Science Fair MICROCOMPUTER TRAINER Command Quick Reference Table

Code	Symbol	Flowchart	Flag	How the command works	Page
O	KA	K→Ar	O,1	Store key in Ar. If there is no key input, the flag is set to 1.	40
1	AO	Ar→Op	1	Displays the value of Ar on the HEX. LED (Port O).	36
2	CH	Ar⇌Br, Yr⇌Zr	1	Exchange the content of Ar, Br and Yr, Zr respectively.	37 55
3	CY	Ar⇌Yr	1	Exchange the content of Ar and Yr.	94
4	AM	Ar→M	1	Put the contents of Ar into M.	56
5	MA	M→Ar	1	Put the contents of M into Ar.	58
6	M+	M+Ar→Ar	O,1	Add M and Ar and store in Ar. Set flag to 1 if there is a carry.	59
7	M−	M−Ar→Ar	O,1	Subtract Ar from M and store in Ar. Set flag to 1 if negative result.	60
8	TIA	○→Ar	1	Put ○ in Ar (number from 0 to F).	36
9	AIA	Ar+○→Ar	O,1	Add ○ to Ar and store in Ar. Set flag to 1 if there is a carry.	41
A	TIY	○→Yr	1	Put ○ in Yr.	56
B	AIY	Yr+○→Yr	O,1	Add ○ to Yr and store in Yr. Set flag to 1 if there is a carry.	56
C	CIA	Ar≠○?	O,1	Compare ○ with Ar. Set flag to 1 if Ar ≠ ○. Set flag to 0 if Ar = ○.	92
D	CIY	Yr≠○?	O,1	Compare ○ with Yr. Set flag to 1 if Yr ≠ ○. Set flag to 0 if Yr = ○.	83
F	JUMP		1	Jump to specified address if flag is 1, otherwise skip.	38 40

Code	Symbol	Flowchart	Flag	How the command works	Page
EO	CAL RSTO	CAL RSTO	1	Turn off the HEX. LED (Port O).	87
E1	CAL SETR	CAL SETR	1	Light up binary LED specified by Yr (Port R).	83
E2	CAL RSTR	CAL RSTR	1	Turn off binary LED specified by Yr (Port R).	85
E3	CAL INPT	CAL INPT	1	Store external input from Port K in Ar. (Not used.)	B1
E4	CAL CMPL	CAL CMPL	1	Inverts the contents of Ar.	90
E5	CAL CHNG	CAL CHNG	1	Exchange Ar, Br, Yr, and Zr, with their auxiliary register.	126
E6	CAL SIFT	CAL SIFT	O,1	Move the contents of Ar one bit to the right. Flag if even.	121
E7	CAL ENDS	CAL ENDS	1	Play the end sound.	122
E8	CAL ERRS	CAL ERRS	1	Play the error sound.	119
E9	CAL SHTS	CAL SHTS	1	Play the short sound (blip).	86
EA	CAL LONS	CAL LONS	1	Play the long sound (beep).	120
EB	CAL SUND	CAL SUND	1	Play the tone indicated by Ar (Do-Re-Mi-Fa-Sol-La-Ti-Do).	118
EC	CAL TIMR	CAL TIMR	1	Delay the program execution by (Ar + 1) ÷ 10 seconds.	61
ED	CAL DSPR	CAL DSPR	1	Display M (5F, 5E) on the binary LEDs (Port R).	89
EE	CAL DEM −	M−Ar→M	1	Subtract Ar from M, convert to decimal, and store in M.	124
EF	CAL DEM +	M+Ar→M	1	Add Ar to M, convert to decimal, and store in M.	122

Ar ... A register (6F)   Ar' ... A auxiliary register (69)   ○ ... a number from 0-F
Br ... B register (6C)   Br' ... B auxiliary register (67)   M ... Memory (50-5F) at
Yr ... Y register (6E)   Yr' ... Y auxiliary register (68)   location (50+Yr)
Zr ... Z register (6B)   Zr' ... Z auxiliary register (66)   Addresses in brackets.

If operation becomes erratic replace the batteries even if the LEDs are lit.

Flag Status and Branch Examples for JUMP Command

KA

Run command
- If there is no key input, the flag is 1
- If there is key input, the flag is 0

K→Ar

no key down? — YES (flag is 1) → ② JUMP to address 04 as specified

NO (flag is 0)

② Don't execute the JUMP command
③ Start executing the CH command

Example
① KA
② JUMP
⟨O⟩
⟨4⟩
③ CH

CIA CIY

Ar≠○?   Yr≠○?

Run command
- If Ar≠○, the flag is 1
- If Ar=○, the flag is 0

(○ is a number 0-F)

Ar≠○? — YES (flag is 1) → ② JUMP to address 2C as specified

NO (flag is 0)

② Don't execute the JUMP command
③ Start executing the TIY command

Example
① CIA
② JUMP
⟨2⟩
⟨C⟩
③ TIY

M+ AIA AIY

Run command
- If carry, the flag is 1
- If no carry, the flag is 0

(overflow is called a carry)

M+Ar→Ar

carry? — YES (flag is 1) → ② JUMP to address 2F as specified

NO (flag is 0)

② Don't execute the JUMP command
③ Start executing the TIY command

Example
① M+
② JUMP
⟨2⟩
⟨F⟩
③ TIY

CAL SIFT

Run command
- If the number is even, the flag is 1
- If the number is odd, the flag is 0

CAL SIFT

even? — YES (flag is 1) → ② JUMP to address 2B as specified

NO (flag is 0)

② Don't execute the JUMP command
③ Start executing the TIY command

Example
① CAL SIFT
② JUMP
⟨2⟩
⟨B⟩
③ TIY

M−

Run command
- If subtract fails (Ar>M), the flag is 1
- If subtract succeeds, the flag is 0

(a borrow is needed when Ar > M)

M−Ar→Ar

borrow? — YES (flag is 1) → ② JUMP to address 2A as specified

NO (flag is 0)

② Don't execute the JUMP command
③ Start executing the TIY command

Example
① M−
② JUMP
⟨2⟩
⟨A⟩
③ TIY

● By inserting two CH commands after the command that changes the flag, the jump can be executed unconditionally.

KA M+ M− AIA AIY CIA CIY CAL SIFT

(the 8 commands with different flags)

- (command) ┄┄ Flag is 0 or 1
- Ar⇄Br, Yr⇄Zr ┄┄ Insert two CH commands
- Ar⇄Br, Yr⇄Zr ┄┄ Flag is always 1
- → Jump unconditionally

Microcomputer Trainer Operating Modes (Pages 40 & 42)
In STEP MODE the micro pauses after each command. Press INCR to proceed. In RUN MODE the program is run without interruption. In modes "with addresses" these are displayed on the binary LEDs.

1 ... RUN MODE
2 ... RUN MODE with addresses
5 ... STEP MODE
6 ... STEP MODE with addresses

Micro Games
9 ... Electronic Organ (Page 17)
A ... Automatic Tunes (Page 18)
B ... Musical Guessing Game (Page 28)

C ... "Rat Bashing" (Page 29)
D ... Tennis Game (Page 30)
E ... Timer (Page 31)
F ... Morse Code (Page 32)

● Appendix B Use of CAL INPT (E3)

CAL INPT is used to get external input into your micro-computer. Note: This is an advanced command.

CAL INPT COMMAND (CALI read external INPuT)

This command reads the value of Port K (K1, K2, K4, and K8) into Ar.
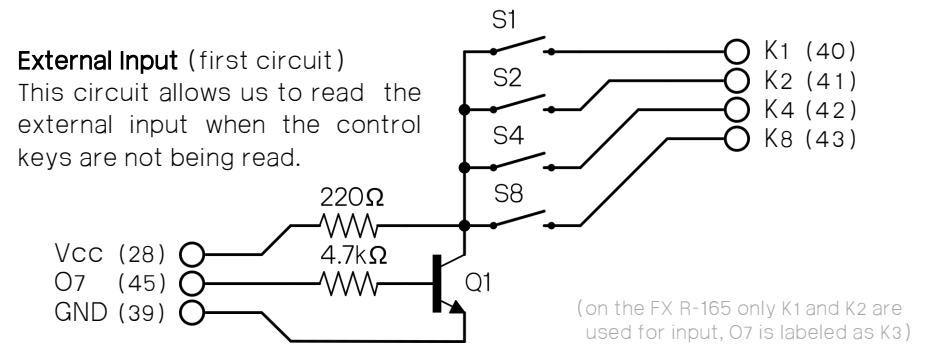
The CAL INPT command requires the HEX. LED (Port O) to be on to operate.

Port K is normally used by the hexadecimal input keyboard. However, the computer only checks the keyboard for input periodically. To allow the micro to distinguish between keyboard input and external input the CAL INPT command makes use of this feature and only checks port K when the keyboard is not in use.

However, as this port is shared it is important that we do not make the computer think that keys are pressed when it is checking the keyboard. Importantly, to make sure we do not interrupt the program we must only send a signal on the external inputs when the control keys (ADRS, INCR, RUN, and RESET) are not being checked.

Fortunately, we can recognize when the computer is checking the control keys by monitoring O7. Port O is part of the microprocessor's HEX. LED display circuit, but is also used to enable the control keys. If the display is off the computer will check these keys constantly.

To use the CAL INPT command you need to connect some external switches to your micro. This requires some additional components.

External Input (first circuit)
This circuit allows us to read the external input when the control keys are not being read.

S1 — K1 (40)
S2 — K2 (41)
S4 — K4 (42)
S8 — K8 (43)

220Ω
Vcc (28)
O7 (45)
4.7kΩ
GND (39)
Q1

(on the FX R-165 only K1 and K2 are used for input, O7 is labeled as K3)

Q1 is an NPN switching transistor, such as the 2N3904.

Alternatively, as we know the HEX. LED must be on to use CAL INPT, we can use the state of the display to work out when we can safely send external input.

External Input (second circuit)
This circuit allows us to read the external input when the keyboard is not being read.

S1 — K1 (40)
S2 — K2 (41)
S4 — K4 (42)
S8 — K8 (43)

D1
S8
O0 (31 or 16)
O3 (49 or 15)
D2
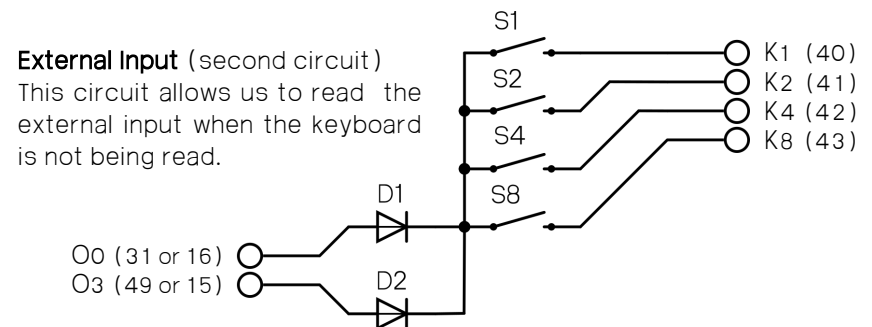
D1 and D2 are two signal diodes, such as the 1N4148.

Note: You should only connect one of these circuits to your microcomputer trainer at a time.

This program reads the external input and displays the value on the HEX. LED when a key on the keyboard is pressed.

PROGRAM

address	command	machine code
OO	TIA	8
O1	⟨O⟩	O
O2	AO	1
O3	KA	O
O4	JUMP	F
O5	⟨O⟩	O
O6	⟨3⟩	3
O7	⌈CAL	E
O8	⌊INPT	3
O9	JUMP	F
OA	⟨O⟩	O
OB	⟨2⟩	2

FLOWCHART

START

OO
O→Ar } Move O to Ar, for the first display.

O2
Ar→Op } Display contents of Ar on HEX. LED.

O3
K→Ar

} Key input: if no key pressed, wait.

O4
key down? } If key pressed, go to next step.
NO

YES
O7
CAL INPT } Get external input and store in Ar.

O9   Return to O2.

A) Connect the **second** circuit shown on page B1 to your micro.

B) Key in the program and check it.

C) Press RESET, 1, RUN to start the program.

D) Now close any combination of the external input switches. The closed switches represent a binary 1 and the open switches a binary O. When you press any of the hexadecimal keys on the keyboard (O-F) the switches are read and the value is shown on the HEX. LED.

Note: If the first circuit is used any external input may cause a key press to be detected and the HEX. LED to update.

About Port K and How the Circuits Work

Your microcomputer trainer uses Port K (K_1, K_2, K_4, and K_8) to read the keyboard. To allow the computer to read 20 keys using just four inputs the micro only enables four keys at a time. It does so by enabling an output from Port R (R_C, R_D, R_E, and R_F) for the hexadecimal keys and Port O (O_7) for the control keys, one column at a time.

Port O is shared with built in HEX. LED. When the display is on the computer does not use O_7. When reading the keyboard, the computer briefly turns the display off, reads the keys, and turns the display back on again. If the display is off the computer constantly uses O_7 to enable the control keys. This stops us from using external inputs when the HEX. LED is off.

The first circuit monitors O_7 and uses a transistor to invert this signal (a logical NOT). This enables our external inputs only when the computer is **not** reading the control keys. However, other keys may still be being read.

A better solution is used in the second circuit. Here, we use two signal diodes to combine the state of O_0 and O_3 (a logical OR) to enable our inputs. When the HEX. LED is lit, one or both of these outputs will be on. As the display is off when the keyboard is being read, this allows us to use both the keyboard and external inputs.