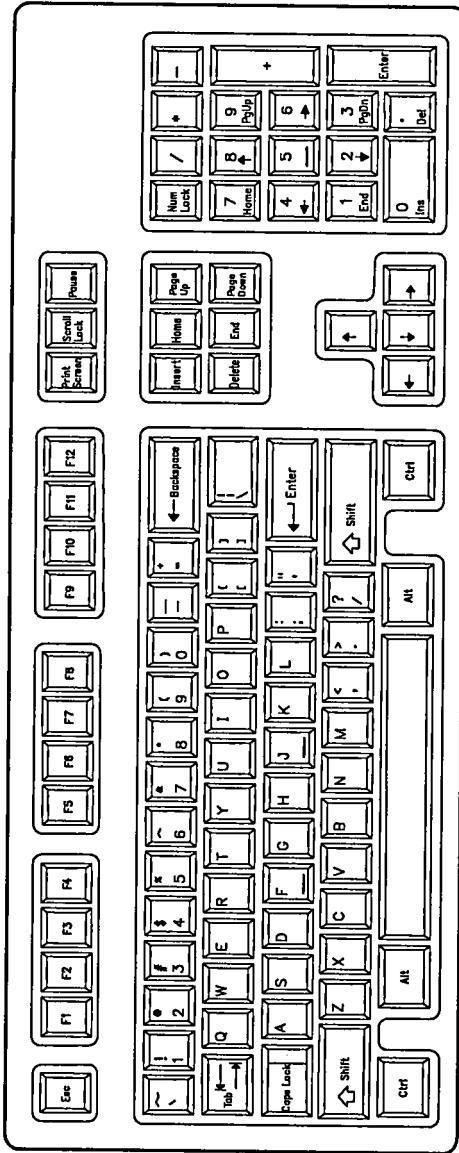
Switzerland (German) Keyboard



U.K. Keyboard



U.S. and Canada (English) Keyboard



Sequential Key-Code Scanning

The keyboard detects all keys pressed, and sends each scan code in the correct sequence. The keyboard stores the scan codes in its buffer until serviced by the system.

Buffer

A 17-byte first-in-first-out (FIFO) buffer in the keyboard stores the scan codes until the system is ready to receive them. A buffer-overflow condition occurs when more than 16 bytes are placed in the keyboard buffer. An overflow code replaces the 17th byte. If more keys are pressed before the system allows keyboard output, the additional data is lost.

When the keyboard is allowed to send data, the bytes in the buffer are sent as in normal operation, and new data entered is detected and sent. Response codes do not occupy a buffer position.

If keystrokes generate a multiple-byte sequence, the entire sequence must fit into the available buffer space or the keystroke is discarded and a buffer-overflow condition occurs.

Keys

With the exception of the Pause key, all keys are make/break. The make scan code of a key is sent to the keyboard controller when the key is pressed. The break scan code is sent when the key is released.

Additionally, except for the Pause key, all keys are typematic. When a key is pressed and held down, the keyboard sends the make code for that key, delays 500 milliseconds $\pm 20\%$, and begins sending make codes for that key at a rate of 10.9 characters per second $\pm 20\%$. The typematic rate and delay can be modified. (See "Set Typematic Rate/Delay (Hex F3)" on page 5-26.)

If two or more keys are held down, only the last key pressed repeats at the typematic rate. Typematic operation stops when the last key pressed is released, even if other keys are still held down. If a key is pressed and held down while keyboard transmission is inhibited, only the first make code is stored in the buffer. This prevents buffer overflow as a result of typematic action.

Note: Scan code set 3 allows key types to be changed by the system. (See "Set 3 Scan Code Tables" on page 5-36 for the default settings.)

Power-On Routine

The following activities take place when power is first applied to the keyboard.

Power-On Reset (POR)

A "power-on reset" (POR) signal occurs a minimum of 150 milliseconds and a maximum of 2.0 seconds from the time power is applied to the keyboard.

Basic Assurance Test (BAT)

The basic assurance test (BAT) consists of a keyboard processor test, a read-only memory (ROM) checksum, and a random-access memory (RAM) test. During the BAT, activity on the "clock" and "data" lines is ignored. The LEDs are turned on at the beginning and off at the end of the BAT. The BAT takes a minimum of 300 milliseconds and a maximum of 500 milliseconds. This is in addition to the time required for the POR.

Upon satisfactory completion of the BAT, the keyboard sends the BAT completion code (hex AA) and keyboard scanning begins. If a BAT failure occurs, the keyboard sends the BAT failure code (hex FC) and the keyboard is disabled pending command input. Completion codes are sent between 450 milliseconds and 2.5 seconds after POR, and between 300 and 500 milliseconds after a Reset command is acknowledged.

Immediately following POR, the keyboard monitors the signals on the keyboard "clock" and "data" lines and sets the line protocol.

Commands from the System

Figure 5-3 shows the commands that the system may send and their hexadecimal values.

Figure 5-3. Keyboard Commands from the System

Command	Hex Value
Set/Reset Status Indicators	ED
Echo	EE
Invalid Command	EF
Select Alternate Scan Codes	F0
Invalid Command	F1
Read ID	F2
Set Typematic Rate/Delay	F3
Enable	F4
Default Disable	F5
Set Default	F6
Set All Keys - Typematic	F7
- Make/Break	F8
- Make	F9
- Typematic Make/Break	FA
Set Key Type - Typematic	FB
- Make/Break	FC
- Make	FD
Resend	FE
Reset	FF

These commands can be sent to the keyboard at any time. The keyboard responds within 20 milliseconds, except when performing the BAT or executing a Reset command.

The following commands are in alphabetical order. They have different meanings when issued by the keyboard. (See "Commands to the System" on page 5-28.)

Default Disable (Hex F5): The Default Disable command resets all conditions to the power-on default state. The keyboard responds with Acknowledge, clears its output buffer, sets the default key types (scan code set 3 operation only) and typematic rate/delay, and clears the last typematic key. The keyboard stops scanning, and waits for the next command.

Echo (Hex EE): The Echo command is a diagnostic aid. When the keyboard receives this command, it responds with Echo and if the keyboard was previously enabled continues scanning.

Enable (Hex F4): When the Enable command is sent, the keyboard responds with Acknowledge, clears its output buffer, clears the last typematic key, and starts scanning.

Invalid Command (Hex EF and F1): Hex EF and hex F1 are invalid commands and are not supported. If one of these is sent, the keyboard responds with a Resend and continues in its prior scanning state. No other activities occur.

Read ID (Hex F2): The Read ID command requests identification information from the keyboard. The keyboard responds with Acknowledge, discontinues scanning, and sends the two keyboard ID bytes. The second byte must follow completion of the first by no more than 500 microseconds. After sending the second ID byte, the keyboard continues scanning.

Resend (Hex FE): The Resend command is sent when the system detects an error in any transmission from the keyboard. It is sent only after a keyboard transmission and before the system allows the next keyboard output. The keyboard responds with the previous output again (unless the previous output was Resend, in which case the keyboard sends the last byte before the Resend command).

Reset (Hex FF): The Reset command starts a program reset and a keyboard internal self-test. The keyboard responds with Acknowledge and ensures that the system accepts the Acknowledge before executing the command. The system signals acceptance of Acknowledge by raising the "clock" and "data" lines for a minimum of 500 microseconds. The keyboard is disabled from the time it receives the Reset command until Acknowledge is accepted, or until another command is sent that overrides the previous command.

Following acceptance of Acknowledge, the keyboard is reinitialized and performs the BAT. After sending the BAT completion code, the keyboard defaults to scan code set 2.

Select Alternate Scan Codes (Hex F0): The Select Alternate Scan Codes command instructs the keyboard to select one of three sets of scan codes. The keyboard responds with Acknowledge and clears both the output buffer and the typematic key (if one is active). The system then sends the option byte and the keyboard responds with another Acknowledge. An option byte value of hex 01 selects scan code set 1, hex 02 selects set 2, and hex 03 selects set 3.

An option byte value of hex 00 causes the keyboard to respond with Acknowledge and send a byte telling the system which scan code set is currently in use.

After establishing the new scan code set, the keyboard returns to the scanning state it was in before receiving the Select Alternate Scan Codes command.

Set All Keys (Hex F7, F8, F9, FA)

The Set All Keys commands instruct the keyboard to set all the keys to the type listed in Figure 5-4.

Hex Value	Command
F7	Set All Keys - Typematic
F8	Set All Keys - Make/Break
F9	Set All Keys - Make
FA	Set All Keys - Typematic Make/Break

The keyboard responds with Acknowledge, clears its output buffer, sets all keys to the type indicated by the command, and continues scanning (if it was previously enabled). Although these commands can be sent using any scan code set, they affect only the operation of scan code set 3.

Set Default (Hex F6): The Set Default command resets all conditions to the power-on default state. The keyboard responds with Acknowledge, clears its output buffer, sets the default key types (scan code set 3 operation only) and typematic rate/delay, clears the last typematic key, and continues scanning (if it was previously enabled).

Set Key Type (Hex FB, FC, FD): The Set Key Type commands instruct the keyboard to set all the keys to the type listed in Figure 5-5.

Hex Value	Command
FB	Set Key Type - Typematic
FC	Set Key Type - Make/Break
FD	Set Key Type - Make

The keyboard responds with Acknowledge, clears its output buffer, and prepares to receive key identification. Key identification is accomplished by the system identifying each key by its scan code value as defined in scan code set 3. Only scan code set 3 values are

valid for key identification. The type of each identified key is set to the value indicated by the command.

These commands can be sent using any scan code set, but affect only the operation of scan code set 3.

Set/Reset Status Indicators (Hex ED): Three status indicators on the PC Enhanced keyboard— Caps Lock, Num Lock, and Scroll Lock— are accessible by the system. The keyboard activates or deactivates these indicators when it receives a valid command-code sequence from the system. The command sequence begins with the Set/Reset Status command. The keyboard responds Acknowledge, discontinues scanning, and waits for the option byte from the system. The bit assignments for this option byte are as listed in Figure 5-6.

Bit	Function
7 - 3	Reserved (must be 0s)
2	Caps Lock Indicator
1	Num Lock Indicator
0	Scroll Lock Indicator

If the bit for an indicator is set to 1, the indicator is turned on. If the bit is set to 0, the indicator is turned off.

The keyboard responds to the option byte with Acknowledge, sets the indicators and, if the keyboard was previously enabled, continues scanning. The state of the indicators will reflect the bits in the option byte and can be activated or deactivated in any combination. If another command is received in place of the option byte, execution of the Set/Reset Mode Indicators command is stopped, with no change to the indicator states, and the new command is processed.

Immediately after power-on, the lights default to the off state. If the Set Default and Default Disable commands are received, the lights remain in the state they were in before the command was received.

Set Typematic Rate/Delay (Hex F3): The Set Typematic Rate/Delay command changes the typematic rate and delay. The keyboard responds Acknowledge, stops scanning, and waits for the system to issue the rate/delay value byte. The keyboard responds to the rate/delay value byte with another Acknowledge, sets the rate and delay to the values indicated, and continues scanning (if it was previously enabled). Bit 7 is always 0. Bits 6 and 5 set the delay. The delay is equal to 1 plus the binary value of bits 6 and 5, multiplied by 250 milliseconds $\pm 20\%$. Bits 4, 3, 2, 1, and 0 set the rate.

The period (interval from one typematic output to the next) is determined by the following equation:

$$\text{Period} = (8 + A) \times (2^B) \times 0.00417 \text{ seconds.}$$

where:

A = binary value of bits 2, 1, and 0.

B = binary value of bits 4 and 3.

The typematic rate (make codes per second) is the inverse of the period.

Figure 5-7. Typematic Rate

Bit	Typematic Rate $\pm 20\%$	Bit	Typematic Rate $\pm 20\%$
00000	30.0	10000	7.5
00001	26.7	10001	6.7
00010	24.0	10010	6.0
00011	21.8	10011	5.5
00100	20.0	10100	5.0
00101	18.5	10101	4.6
00110	17.1	10110	4.3
00111	16.0	10111	4.0
01000	15.0	11000	3.7
01001	13.3	11001	3.3
01010	12.0	11010	3.0
01011	10.9	11011	2.7
01100	10.0	11100	2.5
01101	9.2	11101	2.3
01110	8.6	11110	2.1
01111	8.0	11111	2.0

The default values for the system keyboard are as follows:

Typematic rate = 10.9 characters per second $\pm 20\%$.

Delay = 500 milliseconds $\pm 20\%$.

The execution of this command stops without change to the existing rate if another command is received instead of the rate/delay value byte.

Commands to the System

Figure 5-8 shows the commands that the keyboard may send to the system and their hexadecimal values.

Figure 5-8. Keyboard Commands to the System

Command	Hex Value
Key Detection Error/Overrun	00 (Code Sets 2 and 3)
Keyboard ID (Enhanced)	83AB
BAT Completion Code	AA
BAT Failure Code	FC
Echo	EE
Acknowledge (ACK)	FA
Resend	FE
Key Detection Error/Overrun	FF (Code Set 1)

The commands the keyboard sends to the system are described below, in alphabetical order. They have different meanings when issued by the system. (See "Commands from the System" on page 5-23.)

Acknowledge (Hex FA): The keyboard sends Acknowledge to any valid input other than an Echo or Resend command. If the keyboard is interrupted while sending Acknowledge, it discards Acknowledge and accepts and responds to the new command.

BAT Completion Code (Hex AA): The keyboard sends the BAT completion code following satisfactory completion of BAT. Any other code indicates a failure of the keyboard.

BAT Failure Code (Hex FC): The keyboard sends the BAT failure code if a BAT failure occurs. The keyboard then discontinues scanning and waits for a system response or reset.

Echo (Hex EE): The keyboard sends Echo in response to an Echo command.

Keyboard ID: The Keyboard ID consists of two bytes, hex 83AB (PC Enhanced keyboard). The keyboard responds to the read ID with Acknowledge, discontinues scanning, and sends the two ID bytes. The least-significant byte is sent first, followed by the most-significant byte. Following the output of the keyboard ID, the keyboard begins scanning.

Key Detection Error (Hex 00 or FF): The keyboard sends the key detection error if conditions in the keyboard make it impossible to identify a switch closure. If the keyboard is using scan code set 1, the code is hex FF. For sets 2 and 3, the code is hex 00.

Overrun (Hex 00 or FF): An overrun character is placed in the keyboard buffer and replaces the last code when the buffer capacity has been exceeded. The code is sent to the system when it reaches the top of the buffer. If the keyboard is using scan code set 1, the code is hex FF. For sets 2 and 3, the code is hex 00.

Resend (Hex FE): The keyboard issues a Resend command following receipt of an invalid input or any input with incorrect parity. If the system sends nothing to the keyboard, no response is required.

Scan Codes

The following tables list the key numbers of the three scan code sets and their hexadecimal values. The system defaults to scan code set 2, but can be switched to set 1 or set 3. (See "Select Alternate Scan Codes (Hex F0)" on page 5-24.)

Set 1 Scan Code Tables

In scan code set 1, each key is assigned a base scan code and, in some cases, extra codes to generate artificial shift states in the system. The typematic scan codes are identical to the base scan code for each key.

Figure 5-9 on page 5-30 shows the keys and the scan codes they send, regardless of any shift states in the keyboard or the system. Refer to "Keyboard Charts" on page 5-3 to determine the character associated with each key number.

Figure 5-9. Keyboard Scan Codes, Set 1 (Part 1 of 5)

Key Number	Make Code	Break Code	Key Number	Make Code	Break Code
1	29	A9	47	2D	AD
2	02	82	48	2E	AE
3	03	83	49	2F	AF
4	04	84	50	30	B0
5	05	85	51	31	B1
6	06	86	52	32	B2
7	07	87	53	33	B3
8	08	88	54	34	B4
9	09	89	55	35	B5
10	0A	8A	57	36	B6
11	0B	8B	58	1D	9D
12	0C	8C	60	38	B8
13	0D	8D	61	39	B9
15	0E	8E	62	E0 38	E0 B8
16	0F	8F	64	E0 1D	E0 9D
17	10	90	90	45	C5
18	11	91	91	47	C7
19	12	92	92	4B	CB
20	13	93	93	4F	CF
21	14	94	96	48	C8
22	15	95	97	4C	CC
23	16	96	98	50	D0
24	17	97	99	52	D2
25	18	98	100	37	B7
26	19	99	101	49	C9
27	1A	9A	102	4D	CD
28	1B	9B	103	51	D1
29**	2B	AB	104	53	D3
30	3A	BA	105	4A	CA
31	1E	9E	106	4E	CE
32	1F	9F	108	E0 1C	E0 9C
33	20	A0	110	01	81
34	21	A1	112	3B	BB
35	22	A2	113	3C	BC
36	23	A3	114	3D	BD
37	24	A4	115	3E	BE
38	25	A5	116	3F	BF
39	26	A6	117	40	C0
40	27	A7	118	41	C1
41	28	A8	119	42	C2
42***	2B	AB	120	43	C3
43	1C	9C	121	44	C4
44	2A	AA	122	57	D7
45***	56	D6	123	58	D8
46	2C	AC	125	46	C6

** Key 29 on U.S. keyboard only.

*** Keys 42 and 45 on all but U.S. keyboards.

The remaining keys send a series of codes dependent on the state of the shift keys (Ctrl, Alt, and Shift), and the state of Num Lock (On or Off). Because the base scan code is identical to that of another key, an extra code (hex E0) has been added to the base code to make it unique.

The following charts show the make/break code using the left Shift key. If the right Shift key is used, substitute its make/break code for that of the left Shift key.

Figure 5-10. Keyboard Scan Codes, Set 1 (Part 2 of 5)

Key No.	Base Case, or Shift + Num Lock Make/Break	Shift Case Make/Break	Num Lock on Make/Break
75	E0 52 /E0 D2	E0 AA E0 52 /E0 D2 E0 2A	E0 2A E0 52 /E0 D2 E0 AA
76	E0 53 /E0 D3	E0 AA E0 53 /E0 D3 E0 2A	E0 2A E0 53 /E0 D3 E0 AA
79	E0 4B /E0 CB	E0 AA E0 4B /E0 CB E0 2A	E0 2A E0 4B /E0 CB E0 AA
80	E0 47 /E0 C7	E0 AA E0 47 /E0 C7 E0 2A	E0 2A E0 47 /E0 C7 E0 AA
81	E0 4F /E0 CF	E0 AA E0 4F /E0 CF E0 2A	E0 2A E0 4F /E0 CF E0 AA
83	E0 48 /E0 C8	E0 AA E0 48 /E0 C8 E0 2A	E0 2A E0 48 /E0 C8 E0 AA
84	E0 50 /E0 D0	E0 AA E0 50 /E0 D0 E0 2A	E0 2A E0 50 /E0 D0 E0 AA
85	E0 49 /E0 C9	E0 AA E0 49 /E0 C9 E0 2A	E0 2A E0 49 /E0 C9 E0 AA
86	E0 51 /E0 D1	E0 AA E0 51 /E0 D1 E0 2A	E0 2A E0 51 /E0 D1 E0 AA
89	E0 4D /E0 CD	E0 AA E0 4D /E0 CD E0 2A	E0 2A E0 4D /E0 CD E0 AA

Figure 5-11. Keyboard Scan Codes, Set 1 (Part 3 of 5)

Key No.	Scan Code Make/Break	Shift Case Make/Break
95	E0 35/E0 B5	E0 AA E0 35/E0 B5 E0 2A

Figure 5-12. Keyboard Scan Codes, Set 1 (Part 4 of 5)

Key No.	Scan Code Make/Break	Ctrl Case, Shift Case Make/Break	All Case Make/Break
124	E0 2A E0 37 /E0 B7 E0 AA	E0 37/E0 B7	54/D4

Figure 5-13. Keyboard Scan Codes, Set 1 (Part 5 of 5)

Key No.	Make Code	Ctrl Key Pressed
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126 *	E1 1D 45 E1 9D C5	E0 46 E0 C6
-------	-------------------	-------------

* This key is not typematic. All associated scan codes occur on the make of the key.

Set 2 Scan Code Tables

In scan code set 2, each key is assigned a unique 8-bit make scan code, which is sent when the key is pressed. Each key also sends a break code when the key is released. The break code consists of 2 bytes, the first of which is the break code prefix (hex F0). The second byte is the same as the make scan code for that key. The typematic scan code for a key is the same as the make code.

The following charts show the keys and the scan codes the keys send, regardless of any shift states in the keyboard or the system. Refer to "Keyboard Charts" on page 5-3 to determine the character associated with each key number.

Figure 5-14. Keyboard Scan Codes, Set 2 (Part 1 of 5)

Key Number	Make Code	Break Code	Key Number	Make Code	Break Code
1	0E	F0 0E	47	22	F0 22
2	16	F0 16	48	21	F0 21
3	1E	F0 1E	49	2A	F0 2A
4	26	F0 26	50	32	F0 32
5	25	F0 25	51	31	F0 31
6	2E	F0 2E	52	3A	F0 3A
7	36	F0 36	53	41	F0 41
8	3D	F0 3D	54	49	F0 49
9	3E	F0 3E	55	4A	F0 4A
10	46	F0 46	57	59	F0 59
11	45	F0 45	58	14	F0 14
12	4E	F0 4E	60	11	F0 11
13	55	F0 55	61	29	F0 29
15	66	F0 66	62	E0 11	E0 F0 11
16	0D	F0 0D	64	E0 14	E0 F0 14
17	15	F0 15	90	77	F0 77
18	1D	F0 1D	91	6C	F0 6C
19	24	F0 24	92	6B	F0 6B
20	2D	F0 2D	93	69	F0 69
21	2C	F0 2C	96	75	F0 75
22	35	F0 35	97	73	F0 73
23	3C	F0 3C	98	72	F0 72
24	43	F0 43	99	70	F0 70
25	44	F0 44	100	7C	F0 7C
26	4D	F0 4D	101	7D	F0 7D
27	54	F0 54	102	74	F0 74
28	5B	F0 5B	103	7A	F0 7A
29 **	5D	F0 5D	104	71	F0 71
30	58	F0 58	105	7B	F0 7B
31	1C	F0 1C	106	79	F0 79
32	1B	F0 1B	108	E0 5A	E0 F0 5A
33	23	F0 23	110	76	F0 76
34	2B	F0 2B	112	05	F0 05
35	34	F0 34	113	06	F0 06
36	33	F0 33	114	04	F0 04
37	3B	F0 3B	115	0C	F0 0C
38	42	F0 42	116	03	F0 03
39	4B	F0 4B	117	0B	F0 0B
40	4C	F0 4C	118	83	F0 83
41	52	F0 52	119	0A	F0 0A
42 ***	5D	F0 5D	120	01	F0 01
43	5A	F0 5A	121	09	F0 09
44	12	F0 12	122	78	F0 78
45 ***	61	F0 61	123	07	F0 07
46	1A	F0 1A	125	7E	F0 7E

** Key 29 on U.S. keyboards only.

*** Keys 42 and 45 on all but U.S. keyboards.

The remaining keys send a series of codes dependent on the state of the shift keys (Ctrl, Alt, and Shift), and the state of Num Lock (On or Off). Because the base scan code is identical to that of another key, an extra code (hex E0) has been added to the base code to make it unique.

The following charts show the make/break code using the left Shift key. If the right Shift key is used, substitute its make/break code for that of the left Shift key.

Figure 5-15. Keyboard Scan Codes, Set 2 (Part 2 of 5)

Key No.	Base Case, or Shift + Num Lock Make/Break	Shift Case Make/Break	Num Lock on Make/Break
75	E0 70 /E0 F0 70	E0 F0 12 E0 70 /E0 F0 70 E0 12	E0 12 E0 70 /E0 F0 70 E0 F0 12
76	E0 71 /E0 F0 71	E0 F0 12 E0 71 /E0 F0 71 E0 12	E0 12 E0 71 /E0 F0 71 E0 F0 12
79	E0 6B /E0 F0 6B	E0 F0 12 E0 6B /E0 F0 6B E0 12	E0 12 E0 6B /E0 F0 6B E0 F0 12
80	E0 6C /E0 F0 6C	E0 F0 12 E0 6C /E0 F0 6C E0 12	E0 12 E0 6C /E0 F0 6C E0 F0 12
81	E0 69 /E0 F0 69	E0 F0 12 E0 69 /E0 F0 69 E0 12	E0 12 E0 69 /E0 F0 69 E0 F0 12
83	E0 75 /E0 F0 75	E0 F0 12 E0 75 /E0 F0 75 E0 12	E0 12 E0 75 /E0 F0 75 E0 F0 12
84	E0 72 /E0 F0 72	E0 F0 12 E0 72 /E0 F0 72 E0 12	E0 12 E0 72 /E0 F0 72 E0 F0 12
85	E0 7D /E0 F0 7D	E0 F0 12 E0 7D /E0 F0 7D E0 12	E0 12 E0 7D /E0 F0 7D E0 F0 12
86	E0 7A /E0 F0 7A	E0 F0 12 E0 7A /E0 F0 7A E0 12	E0 12 E0 7A /E0 F0 7A E0 F0 12
89	E0 74 /E0 F0 74	E0 F0 12 E0 74 /E0 F0 74 E0 12	E0 12 E0 74 /E0 F0 74 E0 F0 12

Figure 5-16. Keyboard Scan Codes, Set 2 (Part 3 of 5)

Key No.	Scan Code Make/Break	Shift Case Make/Break
95	E0 4A/E0 F0 4A	E0 F0 12 4A/E0 12 F0 4A

Figure 5-17. Keyboard Scan Codes, Set 2 (Part 4 of 5)

Key No.	Scan Code Make/Break	Ctrl Case, Shift Case Make/Break	Alt Case Make/Break
124	E0 12 E0 7C /E0 F0 7C E0 F0 12	E0 7C/E0 F0 7C	84/F0 84

Figure 5-18. Keyboard Scan Codes, Set 2 (Part 5 of 5)

Key No.	Make Code	Ctrl Key Pressed
----------------	------------------	-------------------------

126 *	E1 14 77 E1 F0 14 F0 77	E0 7E E0 F0 7E
-------	-------------------------	----------------

* This key is not typematic. All associated scan codes occur on the make of the key.

Set 3 Scan Code Tables

In scan code set 3, each key is assigned a unique 8-bit make scan code, which is sent when the key is pressed. Each key also sends a break code when the key is released. The break code consists of 2 bytes, the first of which is the break code prefix (hex F0). The second byte is the same as the make scan code for that key. The typematic scan code for a key is the same as the make code. With this scan code set, each key sends only one scan code, and no keys are affected by the state of any other keys.

The following charts show the keys and the scan codes they send, regardless of any shift states in the keyboard or the system. Refer to "Keyboard Charts" on page 5-3 to determine the character associated with each key number.

Figure 5-19 (Page 1 of 3). Keyboard Scan Codes, Set 3

Key Number	Make Code	Break Code	Default Key State
1	0E	F0 0E	Typematic
2	16	F0 16	Typematic
3	1E	F0 1E	Typematic
4	26	F0 26	Typematic
5	25	F0 25	Typematic
6	2E	F0 2E	Typematic
7	36	F0 36	Typematic
8	3D	F0 3D	Typematic
9	3E	F0 3E	Typematic
10	46	F0 46	Typematic
11	45	F0 45	Typematic
12	4E	F0 4E	Typematic
13	55	F0 55	Typematic
15	66	F0 66	Typematic
16	0D	F0 0D	Typematic
17	15	F0 15	Typematic
18	1D	F0 1D	Typematic
19	24	F0 24	Typematic
20	2D	F0 2D	Typematic
21	2C	F0 2C	Typematic
22	35	F0 35	Typematic
23	3C	F0 3C	Typematic
24	43	F0 43	Typematic
25	44	F0 44	Typematic
26	4D	F0 4D	Typematic
27	54	F0 54	Typematic
28	5B	F0 5B	Typematic
29 **	5C	F0 5C	Typematic
30	14	F0 14	Make/Break
31	1C	F0 1C	Typematic
32	1B	F0 1B	Typematic
33	23	F0 23	Typematic
34	2B	F0 2B	Typematic
35	34	F0 34	Typematic

Figure 5-19 (Page 2 of 3). Keyboard Scan Codes, Set 3

Key Number	Make Code	Break Code	Default Key State
36	33	F0 33	Typematic
37	3B	F0 3B	Typematic
38	42	F0 42	Typematic
39	4B	F0 4B	Typematic
40	4C	F0 4C	Typematic
41	52	F0 52	Typematic
42 ***	53	F0 53	Typematic
43	5A	F0 5A	Typematic
44	12	F0 12	Make/Break
45 ***	13	F0 13	Typematic
46	1A	F0 1A	Typematic
47	22	F0 22	Typematic
48	21	F0 21	Typematic
49	2A	F0 2A	Typematic
50	32	F0 32	Typematic
51	31	F0 31	Typematic
52	3A	F0 3A	Typematic
53	41	F0 41	Typematic
54	49	F0 49	Typematic
55	4A	F0 4A	Typematic
57	59	F0 59	Make/Break
58	11	F0 11	Make/Break
60	19	F0 19	Make/Break
61	29	F0 29	Typematic
62	39	F0 39	Make only
64	58	F0 58	Make only
75	67	F0 67	Make only
76	64	F0 64	Typematic
79	61	F0 61	Typematic
80	6E	F0 6E	Make only
81	65	F0 65	Make only
83	63	F0 63	Typematic
84	60	F0 60	Typematic
85	6F	F0 6F	Make only
86	6D	F0 6D	Make only
89	6A	F0 6A	Typematic
90	76	F0 76	Make only
91	6C	F0 6C	Make only
92	6B	F0 6B	Make only
93	69	F0 69	Make only
95	77	F0 77	Make only
96	75	F0 75	Make only
97	73	F0 73	Make only
98	72	F0 72	Make only
99	70	F0 70	Make only
100	7E	F0 7E	Make only
101	7D	F0 7D	Make only
102	74	F0 74	Make only
103	7A	F0 7A	Make only
104	71	F0 71	Make only
105	84	F0 84	Make only
106	7C	F0 7C	Typematic
108	79	F0 79	Make only
110	08	F0 08	Make only

Figure 5-19 (Page 3 of 3). Keyboard Scan Codes, Set 3

Key Number	Make Code	Break Code	Default Key State
112	07	F0 07	Make only
113	0F	F0 0F	Make only
114	17	F0 17	Make only
115	1F	F0 1F	Make only
116	27	F0 27	Make only
117	2F	F0 2F	Make only
118	37	F0 37	Make only
119	3F	F0 3F	Make only
120	47	F0 47	Make only
121	4F	F0 4F	Make only
122	56	F0 56	Make only
123	5E	F0 5E	Make only
124	57	F0 57	Make only
125	5F	F0 5F	Make only
126	62	F0 62	Make only

** Key 29 on U.S. keyboards only.

*** Keys 42 and 45 on all but U.S. keyboards.

Clock and Data Signals

The keyboard and system communicate over the “clock” and “data” lines. The source of each of these lines is an open-collector device on the keyboard that allows either the keyboard or the system to force a line to an inactive (low) level. When no communication is occurring, the “clock” line is at an active (high) level. The state of the “data” line is held active (high) by the keyboard.

When the system sends data to the keyboard, it forces the “data” line to an inactive level and allows the “clock” line to go to an active level.

An inactive signal will have a value of at least 0 V dc, but not greater than +0.7 V dc. A signal at the inactive level is a logical 0. An active signal will have a value of at least +2.4 V dc, but not greater than +5.5 V dc. A signal at the active level is a logical 1. Voltages are measured between a signal source and the dc ground.

When the keyboard sends data to or receives data from the system, it generates the “clock” signal to time the data. The system can prevent the keyboard from sending data by forcing the “clock” line to an inactive level; the “data” line may be active or inactive during this time.

During the BAT, the keyboard allows the “clock” and “data” lines to go to an active level.

Data Stream

Data transmissions to and from the keyboard consist of an 11-bit data stream (mode 2) sent serially over the “data” line. Figure 5-20 on page 5-40 shows the functions of the bits.

Figure 5-20. Keyboard Data Stream Bit Definitions

Bit	Function
11	Stop Bit (always 1)
10	Parity Bit (odd parity)
9	Data Bit 7 (most-significant)
8	Data Bit 6
7	Data Bit 5
6	Data Bit 4
5	Data Bit 3
4	Data Bit 2
3	Data Bit 1
2	Data Bit 0 (least-significant)
1	Start Bit (always 0)

Note: Mode 1 is a 9-bit data stream that does not have a parity bit or stop bit, and the start bit is always 1.

Data Output

When the keyboard is ready to send data, it first checks for a keyboard-inhibit or system request-to-send status on the “clock” and “data” lines. If the “clock” line is inactive (low), data is stored in the keyboard buffer. If the “clock” line is active (high) and the “data” line is inactive (request-to-send), data is stored in the keyboard buffer, and the keyboard receives system data.

If the “clock” and “data” lines are both active, the keyboard sends the start bit (0), 8 data bits, the parity bit, and the stop bit (1). Data will be valid before the trailing edge and beyond the leading edge of the clock pulse. During transmission, the keyboard checks the “clock” line for an active level at least every 60 milliseconds. If the system lowers the “clock” line from an active level after the keyboard starts sending data, a condition known as line contention occurs, and the keyboard stops sending data. If line contention occurs before the leading edge of the 10th clock signal (parity bit), the keyboard buffer returns the “clock” and “data” lines to an active level. If line contention does not occur by the 10th clock signal, the keyboard completes the transmission. Following line contention, the system can request the keyboard to resend the data.

Following a transmission, the system can inhibit the keyboard until the system processes the input, or until it requests that a response be sent.

Data Input

When the system is ready to send data to the keyboard, it first checks to see if the keyboard is sending data. If the keyboard is sending, but has not reached the 10th clock signal, the system can override the keyboard output by forcing the keyboard "clock" line to an inactive (low) level. If the keyboard transmission is beyond the 10th clock signal, the system must receive the transmission.

If the keyboard is not sending, or if the system elects to override the output from the keyboard, the system forces the keyboard "clock" line to an inactive level for more than 60 microseconds while preparing to send data. When the system is ready to send the start bit (the "data" line will be inactive), it allows the "clock" line to go to an active (high) level.

The keyboard checks the state of the "clock" line at intervals of no more than 10 milliseconds. If a system request-to-send is detected, the keyboard counts 11 bits. After the 10th bit, the keyboard checks for an active level on the "data" line, and if the line is active, forces it inactive, and counts one more bit. This action signals the system that the keyboard has received its data. Upon receipt of this signal, the system returns to a ready state, in which it can accept keyboard output, or goes to the inhibited state until it is ready.

If the keyboard "data" line is found at an inactive level following the 10th bit, a framing error has occurred, and the keyboard continues to count until the "data" line becomes active. The keyboard then makes the "data" line inactive and sends a Resend.

Each system command or data transmission to the keyboard requires a response from the keyboard before the system can send its next output. The keyboard will respond within 20 milliseconds unless the system prevents keyboard output. If the keyboard response is invalid or has a parity error, the system sends the command or data again. However, the two byte commands require special handling. If Set Typematic Rate/Delay (hex F3), Select Alternate Scan Codes (hex F0), or Set/Reset Mode Indicators (hex ED) has been sent and acknowledged, and the value byte has been sent but the response is invalid or has a parity error, the system will resend both the command and the value byte.

Encode and Usage

The keyboard routine, provided by IBM in the ROM BIOS, is responsible for converting the keyboard scan codes into *extended ASCII*. The extended ASCII codes returned by the ROM routine are mapped to the U.S. English keyboard chart. Some operating systems can make provisions for alternate keyboard charts by providing an interrupt replacement routine that resides in the RAM. This section discusses only the ROM routine.

Extended ASCII encompasses 1-byte character codes with possible values of 0 to 255, an extended code for certain extended keyboard functions, and functions handled within the keyboard routine or through interrupts.

The character codes are passed through the BIOS keyboard routine to the system or application program. A -1 means the combination is suppressed in the keyboard routine. The codes are returned in the AL register. See Section 11, "Characters and Keystrokes" for the codes.

Figure 5-21 (Page 1 of 3). Character Codes

Key	Base Case	Uppercase	Ctrl	Alt
1	'	~	-1	(*)
2	1	!	-1	(*)
3	2	@	Null(000) (*)	(*)
4	3	#	-1	(*)
5	4	\$	-1	(*)
6	5	%	-1	(*)
7	6	^	RS(030)	(*)
8	7	&	-1	(*)
9	8	.	-1	(*)
10	9	(-1	(*)
11	0)	-1	(*)
12	-	_	US(031)	(*)
13	=	+	-1	(*)
15	Backspace (008)	Backspace (008)	Del(127)	(*)
16	Tab (009)	Back-tab (*)	(*)	(*)
17	q	Q	DC1(017)	(*)
18	w	W	ETB(023)	(*)
19	e	E	ENQ(005)	(*)
20	r	R	DC2(018)	(*)
21	t	T	DC4(020)	(*)
22	y	Y	EM(025)	(*)
23	u	U	NAK(021)	(*)
24	i	I	HT(009)	(*)

Figure 5-21 (Page 2 of 3). Character Codes

Key	Base Case	Uppercase	Ctrl	Alt
25	o	O	SI(015)	(*)
26	p	P	DLE(016)	(*)
27	[{	Esc(027)	(*)
28]	}	GS(029)	(*)
29	\		FS(028)	(*)
30 Caps Lock	-1	-1	-1	-1
31	a	A	SOH(001)	(*)
32	s	S	DC3(019)	(*)
33	d	D	EOT(004)	(*)
34	f	F	ACK(006)	(*)
35	g	G	BEL(007)	(*)
36	h	H	BS(008)	(*)
37	j	J	LF(010)	(*)
38	k	K	VT(011)	(*)
39	l	L	FF(012)	(*)
40	;	:	-1	(*)
41	,	"	-1	(*)
43	CR(013)	CR(013)	LF(010)	(*)
44 Shift (Left)	-1	-1	-1	-1
46	z	Z	SUB(026)	(*)
47	x	X	CAN(024)	(*)
48	c	C	ETX(003)	(*)
49	v	V	SYN(022)	(*)
50	b	B	STX(002)	(*)
51	n	N	SO(014)	(*)
52	m	M	CR(013)	(*)
53	,	<	-1	(*)
54	.	>	-1	(*)
55	/	?	-1	(*)
57 Shift (Right)	-1	-1	-1	-1
58 Ctrl (Left)	-1	-1	-1	-1
60 Alt (Left)	-1	-1	-1	-1
61	Space	Space	Space	Space
62 Alt (Right)	-1	-1	-1	-1
64 Ctrl (Right)	-1	-1	-1	-1
90 Num Lock	-1	-1	-1	-1
95	/	/	(*)	(*)
100	*	*	(*)	(*)
105	-	-	(*)	(*)
106	+	+	(*)	(*)
108	Enter	Enter	LF(010)	(*)
110	Esc	Esc	Esc	(*)
112	Null (*)	Null (*)	Null (*)	Null(*)
113	Null (*)	Null (*)	Null (*)	Null(*)
114	Null (*)	Null (*)	Null (*)	Null(*)
115	Null (*)	Null (*)	Null (*)	Null(*)

Figure 5-21 (Page 3 of 3). Character Codes

Key	Base Case	Uppercase	Ctrl	Alt
116	Null (*)	Null (*)	Null (*)	Null(*)
117	Null (*)	Null (*)	Null (*)	Null(*)
118	Null (*)	Null (*)	Null (*)	Null(*)
119	Null (*)	Null (*)	Null (*)	Null(*)
120	Null (*)	Null (*)	Null (*)	Null(*)
121	Null (*)	Null (*)	Null (*)	Null(*)
122	Null (*)	Null (*)	Null (*)	Null(*)
123	Null (*)	Null (*)	Null (*)	Null(*)
125 Scroll Lock	-1	84/85 key NumLk	-1	-1
126	Pause(**)	Pause(**)	Break(**)	Pause(**)

(*) Refer to Extended Functions in this section.
 (**) Refer to Special Handling in this section.

Figure 5-22 lists the keys that have meaning only in Num Lock, Shift, or Ctrl states.

The Shift key temporarily reverses the current Num Lock state.

Figure 5-22. Special Character Codes

Key	Num Lock	Base Case	Alt	Ctrl
91	7	Home (*)	-1	Clear Screen
92	4	← (*)	-1	Reverse Word(**)
93	1	End (*)	-1	Erase to EOL(*)
96	8	↑ (*)	-1	(*)
97	5	(*)	-1	(*)
98	2	↓ (*)	-1	(*)
99	0	Ins	-1	(*)
101	9	PgUp (*)	-1	Top of Text and Home
102	6	→ (*)	-1	Advance Word (*)
103	3	PgDn (*)	-1	Erase to EOS (*)
104	.	Del (*,**)	(**)	(**)
105	-	SysRq	-1	-1
106	+	+ (*)	-1	-1

(*) Refer to "Extended Functions" in this section.
 (**) Refer to "Special Handling" in this section.

Extended Functions

For certain functions that cannot be represented by a standard ASCII code, an extended code is used. A character code of 00H (null) is returned in AL. This indicates that the system or application program should examine a second code, which will indicate the actual function. Usually, this second code is the scan code of the primary key that was pressed. This code is returned in AH.

Figure 5-23 is a list of the extended codes and their functions.

Figure 5-23 (Page 1 of 2). Keyboard Extended Functions

Second Code	Function
1	Alt Esc
3	Null Character
14	Alt Backspace
15	Back-tab
16-25	Alt Q, W, E, R, T, Y, U, I, O, P
26-28	Alt [] ←
30-38	Alt A, S, D, F, G, H, J, K, L
39-41	Alt ; ' /
43	Alt \
44-50	Alt Z, X, C, V, B, N, M
51-53	Alt , . /
55	Alt Keypad *
59-68	F1 to F10 Function Keys (Base Case)
71	Home
72	↑ (Cursor Up)
73	Page Up
74	Alt Keypad -
75	← (Cursor Left)
76	Center Cursor
77	→ (Cursor Right)
78	Alt Keypad +
79	End
80	↓ (Cursor Down)
81	Page Down
82	Ins (Insert)
83	Del (Delete)
84-93	Shift F1 to F10
94-103	Ctrl F1 to F10
104-113	Alt F1 to F10
114	Ctrl Print Screen (Start/Stop Echo to Printer)
115	Ctrl ← (Reverse Word)
116	Ctrl → (Advance Word)
117	Ctrl End (Erase to End of Line-EOL)
118	Ctrl PgDn (Erase to End of Screen-EOS)
119	Ctrl Home (Clear Screen and Home)
120-131	Alt 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, -, = keys 2-13
132	Ctrl PgUp (Top 25 Lines of Text and Cursor Home)
133-134	F11, F12

Figure 5-23 (Page 2 of 2). Keyboard Extended Functions

Second Code	Function
135-136	Shift F11, F12
137-138	Ctrl F11, F12
139-140	Alt F11, F12
141	Ctrl Up/8
142	Ctrl Keypad -
143	Ctrl Keypad 5
144	Ctrl Keypad +
145	Ctrl Down/2
146	Ctrl Ins/0
147	Ctrl Del/.
148	Ctrl Tab
149	Ctrl Keypad /
150	Ctrl Keypad *
151	Alt Home
152	Alt Up
153	Alt Page Up
155	Alt Left
157	Alt Right
159	Alt End
160	Alt Down
161	Alt Page Down
162	Alt Insert
163	Alt Delete
164	Alt Keypad /
165	Alt Tab
166	Alt Enter

Shift States

Most shift states are handled within the keyboard routine and are not apparent to the system or application program. In any case, the current status of active shift states is available by calling a software interrupt in the BIOS keyboard routine. The following keys result in altered shift states:

Shift: This key temporarily shifts keys 1 through 13, 16 through 29, 31 through 41, and 46 through 55, to uppercase (base case if in Caps Lock state). Also, the Shift temporarily reverses the Num Lock or non-Num Lock state of keys 91 through 93, 96, 98, 99, and 101 through 104 on a PC Enhanced keyboard. If in Num Lock state, the Shift key temporarily invokes the cursor functions of keys 8 through 10, 12, 13, 23 through 25, 37 through 40, 52, and 54 on a Space Saving keyboard.

Control (Ctrl): This key temporarily shifts keys 3, 7, 12, 15 through 29, 31 through 39, 43, 46 through 52, 75 through 89, 91 through 93, 95 through 108, 112 through 124, and 126 to the Ctrl state. The Ctrl key is also used with the Alt and Delete keys to cause the system reset

function and with the Pause/Break key to cause the break function. The system reset and break functions are described under "Special Handling" on page 5-48.

Alternate (Alt): This key temporarily shifts keys 1 through 29, 31 through 43, 46 through 55, 75 through 89, 95, 100, and 105 through 124 to the Alt state. The Alt key is also used with the Ctrl and Delete keys to cause a system reset.

The Alt key also allows the user to enter any character code from 1 to 255. The user holds down the Alt key and types the decimal value of the desired character on the numeric keypad. The Alt key is then released. If the number is greater than 255, a modulo-256 value is used. This value is interpreted as a character code and is sent through the keyboard routine to the system or application program. Alt is handled in the keyboard routine.

Caps Lock: This key shifts keys 17 through 26, 31 through 39, and 46 through 52 to uppercase. When Caps Lock is pressed again, it reverses the action. Caps Lock is handled in the keyboard routine. When Caps Lock is pressed, it changes the Caps Lock Mode indicator. If the indicator was on, it will go off; if it was off, it will go on.

Scroll Lock or ScrLk: When interpreted by appropriate application programs, this key indicates that the cursor control keys will cause windowing over the text rather than moving the cursor. When the Scroll Lock (ScrLk) key is pressed again, it reverses the action. The keyboard routine simply records the current shift state of the key. It is the responsibility of the application program to perform the function. When Scroll Lock is pressed, it changes the Scroll Lock Mode indicator. If the indicator was on, it will go off; if it was off, it will go on.

Num Lock or NumLk: For the PC Enhanced keyboard, this key shifts keys 91 through 93, 96 through 99, and 101 through 104 to uppercase. When Num Lock is pressed again, it reverses the action.

For the Space Saving keyboard, this key shifts keys 8 through 10, 12, 13, 37 through 40, 23 through 25, and 52 through 54. The NumLk for this keyboard is Shift plus the ScrLk key.

Num Lock for both keyboards is handled in the keyboard routine.

Shift Key Priorities and Combinations: If combinations of the Alt, Ctrl, and Shift keys are pressed and only one is valid, the priority is as follows: the Alt key is first, the Ctrl key is second, and the Shift key is third. The only valid combination is Alt and Ctrl, which is used in the system reset function.

Special Handling

System Reset

The combination of any Alt, Ctrl, and Delete keys results in the keyboard routine that starts a system reset or restart. System reset is handled by BIOS.

Break

The combination of the Ctrl and Pause/Break keys results in the keyboard routine signaling INT 1BH. The extended characters (AL) = hex 00 and (AH) = hex 00 are also returned.

Pause

The Pause key causes the keyboard interrupt routine to loop, waiting for any character or function key to be pressed. This provides a method of temporarily suspending an operation, such as listing or printing, and then resuming the operation. The method is not apparent to either the system or the application program. The keystroke used to resume operation is discarded. Pause is handled in the keyboard routine.

Print Screen

The Print Screen key results in an interrupt invoking the print-screen routine. This routine works in the alphanumeric or graphics mode, with unrecognizable characters printing as blanks.

System Request (SysRq)

When the SysRq (Alt and Print Screen) key is pressed, a hex 8500 is placed in AX, and an INT 15H is executed. When the SysRq key is released, a hex 8501 is placed in AX, and another INT 15H is executed. If an application uses the key, the following steps must be performed:

1. Save the previous address.
2. Overlay interrupt vector hex 15.
3. Check AH for a value of hex 85:

If yes, process may begin.

If no, go to previous address.

The application program must preserve the values in all registers, except AX, upon return. A system request is handled in the keyboard routine.

Other Characteristics

The keyboard routine does its own buffering. If a key is pressed when the buffer is full, the key is ignored and the alarm is activated.

The keyboard routine also suppresses the typematic action of the following keys: Ctrl, Shift, Alt, Num Lock (NumLk), Scroll Lock (ScrLk), Caps Lock, and Ins (Insert).

During each INT 09H from the keyboard, an INT 15H, function (AH) = hex 4F is generated by the BIOS after the scan code is read from the keyboard adapter. The scan code is passed in the (AL) register with the carry flag set. This is to enable an operating system to intercept each scan code prior to its being handled by the INT 09H routine, and have a chance to change or act on the scan code. If the carry flag is changed to 0 on return from INT 15H, the scan code will be ignored by the interrupt handler.

Cables and Connectors

The keyboard cable connects to the system with a 6-pin miniature DIN connector. Figure 5-24 shows the pin configuration and signal assignments.

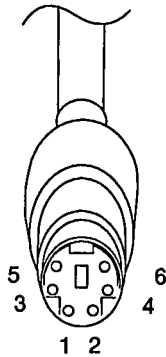


Figure 5-24. Keyboard Connector Signal and Voltage Assignments

DIN Connector

Pins

Signal Name

1	+ Data
2	Reserved
3	Ground
4	+ 5.0 V dc
5	+ Clock
6	Reserved
Shield	Frame Ground

Specifications

The following are specifications for the keyboard.

	Keyboard	
Power Requirements	+5 V dc \pm 10% 275 milliamperes	
Size	Millimeters	Inches
• Length:	450	17.7
• Depth:	158	6.2
• Height:	39	2.3
Legs extended	55	2.2
Weight	Kilograms	Pounds
	0.93	2.05

