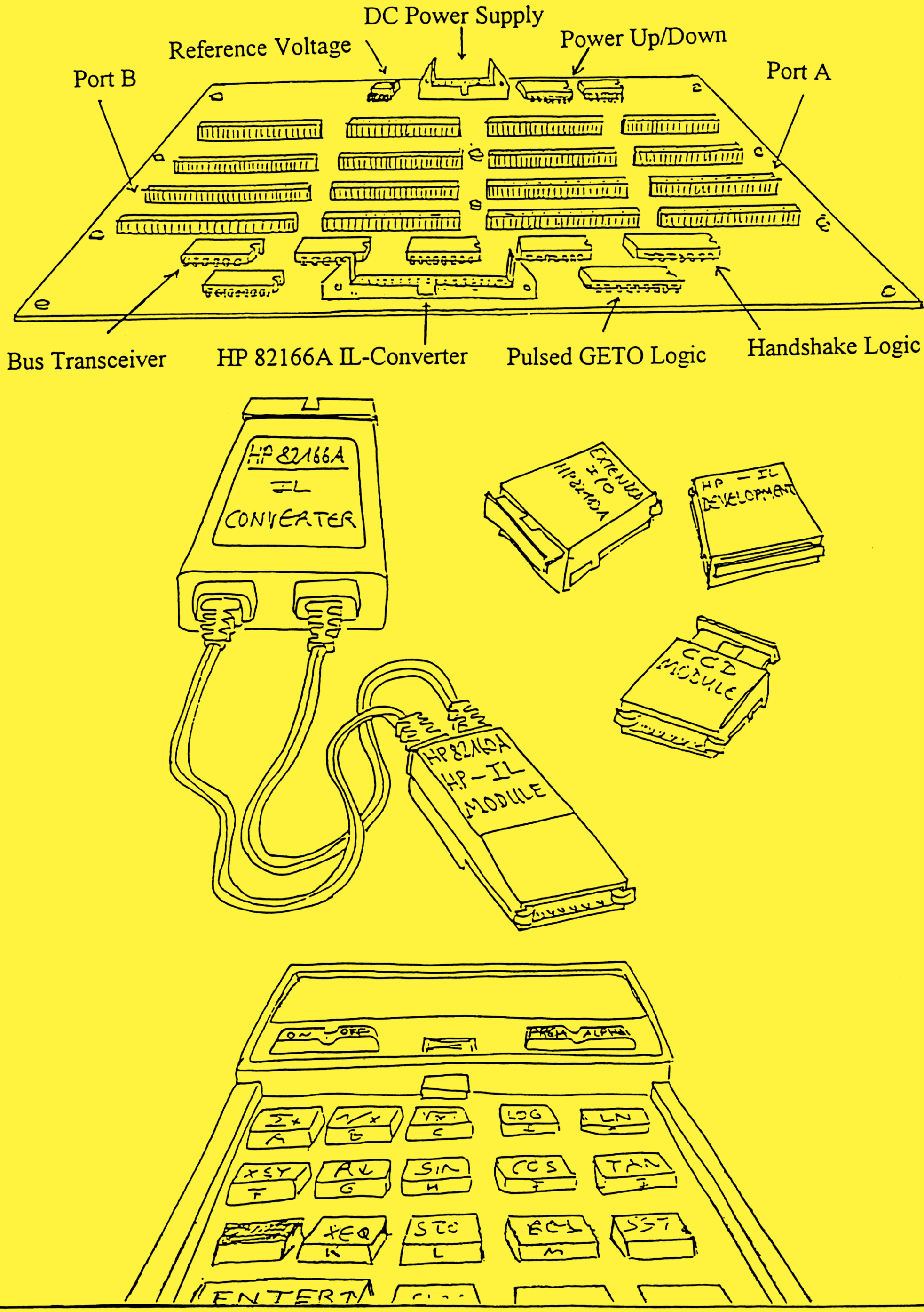
HP-41 Input/Output Board



with best wishes
to the author of the
amazing handheld
computer book

"CONTROL THE WORLD
WITH HP-IL"

by

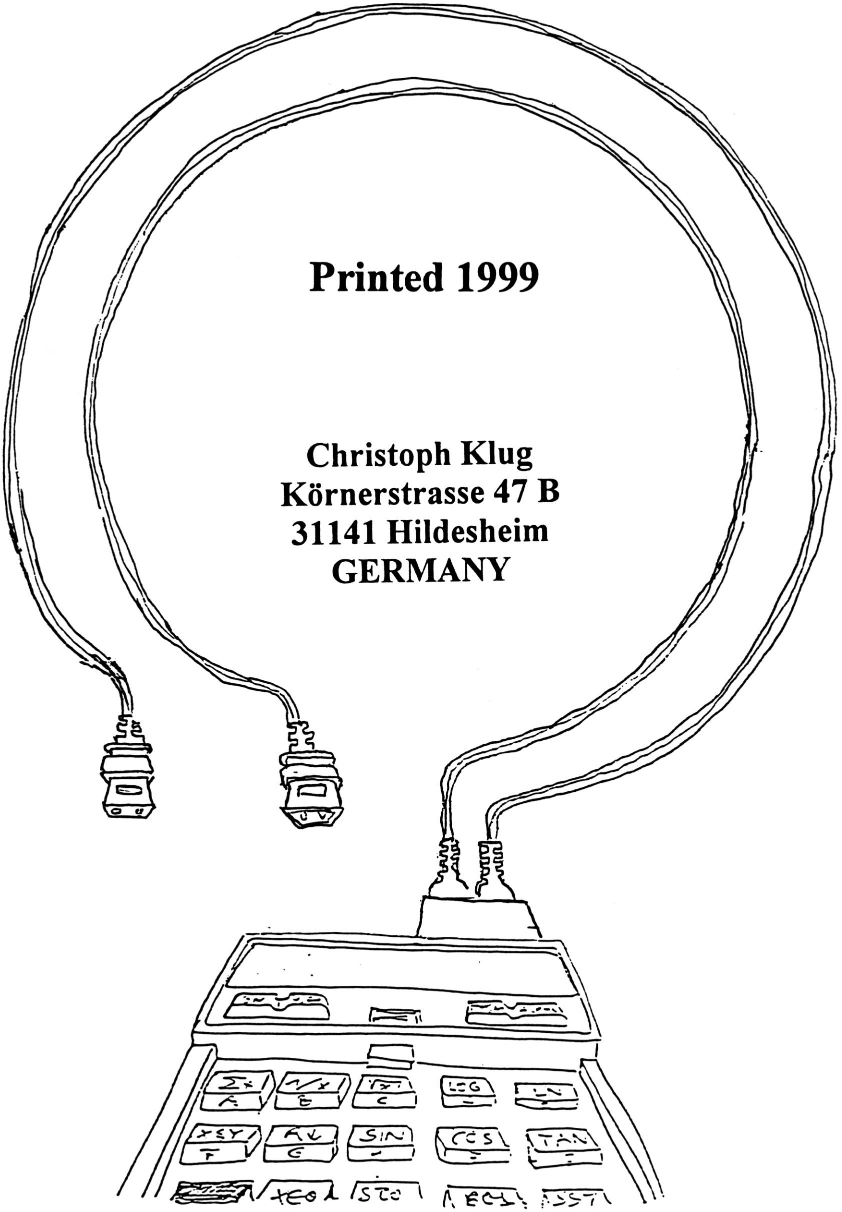
Gary Friedman

5084 Glovia Ave
Encino CA 91436
USA

from

Christoph Klug

HP 82166 A 16 BIT INPUT / OUTPUT BOARD



Printed 1999

Christoph Klug
Körnerstrasse 47 B
31141 Hildesheim
GERMANY

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Interfacing extern measurement and control hardware to HP-41 handheld computer by using the HP 82166A IL-Converter.

Burning Zeprom-Modules

Building Double X-Memory Modules

HP-41 hardware modification extern interrupt circuit

Data Transfer / Upload from HP-41 handheld computer to PC

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

CONTENTS

CHAPTER I	INTRODUCTION
CHAPTER II	HP-41 CONTROLLER
CHAPTER III	I/O-BOARD HARDWARE
CHAPTER IV	DC POWER SUPPLY
CHAPTER V	I/O-BOARD MODULES
CHAPTER VI	PRACTICAL TIPS
CHAPTER VII	ADVANCED PROGRAMMING
CHAPTER IIX	REFERENCES
CHAPTER IX	CENTRONIX PRINTER
CHAPTER X	HP-41 BARCODES
CHAPTER XI	ZEPROM-MODULE
CHAPTER XII	DOUBLE X-MEMORY MODULE
CHAPTER XIII	EXTERN HP-41 INTERRUPT
CHAPTER XIV	I/O-BOARD DATA TRANSFER
CHAPTER XV	HP-41↔PC DATA TRANSFER
CHAPTER XVI	AUDIO MEASUREMENT

CHAPTER I
INTRODUCTION

General Information	I.01
HP-41 Controller	I.01
EXT I/O- and Development Modul	I.01
EXT I/O-Module	I.01
Development Module	I.01
Time-Module	I.02
CCD-Module	I.02
Zeprom-Module	I.02
Extern Interrupt	I.02
HP-41 and PC	I.03
Hardware Feature List	I.03
Port Configuration	I.03
Plug In Modules	I.03
The IL-Messlab	I.04
Quality Tests	I.04
I/O-Board Manual	I.04
Source of Equipment	I.05
Conclusion	I.05
I/O-Board Schematic Diagram	I.06
Port Addressing	I.07
Plug In Modules	I.08

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

General Information :

Most people use the HP 82166 A IL-Converter to adapt a standard parallel printer to HP Interface Loop. But you can use the powerful IL-Converter to connect electronic hardware to the Interface Loop, controlled by the HP-41 handheld computer. I developed an Input/Output Board for the HP 82166 A IL-Converter, designed as a mainboard with four 16 bit extension slots.

HP-41 Interface Loop Controller :

Best HP-41 IL-Controller is the powerful CX model with intern X-Functions, X-Memory and Time-Module. Additionally you need HP 82160 IL-Module and EXT I/O-Module to control the Interface Loop. Instead of you can use the Development-Module. For maximum performance you can complete the handheld with the German CCD-Module. Hard- and software of I/O-Board are developed to work optimal in combination with other Loop-Devices like Cassette Drive, Thermal Printer or Video Interface. For that reason you can configurate extensive IL-Systems.

EXT I/O-Module and Development-Module :

For controlling I/O-Board with HP-41 you must alter some internal status register of the HP 82166 A IL-Converter. Therefore you need the EXT I/O-Module or alternatively the Development-Module. For EXT I/O-Module 695 Bytes (= 100 Registers) of software are used by the HP-41 programmed to control I/O-Board, or 811 Bytes (= 116 Registers) of software for Development-Module.

I/O-Board Software for EXT I/O-Module :

Controlling the I/O-Board with HP-41 CX and EXT I/O-Module is easier and faster than with Development-Module ! The I/O-Module uses the ALPHA-Register to transfer data to IL-Converter. Avoiding problems with loss of leading null bytes in ALPHA-Register, I/O-Module generally works with leading dummy byte D. For controlling the I/O-Board with HP-41 CX and EXT I/O-Module, 24 commands are provided for power up/down, initialisation, addressing, manual service request, interrupt, clear, 16-bit I/O-transfer by ALPHA-Register and by X-Register and 8 bit I/O-transfer by X-Register. For 8 bit I/O-transfer the software provided needs the X-Memory Module for storage.

I/O-Board Software for Development-Module :

Controlling I/O-Board with HP-41 CX and Development-Module is more complex and slower than with I/O-Module ! The Development-Module generates a Buffer to transfer data to IL-Converter. An advantageous feature of the Development-Module is the INTR-routine, which starts HP-41 automatically from an active MSRQ-signal ! For controlling the I/O-Board with HP-41 CX and Development-Module, 22 commands are provided for power up/down, addressing + initialisation, manual service request, interrupt, clear, 16-bit I/O-transfer by X-Register and by ALPHA-Register, 8 bit I/O-transfer by X-Register.

I/O-Board and Time-Module :

You can use Time Module commands to automatic control I/O-Board. For example power up the system using an alarm function and start some activities like measurement, storing data in main memory or cassette drive, then set new time alarm and put the I/O-Board to sleep waiting for next cycle.

I/O-Board and CCD-Module :

For controlling I/O-Board you do not require the german CCD-Module, but this helpful module expands HP-41 with 100 powerful commands programmed in machine-language. Some are fantastic for use with I/O-Board and make work easy : Synthetic programming, binary-functions for logic bit operations, matrix-functions for data collection applications.

I/O-Board and Zeprom-Module :

The Zeprom-Module is a EPROM housed in a HP-41 plug in modul case, produced by Zengrange (London) who also produced the well known HP-41 Zenrom-Module. Permanent storing complete I/O-Board control command set inside Zeprom is done by adapting module to small plug in burning converter tool and using corresponding Programer-Rom software. Using Zeprom-Module, HP-41 main memory is complete free for other program applications and I/O-Board software is protected against memory lost. 51 commands controlling I/O-Board plus 12 utility functions now belonging to CAT 2 and assigned to three User keyboards, which selected by softkeys. Zeprom-Module sum up extension modules and I/O-Board software in only one HP-41 plug in port.

Extern Interrupt :

Inside HP-41 case you can mount a small hardware extension circuit for switching handheld computer from sleep-modus to run-modus by extern interrupt signal. As response to extern event HP-41 starts automatic control of I/O-Board. Because interrupt circuit workes with an opto-coupler element there is no risc for damanging HP-41 ! During a running program extern interrupt signal can not switch off handheld computer.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 and PC :

Normally I/O-Board data proccessing is done completely by HP-41. But it is possible to transfer HP-41 data-files to PC. Use a HP-IL ↔ PC Interface Card and Link Plus or Trans41 software. Link Plus only runs on 286/16 MHz PC´s and on slow 386SX/25 MHz PC´s and emulates two Cassette Drives, a Video Display, a Printer, and a Dos file. Trans41 runs on modern PC´s and emulates a Printer, a Cassette Drive and a Dos file. Collect data by HP-41 and I/O-Board in the field. Now transfer HP-41 data-files to PC in a DOS file. Than import data to EXCEL or other powerful software packages.

I/O-Board Hardware Feature List :

The board uses a basic application for handshake timing from Gary Friedmann, described in his book "Control The World With HP-IL". Some more helpful circuits added to the board to improve I/O performance. You find hardware solutions for port addressing, Power On reset, MSRQ (Manual Service Request), Clear function, Power Up/Down function, MSRQ Lock when Power Down and a Reference Voltage. Power supply is external : A special 6V DC-supply unit with optional solar powered rechargeable cell for modular applications. Output voltages are +5V and $\pm$ 15V for digital- and analog circuits. Stand by current of DC-supply (Power Down) is lower than 10 μA !

I/O-Board Port Configuration :

The I/O-Board supports four 16 Bit slots. Every slot is divided into two 8 Bit ports A and B. All slots are connected by a common bus with power supply, handshake lines and data lines. The logic of I/O-Board hardware maximally addresses two 16 Bit input modules and two 16 Bit output modules plugged in at same time ! Address setting is done by jumpers on the modules, not by slot position. Inserted 8 Bit modules need additional software addressing. The slot architecture of the board, hardware and software addressing allows some port configurations for digital and analog input/output.

I/O-Board Plug In Modules :

I/O-Board uses 8 bit or 16 bit add-on modules. On next page is the list of the basic modules for completing motherboard hardware. Furthermore some special modules exist like analog filter modules and rms measurement modules or a computer controlled oscillator module. The modular hardware concept of the I/O-Board makes it possible to configurate the interface system with I/O ports to every task you want. You can also develop special modules for your own applications and hardware projects. The I/O-Board is a good basic IL-Device to implement your ideas quickly !

- □ 8 Bit digital input modules and opto isolated input modules.
- □ 8 Bit digital output modules, opto isolated output modules and open collector output modules.
- □ 8 Bit analog digital converter modules and 8 Bit digital analog converter modules.
- □ 12 Bit analog digital converter modules and 12 Bit digital analog converter modules.
- □ 16 Bit counter modules.
- □ Quad Multiplexer modules.
- □ Transfer modules for data exchange between two I/O-Boards.
- □ Diagnose modules and Test modules.

The IL-Messlab :

With the same basic circuit architecture used by I/O-Board I developed a small Euro-Board for the use in 19 Inch Rack Systems.

As an example for this I build the IL-Messlab system, a HP-41 controlled measurement unit, with programmable Power Supply, Function Generator, Frequency Counter, Digital Voltmeter and Interface Extension Port.

The measurement system is controlled by 60 software functions available on 5 user keyboards. The 4 kByte programm is written in User Code and stored in an Eramco RSU (128 kByte rambox in cardreader case). Same programm is burned in a small 16 kByte Zeprom-Module, together with copys of I/O-Module and CCD-Module.

The IL-Messlab is an impressing example to realize measurement and controlling with the small HP-41 computer system and HP 82166 A IL-Converter !

Quality Tests :

Correct and bugfree function of software and interface hardware have been tested with some HP-41 Controllers, some IL-Converters, and eight samples of the I/O-Board which I have built ! Measurement tools and software programs for testing mother board hardware and plug in module circuits exist.

I/O-Board Manual :

The English language manual for I/O-Board includes circuit descriptions, circuit diagrams and software documentation for HP-41 CX including barcode plots. The manual is a rich source for users, who want to use the IL-Converter in their own electronic equipment, and for those, who want to learn step by step something about interface technology (read and write bytes to external hardware devices, voltage conversation to the analog area). Test programs included for checking hardware functions. Some practical tips for building, installing and starting with I/O-Board complete the manual, including advanced programming tips and reference lists.

Furthermore manual includes a program for printing HP-41 barcodes on HP DeskJet 500 printer. This needs an HP-41 with HP-IL module, Extended Functions (on a plug-in module or built into an HP-41CX), a CCD-Module plus an HP 82166A IL-Converter to connect the DeskJet 500, or an HP-IL PC interface card to print the barcodes to a printer connected to a PC.

The manual is written for use with I/O-Board, but the manual can be read on ist own for the details and programs it gives. Describing the advanced development, manual continues Gary Friedman's book "Control The World With HP-IL".

Source of Equipment :

The HP 82166 A IL-Converter is the key part for I/O-Board. Some kits for building this unit including IL-Terminal, IL-Transformer and IL-Chip exist. Printed circuit boards exist for the I/O-Board but presently with only single-sided layout. You must make a lot of additional connections in wire wrapping or soldering technique. That is easy for electronic professionals. For people who have no complex measurement equipment I can align some critical components. Electronic novices can get a completely finished and tested version of I/O-Board including DC Power Supply. Building plug in modules for I/O-Board is not complex and can done by newcomers to electronic construction.

Conclusion :

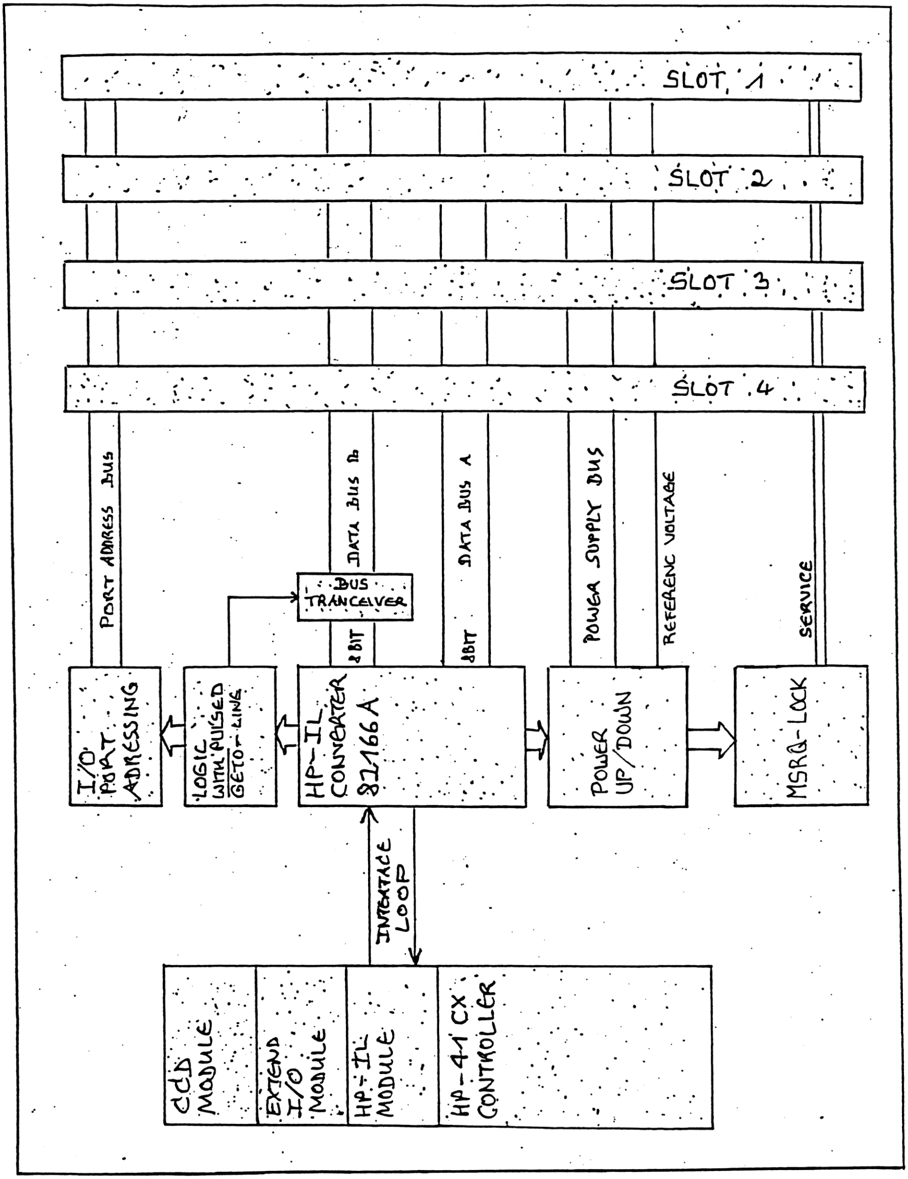
Today the HP-41 is a nostalgic handheld computer. With added accessories like plug in expansion modules you can bypass hardware limitations of the system. Using the IL-Converter and I/O-Board you open up the interesting field of controlling and developing external hardware. Now you can realize measurement and control from your HP-41, a task normally done with larger systems. Interfacing the handheld to modern PC you can also use modern software tools to analyse the data.

For more informations about HP-41, HP 82166A IL-Converter, Input/Output Board and belonging manual write to :

Christoph Klug Körnerstraße 47 B 31141 Hildesheim Germany

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

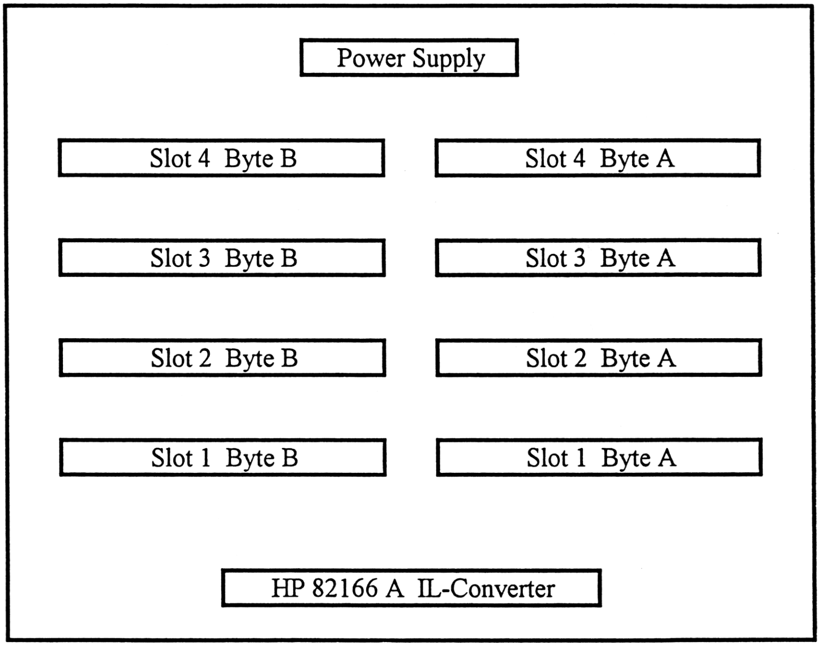
I/O-Board Schematic Diagram :



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Port Addressing :

The I/O-Board supports four 16 bit slots. Every slot is divided into two 8 bit ports A and B. All slots are connected by a common bus with power supply, handshake lines and data lines. The slots are mechanically coded to prevent reversed plug in of modules.

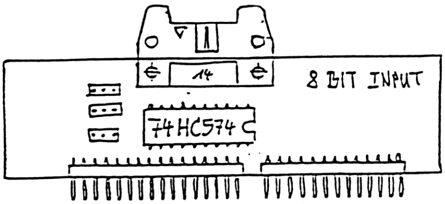


For the I/O-Board generally exist 8 bit and 16 bit Input Modules and Output Modules. A 16 bit module can alternatively be replaced by two 8 bit modules.

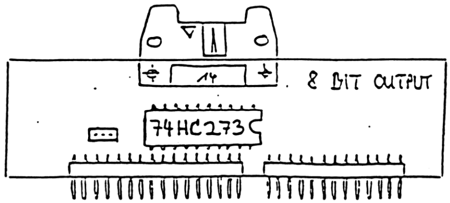
The logic of I/O-Board hardware maximally addresses two 16 bit Input Modules and two 16 bit Output Modules plug in at same time ! Address setting is done by jumpers on the modules, not by slot position. Inserted 8 bit modules need additional software addressing.

Slot architecture of board and used hardware- and software addressing allows some port configurations for digital and analog input / output.

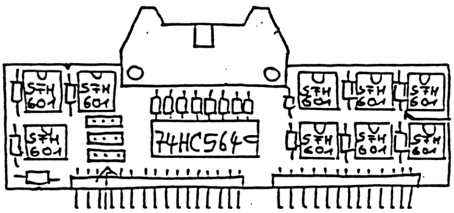
8 Bit Input-Module



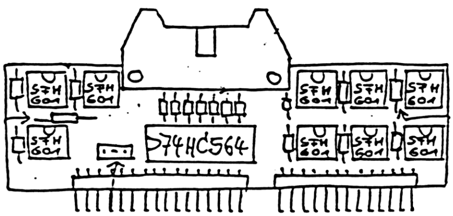
8 Bit Output-Module



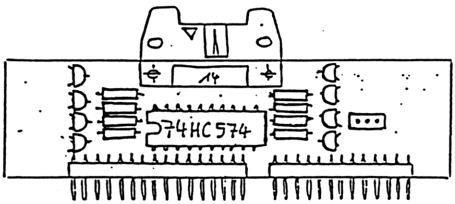
8 Bit Isolated Input-Module



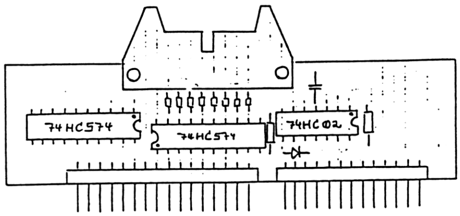
8 Bit Isolated Output-Module



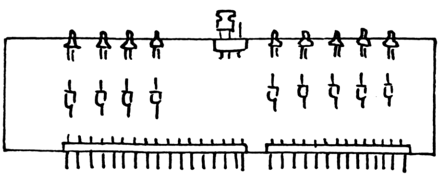
8 Bit Open Collector Module



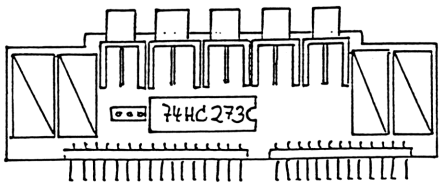
Transfer-Module



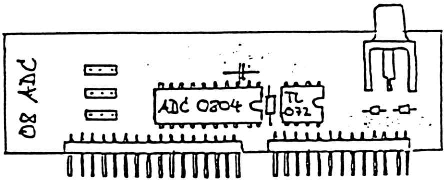
Test-Module



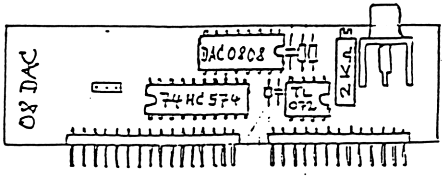
Quad Multiplexer Module



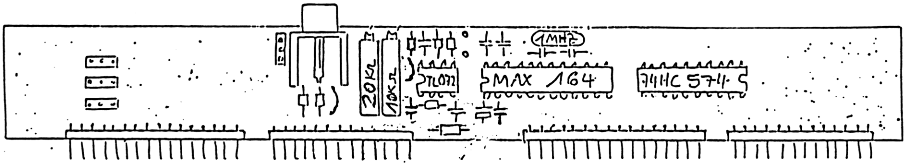
8 Bit Analog Digital Converter



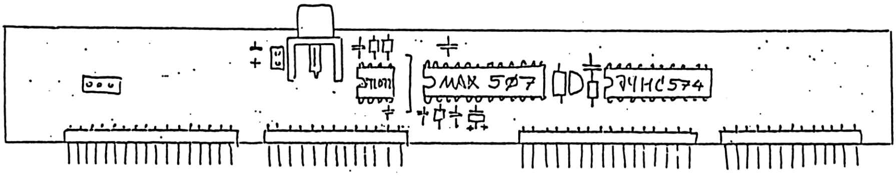
8 Bit Digital Analog Converter



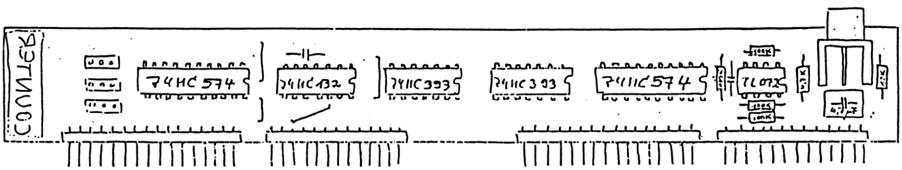
12 Bit Analog Digital Converter



12 Bit Digital Analog Converter



16 Bit Counter-Module

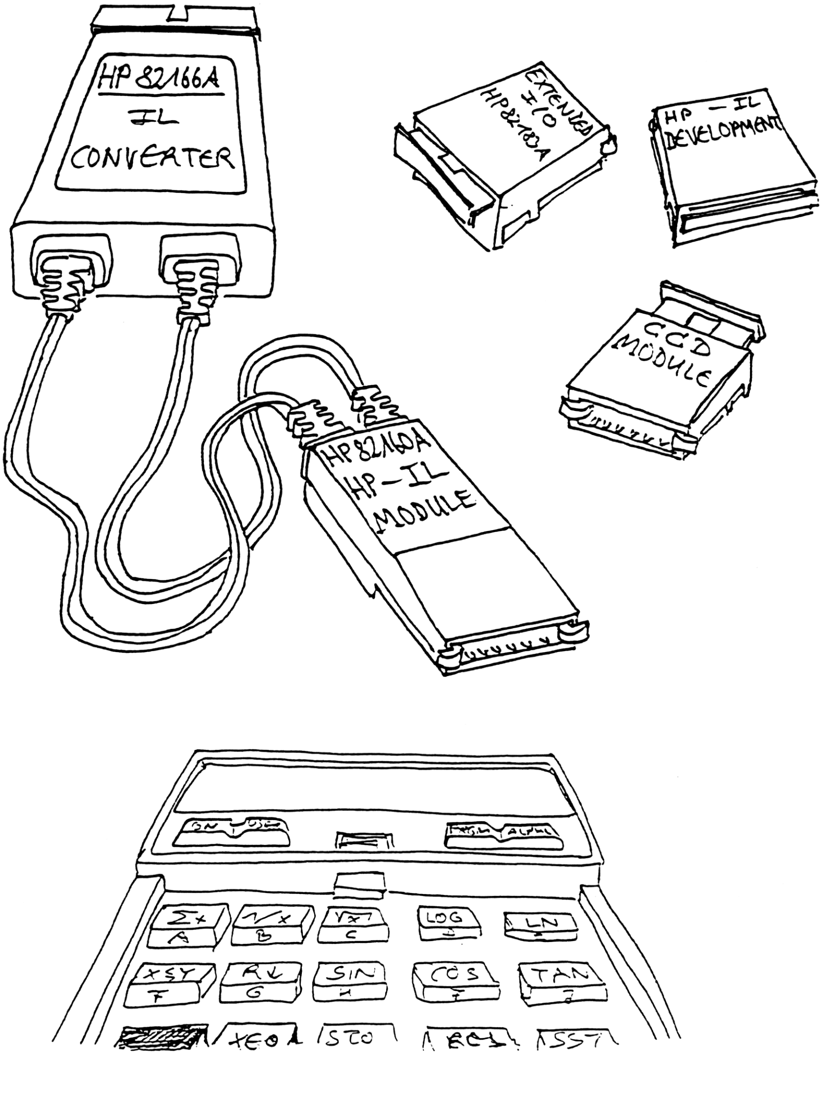


CHAPTER II
HP-41 CONTROLLER

HP-41CX Configuration	II.01
Software for I/O-Module	II.03
Function List	II.04
Program Listings	II.06
Examples	II.09
Software for Development-Module	II.12
Function List	II.14
Program Listings	II.17
Example	II.21
CCD-Module	II.22
Example	II.23
Zeprom-Module	II.24
HP-41 C/CV Configuration	II.25

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Configuration of HP-41 CX IL-Controller :



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

I/O-Board HP-41 Software
for
I/O-Module and Development-Module

The I/O-Board and HP 82166 A IL-Converter are connected to HP-41 handheld computer by HP 82160 A IL-Module. For controlling I/O-Board with HP-41 you must alter some statusregister of the HP 82166 A IL-Converter. Therefore you need the I/O-Module or alternatively the Development-Module. For both HP-41 expansion modules you find software descriptions and documentation on the following pages.

Here is a short list of byte consumption of the I/O-Module control software stored in HP-41 main memory :

$I/O	204 Bytes	30 Register
$IN1X	136 Bytes	20 Register
$IN1A	355 Bytes	51 Register
Σ I/O-Module	695 Bytes	100 Register

And now a short list of byte consumption of the Development-Module control software stored in HP-41 main memory :

DI/O	398 Bytes	57 Register
DOUT1	413 Bytes	59 Register
Σ Development-Module	811 Bytes	116 Register

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

I/O-Board Software for HP-41 CX IL-Controller and I/O-Module :

Controlling I/O-Board with HP-41 CX and I/O-Module is easier and faster than with Development-Module ! The I/O-Module uses the ALPHA-Register to transfer data to IL-Converter. Avoiding problems with loss of leading null bytes in ALPHA-Register, I/O-Module generally works with leading dummy byte D .

For controlling the I/O-Board with HP-41 CX and I/O-Module, 24 commands are given to you for power up/down, initialisation, addressing, manual service request, interrupt, clear, 16-bit I/O-transfer by ALPHA-Register and by X-Register and 8 bit I/O-transfer by X-Register.

For 8 bit I/O-transfer given software needs the X-Memory Module for storage. Alternatively, if you have not X-Memory or HP-41 CX model, you can alter the programm to use Main Memory.

See complete I/O-Board function list and explanations on following sides ! Common sign of these commands is the leading $ character. HP-41 Barcodes of the presented programm listings you find in appendix.

Some example software routines are added for testing LED-Module, Counter-Module, ADC-Module, DAC-Module and for controlling I/O-Board with Time-Module commands.

The following corresponding commands DDL, LAD, UNL, DDT, TAD, UNT of I/O-Module and Development-Module work in a different way ! Insert a module which contains needed functions to lower HP-41 port, or remove the module which is not needed when entering code in programm-modus or assign the USER-keyboard. Alternatively use definite XROM-numbers. In this case you can use both modules together with your HP-41, when programming is finished.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Input / Output-Board Control Functions :

$I/O	Initiate HP 82166 A IL Converter with default values : Strobed Output, positive Data-Logic, negative Handshake-Logic, 100 us DAVO Timeintervall, 16 bit bidirectional Databus, and DAVO Timeout Disable.
$I↗O	Address I/O-Board as active Loop Device. Use this selection as pre-function in combination with other I/O-Board functions when more Loop Devices exist.
PWRUP	Switch I/O-Board to Power On modus.
PWRDN	Switch I/O-Board to Stand By Modus.
$IN1	Read two bytes from Input Port 1 to ALPHA-Register.
$IN2	Read two bytes from Input Port 2 to ALPHA-Register.
$OUT1	Write two bytes from ALPHA-Register to Output Port 1.
$OUT2	Write two bytes from ALPHA-Register to Output Port 2.
$IN1X	Read 16 bit word from Input Port 1 as decimal number to X-Register.
$IN2X	Read 16 bit word fom Input Port 2 as decimal number to X-Register.
$OUT1X	Writes decimal number from X-Register as 16 bit word to Output Port 1.
$OUT2X	Writes decimal number from X-Register as 16 bit word to Output Port 2.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Input / Output-Board Control Functions :

$IN1A	Read byte A from Input Port 1 as decimal number to X-Register.
$IN1B	Read byte B from Input Port 1 as decimal number to X-Register.
$IN2A	Read byte A from Input Port 2 as decimal number to X-Register.
$IN2B	Read byte B from Input Port 2 als decimal number to X-Register.
$OUT1A	Write decimal number from X-Register as byte A to Output Port 1.
$OUT1B	Write decimal number from X-Register as byte B to Output Port 1.
$OUT2A	Write decimal number from X-Register as byte A to Output Port 2.
$OUT2B	Write decimal number from X-Register as byte B to Output Port 2.
$CRFL	Create X-Memory Datafile used by software addressing of 8 bit Ports A und B.
$MSRQ	Start Manual - Service - Request routine of I/O-Board.
$INTR	Interrupt routine activated by active Manual Service Request. Alter programm for your own demands.
CLRDEV	Send Clear command to I/O-Board modules and to the other Loop Devices.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Software :

Initial and address IL-Converter
Manual Service Request and Interupt
16 bit I/O transfer by Alpha-Register

$I/O	$I↗O	$MSRQ	$INTR
$IN1	$IN2	$OUT1	$OUT2

Synthetic text in program line 05 = 068, 064, 000, 020, 000

```
01*LBL "$I/O"
02 "HP82166A"
03 FINDID
04 SELECT
05 "D@⊕⊕⊕"
06 LAD
07 0
08 DDL
09 4
10 OUTAN
11 UNL
12 ADRON
13*LBL "$I^O"
14 "HP82166A"
15 FINDID
16 SELECT
17 MANIO
18 SF 17
19 CLA
20 CLX
21 RTN
22*LBL "$IN1"
23 TRIGGER
24 X<> X
25 X<> X
26 TRIGGER
27 2
28 INAN
29 CLX
30 RTN
31*LBL "$IN2"
32 TRIGGER
33 TRIGGER
34 TRIGGER
35 2
36 INAN
37 CLX
38 RTN
39*LBL "$OUT1"
40 TRIGGER
41 2
42 OUTAN
43 CLX
44 RTN
45*LBL "$OUT2"
46 TRIGGER
47 TRIGGER
48 2
49 OUTAN
50 CLX
51 RTN
52*LBL "$MSRQ"
53 CLX
54 X<>F
55 INSTAT
56 FS? 06
57 GTO "$INTR"
58 X<>Y
59 X<>F
60 "SYS OK"
61 ASTO X
62 CLA
63 RTN
64*LBL "$INTR"
65 X<>Y
66 X<>F
67 "$ MSRQ"
68 ASTO X
69 CLA
70 RTN
71 END
```

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Software :

16 bit I/O transfer by X-Register

$IN1X	$IN2X	$OUT1X	$OUT2X

```
01*LBL "$IN1X"
02 XEQ "$IN1"
03 ATOXR
04 ATOXR
05 256
06 *
07 +
08 CLA
09 RTN
10*LBL "$IN2X"
11 XEQ "$IN2"
12 ATOXR
13 ATOXR
14 256
15 *
16 +
17 CLA
18 RTN
19*LBL "$OUT1X"
20 ENTER^
21 ENTER^
22 256
23 /
24 INT
25 ENTER^
26 ENTER^
27 256
28 *
29 ST- Z
30 RDN
31 "D"
32 XTOA
33 RDN
34 XTOA
35 XEQ "$OUT1"
36 RTN
37*LBL "$OUT2X"
38 ENTER^
39 ENTER^
40 256
41 /
42 INT
43 ENTER^
44 ENTER^
45 256
46 *
47 ST- Z
48 RDN
49 "D"
50 XTOA
51 RDN
52 XTOA
53 XEQ "$OUT2"
54 END
```

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Software :

8 bit I/O transfer by X-Register

$IN1A	$IN1B	$IN2A	$IN2B
$OUT1A	$OUT1B	$OUT2A	$OUT2B

```
01*LBL "$IN1A"
02 "$I/O-FL"
03 4
04 SEEKPTA
05 TRIGGER
06 X<> X
07 X<> X
08 TRIGGER
09 2
10 INAN
11 ATOXR
12 ATOXR
13 SAVEX
14 CLA
15 RTN
16*LBL "$IN1B"
17 "$I/O-FL"
18 5
19 SEEKPTA
20 TRIGGER
21 X<> X
22 X<> X
23 TRIGGER
24 2
25 INAN
26 ATOXR
27 SAVEX
28 CLA
29 RTN
30*LBL "$IN2A"
31 "$I/O-FL"
32 6
33 SEEKPTA
34 TRIGGER
35 TRIGGER
36 TRIGGER
37 2
38 INAN
39 ATOXR
40 ATOXR
41 SAVEX
42 CLA
43 RTN
44*LBL "$IN2B"
45 "$I/O-FL"
46 7
47 SEEKPTA
48 TRIGGER
49 TRIGGER
50 TRIGGER
51 2
52 INAN
53 ATOXR
54 SAVEX
55 CLA
56 RTN
57*LBL "$OUT1A"
58 "$I/O-FL"
59 0
60 SEEKPTA
61 X<>Y
62 SAVEX
63 0
64 SEEKPT
65 "D"
66 GETX
67 XTOA
68 GETX
69 XTOA
70 TRIGGER
71 2
72 OUTAN
73 CLA
74 CLX
75 RTN
76*LBL "$OUT1B"
77 "$I/O-FL"
78 1
79 SEEKPTA
80 X<>Y
81 SAVEX
82 0
83 SEEKPT
84 "D"
85 GETX
86 XTOA
87 GETX
88 XTOA
89 TRIGGER
90 2
91 OUTAN
92 CLA
93 CLX
94 RTN
95*LBL "$OUT2A"
96 "$I/O-FL"
97 2
98 SEEKPTA
99 X<>Y
100 SAVEX
101 2
102 SEEKPT
103 "D"
104 GETX
105 XTOA
106 GETX
107 XTOA
108 TRIGGER
109 TRIGGER
110 2
111 OUTAN
112 CLA
113 CLX
114 RTN
115*LBL "$OUT2B"
116 "$I/O-FL"
117 3
118 SEEKPTA
119 X<>Y
120 SAVEX
121 2
122 SEEKPT
123 "D"
124 GETX
125 XTOA
126 GETX
127 XTOA
128 TRIGGER
129 TRIGGER
130 2
131 OUTAN
132 CLA
133 CLX
134 RTN
135*LBL "$CRFL"
136 "$I/O-FL"
137 8
138 CRFLD
139 END
```

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Test Software LED-Module :

Following HP-41 CX software flashes all LED´s of LED-Module, one after another. Two TRIGGER commands first address Output Port 2. Then complete 16 bit-stream in programm line 04 and 05 is sent out by OUTAN. **$LIGHT** is an example for possible bit-stream data output with I/O-Board.

Synthetic text in programm line 04 = 068, 001, 001, 002, 002, 004, 004, 008, 008, 016, 016, 032, 032, 064, 064,
Synthetic text in programm line 05 = APPEND 128, 128,

```
01*LBL "$LIGHT"
02 TRIGGER
03 TRIGGER
04 "D⊕⊕⊕⊕⊕⊕⊕⊕⊕⊕   @@"
05 "⊁⊕⊕"
06 16
07 OUTAN
08 END
```

Software for Counter-Module :

With following short HP-41 CX software the 16 bit Counter-Module works as frequency-counter in the audio range from 20 Hz ....20 KHz. The CLRDEV command resets counter to zero. Value in programm line 04 depends on the internal clock frequency of used HP-41 IL-Controller. Determine your correct value using a reference frequency-counter.

```
01*LBL "$COUNT"
02 CLRDEV
03 XEQ "$IN1X"
04 2,295
05 /
06 END
```

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Test Software for DAC and ADC :

Following HP-41CX software is used to generate an increasing voltage with digital analog converter. **$DAC** is a 16 bit counter routine. To prevent IL-Controller from low battery failure Flag 49 is tested and powers down system.

```
01*LBL "$DAC"
02 0
03 STO 00
04 STO 01
05*LBL 00
06 "D"
07 RCL 00
08 XTOA
09 RCL 01
10 XTOA
11 XEQ "$OUT1"
12 FS? 49
13 PWRDN
14 FS? 49
15 OFF
16 1
17 ST+ 01
18 256
19 RCL 01
20 X≠Y?
21 GTO 00
22 0
23 STO 01
24 1
25 ST+ 00
26 256
27 RCL 00
28 X≠Y?
29 GTO 00
30 END
```

Following HP-41 CX software is used for testing I/O-Ports, especially digital analog converter and analog digital converter. Connect both units in analog area together and test correct datatransfer with **$ADC** programm. Transmitted output value and received input value are displayed at same time.

```
01*LBL "$ADC"
02 FIX 4
03 "START WERT=?"
04 PROMPT
05 STO 00
06*LBL 01
07 RCL 00
08 XEQ "$OUT1X"
09 XEQ "$IN1X"
10 10000
11 /
12 RCL 00
13 +
14 PSE
15 1
16 ST+ 00
17 FS? 49
18 PWRDN
19 FS? 49
20 OFF
21 GTO 01
22 END
```

I/O-Board and Time-Module :

Following HP-41 CX software program is an example for controlling the I/O-Board by Time-Module commands. The **$SAMP** routine checks the correct switch function of Power Up / Down hardware from I/O-Board. **$SAMP** collects 101 Samples of input datas and stores them in HP-41 main memory. The whole process cyclus is controled by a 30 second time interval. **$SAMP** need **SIZE** 102. Synthetic text in programm line 04 = 068, 000, 000. ↗ = SHIFT ENTER in programm line 24.

```
01*LBL "$SAMP"
02 PWRUP
03 XEQ "$I/O"
04 "D⊕⊕"
05 XEQ "$OUT1"
06 XEQ "$OUT2"
07 101
08 RCL 00
09 X=Y?
10 PWRDN
11 X=Y?
12 OFF
13 FS? 49
14 PWRDN
15 FS? 49
16 OFF
17 CLX
18 ENTER^
19 ENTER^
20 DATE
21 TIME
22 0,003
23 HMS+
24 "^^$SAMP"
25 XYZALM
26 1
27 ST+ 00
28 XEQ "$IN1"
29 ATOXR
30 ATOXR
31 256
32 *
33 +
34 STO IND 00
35 "DZZ"
36 XEQ "$OUT1"
37 XEQ "$OUT2"
38 RCL 00
39 PSE
40 PWRDN
41 OFF
42 END
```

$DATA is a routine to analyze the main memory contents generated by **$SAMP**. The programm compares the 101 collected input data words with reference value. Equal values document a stable function of Power Up / Down hardware.

```
01*LBL "$DATA"
02 0
03 STO 00
04 "WERT=?"
05 PROMPT
06*LBL 01
07 1
08 ST+ 00
09 X<>Y
10 RCL IND 00
11 X<>Y
12 X=Y?
13 GTO 01
14 FIX 0
15 "WERT="
16 ARCL 00
17 "⊦DEF"
18 AVIEW
19 GTO 01
20 .END.
```

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

I/O-Board Software for HP-41 CX IL-Controller and Development-Module :

Controlling I/O-Board with HP-41 CX and Development-Module is more complex and slower than with I/O-Module ! The Development-Module generates a Buffer to transfer data to IL-Converter. An advantage feature of Development-Module is the INTR-routine, which starts HP-41 automatically by an active MSRQ-signal !

For controlling the I/O-Board with HP-41 CX and Development-Module, 22 commands are given to you for power up/down, addressing + initialisation, manual service request, interrupt, clear, 16-bit I/O-transfer by X-Register and by ALPHA-Register, 8 bit I/O-transfer by X-Register.

See complete I/O-Board function list and explanations on following sides ! Common sign of these commands is the leading D character. HP-41 Barcodes of the presented programm listings you find in appendix.

As example software a routine is given for testing LED-Module. The commands DIN1, DIN2 and DOUT1, DOUT2 are added to Development-Module function list to get the full compatibility with presented I/O-Module functions $IN1, $IN2 and $OUT1, $OUT2, which use the ALPHA-Register.

The commands SF33 and CF33 are special Development-Modul functions. Do not enter the standard HP-41 commands SF_33 and CF_33 to alter status of Flag 33 in your programms !

The following corresponding commands DDL, LAD, UNL, DDT, TAD, UNT of I/O-Module and Development-Module work in a different way ! Insert a module which contains needed functions to lower HP-41 port, or remove the module which is not needed when entering code in programm-modus, or assign the USER-keyboard. Alternatively use definite XROM-numbers. In this case you can use both modules together with your HP-41, when programming is finished.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Following diagram shows the contents of Buffer used for I/O-transfer by Development-Module :

00	DOUT1A
01	DOUT1B
02	DOUT2A
03	DOUT2B
04	DIN1A
05	DIN1B
06	DIN2A
07	DIN2B
08	
09	
10	
11	
12	
13	

Use the CCD-Module to copy complete Buffer to X-Memory. You can store and recall some difference I/O Buffer in X-Memory.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

DI/O	Initiate HP 82166 A IL Converter with default values : Strobed Output, positive Data-Logic, negative Handshake-Logic, 100 us DAVO Timeintervall, 16 bit bidirectional Databus, and DAVO Timeout Dissable.
PWRUP	Switch I/O-Board to Power On modus.
PWRDN	Switch I/O-Board to Stand By modus.
DIN1X	Addresses I/O-Board as active Loop Device Read 16 bit word from Input Port 1 as decimal number to X-Register.
DIN2X	Addresses I/O-Board as active Loop Device Read 16 bit word from Input Port 2 as decimal number to X-Register..
DOUT1X	Addresses I/O-Board as active Loop Device Writes decimal number from X-Register as 16 bit word to Output Port 1.
DOUT2X	Addresses I/O-Board as active Loop Device Writes decimal number from X-Register as 16 bit word to Output Port 2.
DCLR	Addresses I/O-Board as active Loop Device Send Clear command to I/O-Board modules.
DMSRQ	Start Manual - Service - Request routine of I/O-Board.
INTR	Interrupt routine activated by active Manual Service Request. Alter programm for your own demands.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

DIN1	Addresses I/O-Board as active Loop Device Read two bytes from Input Port 1 to ALPHA-Register.
DIN2	Addresses I/O-Board as active Loop Device Read two bytes from Input Port 2 to ALPHA-Register.
DOUT1	Addresses I/O-Board as active Loop Device Write two bytes from ALPHA-Register to Output Port 1.
DOUT2	Addresses I/O-Board as active Loop Device Write two bytes from ALPHA-Register to Output Port 2.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

DIN1A	Addresses I/O-Board as active Loop Device Read byte A from Input Port 1 as decimal number to X-Register.
DIN1B	Addresses I/O-Board as active Loop Device Read byte B from Input Port 1 as decimal number to X-Register..
DIN2A	Addresses I/O-Board as active Loop Device Read byte A from Input Port 2 as decimal number to X-Register
DIN2B	Addresses I/O-Board as active Loop Device Read byte B from Input Port 2 as decimal number to X-Register.
DOUT1A	Addresses I/O-Board as active Loop Device Write decimal number from X-Register as byte A to Output Port 1.
DOUT1B	Addresses I/O-Board as active Loop Device Write decimal number from X-Register as byte B to Output Port 1.
DOUT2A	Addresses I/O-Board as active Loop Device Write decimal number from X-Register as byte A to Output Port 2.
DOUT2B	Addresses I/O-Board as active Loop Device Write decimal number from X-Register as byte B to Output Port 2.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Software :

16 bit I/O transfer by Alpha-Register
8 bit I/O transfer by X-Register

DIN1	DIN2	DOUT1	DOUT2
DIN1A	DIN1B	DIN2A	DIN2B
DOUT1A	DOUT1B	DOUT2A	DOUT2B

```
01*LBL "DOUT1"
02 ASTO X
03 1
04 PT=
05 RDN
06 A-XR
07 X-BUF
08 RDN
09 0
10 PT=
11 RDN
12 A-XR
13 X-BUF
14 RDN
15 XEQ 01
16 ARCL X
17 CLX
18 RTN
19*LBL "DOUT2"
20 ASTO X
21 3
22 PT=
23 RDN
24 A-XR
25 X-BUF
26 RDN
27 2
28 PT=
29 RDN
30 A-XR
31 X-BUF
32 RDN
33 XEQ 02
34 ARCL X
35 CLX
36 RTN
37*LBL "DOUT1A"
38 0
39 PT=
40 RDN
41 X-BUF
42 GTO 01
43*LBL "DOUT1B"
44 1
45 PT=
46 RDN
47 X-BUF
48*LBL 01
49 "HP82166A"
50 FINDID
51 TRIGGER
52 CLA
53 SF 17
54 SF33
55 LAD
56 RDN
57 0
58 PT=
59 RDN
60 2
61 OUTBUFX
62 RDN
63 CF33
64 RTN
```

HP-41 CX Software :

16 bit I/O transfer by Alpha-Register
8 bit I/O transfer by X-Register

DIN1	DIN2	DOUT1	DOUT2
DIN1A	DIN1B	DIN2A	DIN2B
DOUT1A	DOUT1B	DOUT2A	DOUT2B

```
 65*LBL "DOUT2A"
 66 2
 67 PT=
 68 RDN
 69 X-BUF
 70 GTO 02
 71*LBL "DOUT2B"
 72 3
 73 PT=
 74 RDN
 75 X-BUF
 76*LBL 02
 77 "HP82166A"
 78 FINDID
 79 TRIGGER
 80 TRIGGER
 81 CLA
 82 SF 17
 83 SF33
 84 LAD
 85 RDN
 86 2
 87 PT=
 88 RDN
 89 2
 90 OUTBUFX
 91 RDN
 92 CF33
 93 RTN
 94*LBL "DIN1"
 95 XEQ 03
 96 4
 97 PT=
 98 1
 99 BUF-XB
100 "D"
101 X-AR
102 1
103 BUF-XB
104 X-AR
105 CLX
106 RTN
107*LBL "DIN2"
108 XEQ 04
109 6
110 PT=
111 1
112 BUF-XB
113 "D"
114 X-AR
115 1
116 BUF-XB
117 X-AR
118 CLX
119 RTN
120*LBL "DIN1A"
121 XEQ 03
122 4
123 PT=
124 1
125 BUF-XB
126 RTN
127*LBL "DIN1B"
128 XEQ 03
129 5
130 PT=
131 1
132 BUF-XB
133 RTN
134*LBL 03
135 "HP82166A"
136 FINDID
137 TRIGGER
138 X<> X
139 X<> X
140 TRIGGER
141 CLA
142 SF 17
143 SF33
144 TAD
145 4
146 PT=
147 2
148 INBUFX
149 CF33
150 RTN
151*LBL "DIN2A"
152 XEQ 04
153 6
154 PT=
155 1
156 BUF-XB
157 RTN
158*LBL "DIN2B"
159 XEQ 04
160 7
161 PT=
162 1
163 BUF-XB
164 RTN
165*LBL 04
166 "HP82166A"
167 FINDID
168 TRIGGER
169 TRIGGER
170 TRIGGER
171 CLA
172 SF 17
173 SF33
174 TAD
175 6
176 PT=
177 2
178 INBUFX
179 CF33
180 END
```

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Software :

Initial and address IL-Converter
Send Clear command to Modules
Manual Service Request and Interupt
16 bit I/O transfer by X-Register

DI/O	DCLR	DMSRQ	INTR
DIN1X	DIN2X	DOUT1X	DOUT2X

```
01*LBL "DI/O"
02 FS? 33
03 CF33
04 "HP82166A"
05 FINDID
06 CLA
07 SF 17
08 SF33
09 LAD
10 8
11 BSIZEX
12 0
13 PT=
14 AIPT
15 64
16 X-BUF
17 0
18 X-BUF
19 20
20 X-BUF
21 0
22 X-BUF
23 0
24 DDL
25 0
26 PT=
27 4
28 OUTBUFX
29 UNL
30 CF33
31 CLX
32 RTN
33*LBL "DOUT1X"
34 "HP82166A"
35 FINDID
36 TRIGGER
37 CLA
38 SF 17
39 SF33
40 LAD
41 RDN
42 0
43 PT=
44 RDN
45 256
46 X<>Y
47 X<Y?
48 GTO 01
49*LBL 02
50 X-BUF
51 0
52 PT=
53 2
54 OUTBUFX
55 CF33
56 RDN
57 RDN
58 RTN
59*LBL 01
60 0
61 X-BUF
62 RDN
63 GTO 02
64*LBL "DOUT2X"
```

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Software :

Initial and address IL-Converter
Send Clear command to Modules
Manual Service Request and Interupt
16 bit I/O transfer by X-Register

DI/O	DCLR	DMSRQ	INTR
DIN1X	DIN2X	DOUT1X	DOUT2X

```
 65 "HP82166A"
 66 FINDID
 67 TRIGGER
 68 TRIGGER
 69 CLA
 70 SF 17
 71 SF33
 72 LAD
 73 RDN
 74 2
 75 PT=
 76 RDN
 77 256
 78 X<>Y
 79 X<Y?
 80 GTO 03
 81*LBL 04
 82 X-BUF
 83 2
 84 PT=
 85 2
 86 OUTBUFX
 87 CF33
 88 RDN
 89 RDN
 90 RTN
 91*LBL 03
 92 0
 93 X-BUF
 94 RDN
 95 GTO 04
 96*LBL "DIN1X"
 97 "HP82166A"
 98 FINDID
 99 TRIGGER
100 X<> X
101 X<> X
102 TRIGGER
103 CLA
104 SF 17
105 SF33
106 TAD
107 RDN
108 4
109 PT=
110 MIPT
111 2
112 INBUFX
113 BUF-XB
114 AIPT
115 CF33
116 RTN
117*LBL "DIN2X"
118 "HP82166A"
119 FINDID
120 TRIGGER
121 TRIGGER
122 TRIGGER
123 CLA
124 SF 17
125 SF33
126 TAD
127 RDN
128 6
129 PT=
130 MIPT
131 2
132 INBUFX
133 BUF-XB
134 AIPT
135 CF33
136 RTN
137*LBL "DCLR"
138 "HP82166A"
139 FINDID
140 CLA
141 SF 17
142 SF33
143 LAD
144 SDC
145 CF33
146 RTN
147*LBL "DMSRQ"
148 AUTOIO
149 FS? 44
150 OFF
151 3
152 ENTER^
153 64
154 WREG
155 0
156 ENTER^
157 64
158 WREG
159 SF 18
160 CLX
161 RTN
162*LBL "INTR"
163 FRNS?
164 RFRM
165 SRQR?
166 GTO 01
167 RTN
168*LBL 01
169 "MAN SER REQU"
170 AVIEW
171 IDY
172 SRQR?
173 RTN
174 CLD
175 RTN
176 END
```

Test Software LED-Module :

Following HP-41 CX software flashes all LED´s of LED-Module, one after another. First the Buffer is loaded with bytes. Then I/O-Board Output Port 2 is addressed. Now the complete 30 byte string is transmitted from Buffer to I/O-Board. DLIHGT software is an example for possible byte-string output with Development-Module ! Buffer size depends on number of transmitted bytes.

```
01*LBL "DLIGHT"
02 30
03 BSIZEX
04 0
05 PT=
06 AIPT
07 128
08 X-BUF
09 1
10 X-BUF
11 64
12 X-BUF
13 2
14 X-BUF
15 32
16 X-BUF
17 4
18 X-BUF
19 16
20 X-BUF
21 8
22 X-BUF
23 8
24 X-BUF
25 16
26 X-BUF
27 4
28 X-BUF
29 32
30 X-BUF
31 2
32 X-BUF
33 64
34 X-BUF
35 1
36 X-BUF
37 128
38 X-BUF
39 2
40 X-BUF
41 64
42 X-BUF
43 4
44 X-BUF
45 32
46 X-BUF
47 8
48 X-BUF
49 16
50 X-BUF
51 16
52 X-BUF
53 8
54 X-BUF
55 32
56 X-BUF
57 4
58 X-BUF
59 64
60 X-BUF
61 2
62 X-BUF
63 128
64 X-BUF
65 1
66 X-BUF
67 "HP82166A"
68 FINDID
69 TRIGGER
70 TRIGGER
71 SF 17
72 SF33
73 LAD
74 CLA
75 SF 00
76*LBL 01
77 0
78 PT=
79 30
80 OUTBUFX
81 FS?C 00
82 GTO 01
83 CF33
84 CLX
85 END
```

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

I/O-Board Software for HP-41 CX IL-Controller and CCD-Module :

For controlling I/O-Board you do not require the German CCD-Module, but this helpful module expands HP-41 handheld computer with 100 powerful commands, programmed in machine-language. Some of them are fantastic for use with I/O-Board :

With CCD-Module you can easily enter synthetic ALPHA-text lines : Switch on to ALPHA-Mode and deactivate USER-Mode. Now you key in bytes direct with SHIFT, ENTER↗ in decimal-format, or with SHIFT, ENTER↗, H in hex-format.

CCD-Module contents a set of binary functions. It is more extensive than the binary function set of Development-Module. You find logic-operations, bitmanipulation, bitshifting, bitrotation, complements, and you can set wordsize. These functions are optimal for use with I/O-Board.

Using I/O-Board in data collection applications, you can process values with given matrix-functions of CCD-Module

CCD-Module offers some commands which can be used with HP Interface Loop : CAT 0 lists all Loop-Devices. You can stop CAT 0 with R/S and select actual shown Device with ENTER↗. Or clear Device by pressing C . Command CAT 7 lists directory of Cassette Drive.

A load byte routine LB for synthetic programming with CCD-Module you find on next side. A plott-programm for HP-41 Barcodes with IL-Converter and HP Desk Jet 500 is given in appendix.

To avoid problems with incompatibility of CCD-Module and Development-Module, when used together, insert CCD-Module to lower port of HP-41 !

Synthetic Program Lines :

With the following short routine **LB** you can create synthetic program lines of any length in your HP-41 memory. The „Load **Byte**“ routine takes advantage of some powerful CCD-Module functions. : It is a short replacement for classic Byte-Jumpers, Byte-Grabbers or the PPC-Rom **LB** function.

With the CCD-Module you can easily edit synthetic ALPHA Text, but the extended **XEQ** function of the CCD-Module can only create synthetic two byte functions ! Use **LB** to create synthetic short form exponents, synthetic three byte GTO´s and more :

```
LBL "LB"
A+
LBL 00
"BYTE=?"
PROMPT
X<>Y
A-
X<>Y
POKEB
RDN
GTO 00
END
```

For comfortable synthetic programming assign the functions **PC>X** , **LB** and **X>PC** to the USER-Keys **A** (11), **B** (12) and **C** (13). Then follows the steps to use **LB** :

- ☐ Go to program row, where you want to create a synthetic line. **PRGM**-Mode On. Insert one "+" (Plus) per byte. (Key in for two bytes "++", for three bytes "+++", and so on).
- ☐ Go back to the first Plus. Switch **PRGM**-Mode Off. Key with **PC>X** absolut address to **X** -Register.
- ☐ Now start **"LB".** and load bytes with **R/S.** Stop byte prompt with keying **X>PC**
- ☐ **PRGM**-Mode On : Here you see the the actual created synthetic program line !

HP 82166 A Input / Output Board :

HP-41 and Zeprom-Module :

The Zeprom-Module is a special EPROM, housed in a HP-41 plug in module case. It is produced by Zengrange (London), who also developed the well known HP-41 Zenrom-Module. Using special hard- and software tools, user can store own program applications inside Zeprom-Module. Doing this with the control software of this manual, Zeprom-Module gives you maximal advantage for working with HP-41 and I/O-Board :

☐ Software inside Zeprom-Module is stored permanent and protected against memory lost.

☐ HP-41 main memory is completely free for your own program applications.

☐ Zeprom-Module contains rom copys of CCD-Module and I/O-Module. Complete hardware extensions and software needed for use with I/O-Board now realized in only one HP-41 plug in port.

☐ Software inside Zeprom-Module creates three different keyboards with I/O-Board control functions for fast and comfortable use. The keyboards selected by pressing softkeys.

☐ I/O-Board core of Zeprom-Module contains 51 commands for controlling I/O-Board and 12 utility functions. Advanced functions included like I/O-Board alarm functions (CHAPTER VII) or for printing Barcodes (CHAPTER IX).

Detailed informations about burning Zeprom-Module and using internal software for controlling I/O-Board you will find in CHAPTER XI. The high price for Zeprom-Module is the only disadvantage (£ 90,- plus VAT plus shipping). Comprising coasts of the provided internal rom modules, the profit of comfortable operation and reaching your maximal system performance, reflect on Zeprom-Module as powerful HP-41 extension.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41C and HP-41CV Configuration :

The minimal HP-41 port configuration for controlling I/O-Board needs only the IL-Module HP 82160A and the EXT I/O-Module HP 82183A :

I/O-Module	
IL-Module	

The minimal software program solution for controlling I/O-Board needs only six commands : $I/O and $I↑O for initialisation IL-Converter, $IN1 and $IN2 for data input to Alpha Register and $OUT1 and $OUT2 for data output by Alpha Register.

Execute $IN1 or $IN2 for 16 bit data input. Than use I/O-Module command ATOXR two times for transfering input data one byte after another from Alpha to X-Register.

Write dummy byte "D" to Alpha Register and load 16 bit output data one byte after another from X-Register to Alpha Register by using I/O-Module command XTOAR two times. Than execute $OUT1 or $OUT2 for data output.

This operating technic is easy for any control application and requires no synthetic programming. To avoid the synthetic text line from $I/O programm, in this software version synthetic text line is replaced by using standard commands.

Three additionaly utility commands $MSRQ, $INTR and $CHK not neccessary for operating, but helpful for testing I/O-Board status. Some more comfort gives you the 16 bit data I/O by X-Register using $IN1X, $IN2X and $OUT1X, $OUT2X commands.

For 8 bit data I/O by X-Register use $IN1A, $IN1B, $IN2A, $IN2B and $OUT1A, $OUT1B, $OUT2A, $OUT2B. The 8 bit data I/O commands normally workes with 8 register X-Memory data file "$I/O-FL" for software port addressing. In this version data is stored in main memory register 00...07, if no X-Function Module with X-Memory is availlable.

Single bit operations you can realize by using X< >FIO command of I/O-Module. This exchanges byte number in X-Register with flag status 00...07. For testing input data bits use FS? or FC? command, for setting output data bits use SF or CF command.

For saving main memory space for your own software programs, delete this parts of I/O-Board control program, you do not need for your application !

HP 82166 A Input / Output Board :

```
01*LBL "$I/O"
02*LBL 10
03 "HP82166A"
04 FINDID
05 SELECT
06 LAD
07 "D"
08 64
09 XTOAR
10 0
11 XTOAR
12 20
13 XTOAR
14 0
15 XTOAR
16 0
17 DDL
18 4
19 OUTAN
20 UNL
21 ADRON
22 0
23 STO 00
24 STO 01
25 STO 02
26 STO 03
27*LBL "$I↑O"
28 "HP82166A"
29 FINDID
30 SELECT
31 MANIO
32 SF 17
33 CLA
34 CLX
35 RTN
-------------------
36*LBL "$MSRQ"
37 CLX
38 X<>F
39 INSTAT
40 FS? 06
41 GTO "$INTR"
42 X<>Y
43 X<>F
44 "$OK"
45 ASTO X
46 CLA
47 RTN
48*LBL "$INTR"
49 X<>Y
50 X<>F
51 "$SRQ"
52 ASTO X
53 CLA
54 RTN
55*LBL "$CHK"
56 SF 25
57 PWRUP
58 FC? 25
59 GTO 11
60 XEQ 10
61 XEQ "$MSRQ"
62 RTN
63*LBL 11
64 "$ERR"
65 ASTO X
66 CLA
67 RTN
-------------------
68*LBL "$IN1"
69*LBL 20
70 TRIGGER
71 X<> X
72 X<> X
73 TRIGGER
74 2
75 INAN
76 CLX
77 RTN
78*LBL "$IN2"
79*LBL 21
80 TRIGGER
81 TRIGGER
82 TRIGGER
83 2
84 INAN
85 CLX
86 RTN
87*LBL "$OUT1"
88*LBL 22
89 TRIGGER
90 2
91 OUTAN
92 CLX
93 RTN
94*LBL "$OUT2"
95*LBL 23
96 TRIGGER
97 TRIGGER
98 2
99 OUTAN
100 CLX
101 RTN
-------------------
102*LBL "$IN1X"
103 XEQ 20
104 ATOXR
105 ATOXR
106 256
107 *
108 +
109 CLA
110 RTN
111*LBL "$IN2X"
112 XEQ 21
113 ATOXR
114 ATOXR
115 256
116 *
117 +
118 CLA
119 RTN
120*LBL "$OUT1X"
121 ENTER^
122 ENTER^
123 256
124 /
125 INT
126 ENTER^
127 ENTER^
128 256
129 *
130 ST- Z
131 RDN
132 "D"
133 XTOAR
134 RDN
135 XTOAR
136 XEQ 22
137 RTN
138*LBL "$OUT2X"
139 ENTER^
140 ENTER^
141 256
142 /
143 INT
144 ENTER^
145 ENTER^
146 256
147 *
148 ST- Z
149 RDN
150 "D"
151 XTOAR
152 RDN
153 XTOAR
154 XEQ 23
155 RTN
-------------------
156*LBL "$IN1A"
157 TRIGGER
158 X<> X
159 X<> X
160 TRIGGER
161 2
162 INAN
163 ATOXR
164 ATOXR
165 STO 04
166 CLA
167 RTN
168*LBL "$IN1B"
169 TRIGGER
170 X<> X
171 X<> X
172 TRIGGER
173 2
174 INAN
175 ATOXR
176 STO 05
177 CLA
178 RTN
179*LBL "$IN2A"
180 TRIGGER
```

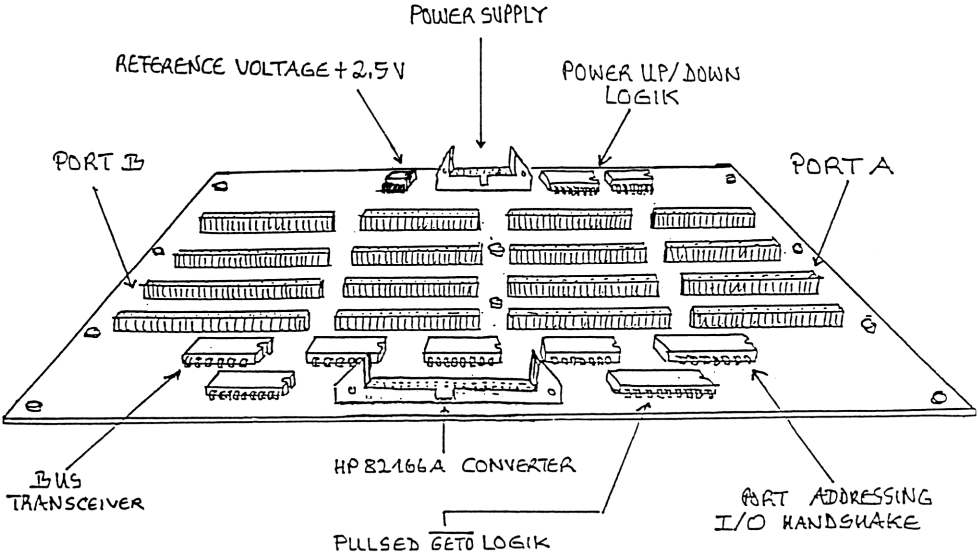
```
181 TRIGGER
182 TRIGGER
183 2
184 INAN
185 ATOXR
186 ATOXR
187 STO 06
188 CLA
189 RTN
190*LBL "$IN2B"
191 TRIGGER
192 TRIGGER
193 TRIGGER
194 2
195 INAN
196 ATOXR
197 STO 07
198 CLA
199 RTN
200*LBL "$OUT1A"
201 STO 00
202 "D"
203 RCL 00
204 XTOAR
205 RCL 01
206 XTOAR
207 TRIGGER
208 2
209 OUTAN
210 CLA
211 CLX
212 RTN
213*LBL "$OUT1B"
214 STO 01
215 "D"
216 RCL 00
217 XTOAR
218 RCL 01
219 XTOAR
220 TRIGGER
221 2
222 OUTAN
223 CLA
224 CLX
225 RTN
226*LBL "$OUT2A"
227 STO 02
228 "D"
229 RCL 02
230 XTOAR
231 RCL 03
232 XTOAR
233 TRIGGER
234 TRIGGER
235 2
236 OUTAN
237 CLA
238 CLX
239 RTN
240*LBL "$OUT2B"
241 STO 03
242 "D"
243 RCL 02
244 XTOAR
245 RCL 03
246 XTOAR
247 TRIGGER
248 TRIGGER
249 2
250 OUTAN
251 CLA
252 CLX
253 RTN
254 END
```

CHAPTER III
I/O-BOARD HARDWARE

Feature List	**III.00**
Octal Bus Transceiver	**III.01**
Port Addressing	**III.02**
Power-On-Reset and Clear	**III.04**
Power-Up/Down and MSRQ	**III.05**
Supply Voltages	**III.06**
Reference Voltage	**III.06**
Power Supply Connector	**III.07**
Extern Wiring	**III.08**
Supply Currents	**III.09**
Soldering Side	**III.10**
Wiring Diagram	**III.11**
Component Side	**III.14**
Component List	**III.15**
Circuit Diagram	**III.16**
I/O-Board Chassis	**III.17**

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

I/O-Board Hardware Feature List :



- EXTERN AC- OR DC POWER SUPPLY
- SOLAR POWERED RECHARGEABLE CELL AVAILLABLE
- MOTHERBOARD DESIGN WITH PLUG IN MODULES
- TWO 16 BIT INPUT SLOTS / TWO 16 BIT OUTPUT SLOTS
- ALTERNATIV PLUG IN OF 8 BIT MODULES POSSIBLE
- PORT ADDRESSING WITH PULSED GETO-LINE
- EXTERN POWER UP / DOWN CONTROL SIGNAL
- MSRQ LOGIC (MANUAL SERVICE REQUEST)
- MSRQ - POWER DOWN LOCK
- REFERENCE VOLTAGE ON BOARD
- CLEAR FUNCTION FOR INSERTED MODULES

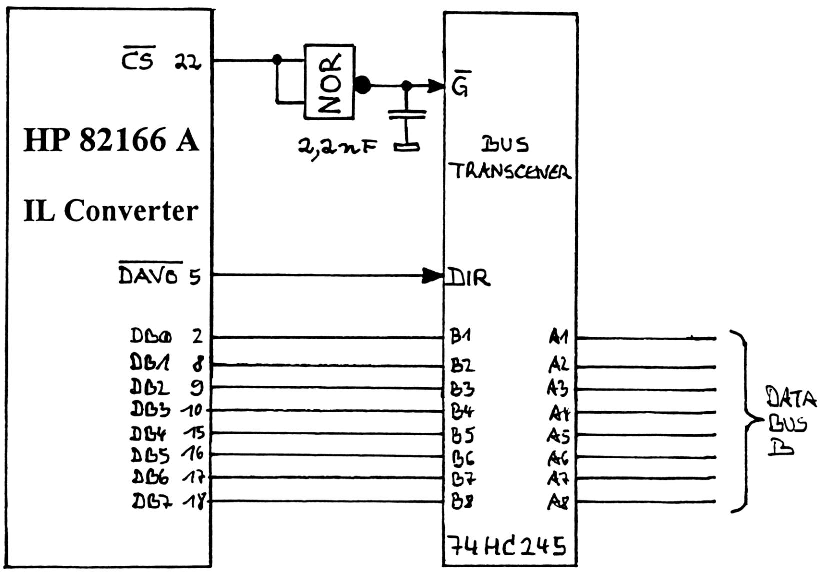
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Octal Bus Transceiver on Port B :

To obtain 16 bit wordsize for I/O datatransfer, Data Bus A (high significant byte) and Data Bus B (low significant byte) of IL-Converter are used. Data Bus A transfers only I/O-Board data. Data Bus B is used for intern IL-Converter data transfer and for extern I/O-Board data transfer !

The octal bus transceiver 74HC245 wired to Data Bus B selects extern data, addressed by $\overline{CS}$ line of IL-Converter. $\overline{CS}$ pulse is inverted by nor gate, driving the enable input $\overline{G}$ of octal bus transceiver. Limiting rise-time and fall-time of nor gate output signal pulse by 2,2 nF MKT condensor prevents the ⊕ 5V supply line from voltage spikes !

Communication direction of octal bus transceiver is set by $\overline{DAVO}$ line of IL-Converter.

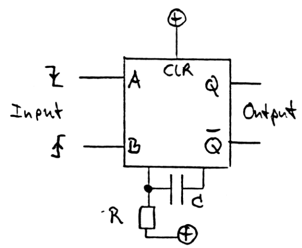


HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Port Addressing by Pulsed GETO-Line :

Port Addressing of I/O-Board is done only by pulsed GETO-Line (Trigger signal). This techique does not use the Clear-Line or the Power-Down-Line of IL-Converter, as Gary Friedman describes in his book „Control the World with HP-IL“. Advantage of the pulsed GETO-Line is full compatibility when interacting with other standard Loop-Devices !

The HP-41 CX software control pulsed GETO-Line by a sequence of TRIGGER commands. Typical time interval is 60 ms (milli-seconds). Exact value depends on internal clock of used handheld computer. The timing of address logic of I/O-Board must be tuned exact to used handheld !



Therefore no resistant values are given, needed by the monostable multivibrators 74HC123. Determine your individual resistance values by own pulse length measurements, using ramp-generator and oscilloscope. Because timing depends on used supply voltage and IC-producer.

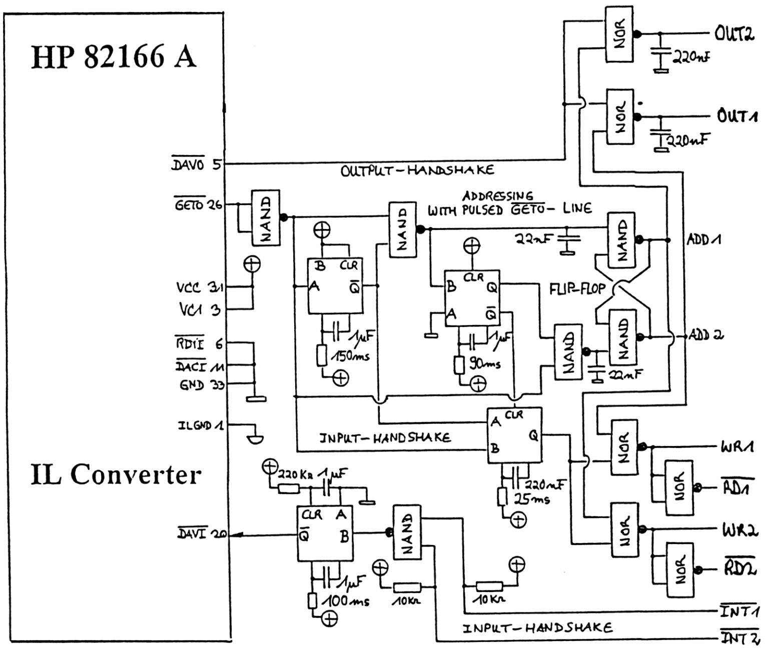
Input handshake need 100 ms timing (take over from Gray Friedmann). The pulsed address logic needs 150 ms, 90 ms and 25 ms timing. Where exact timing is not critical, resistant values are given to you in circuit diagram !

$OUT1	$OUT2	$IN1	$IN2
TRIGGER	TRIGGER	TRIGGER	TRIGGER
	TRIGGER	NOP	TRIGGER
		TRIGGER	TRIGGER

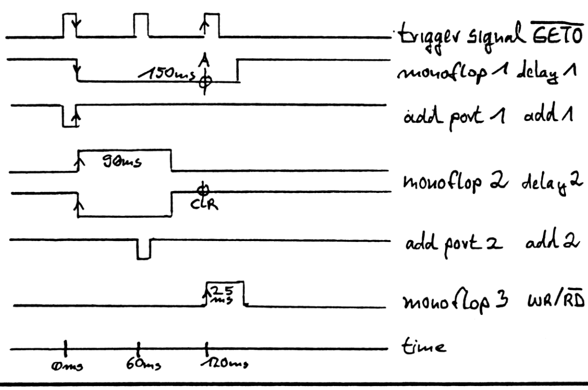
To address Input Ports of I/O-Board the control software uses pattern of TRIGGER commands. The needed pause is generated by NOP's (no operation command). Using the **X<>X** function two times you get the wanted 60 ms time interval.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

The pulsed GETO-Line hardware is connected to a flip-flop for storage of address status. Selection of Input Port 1 / 2 or Output port 1 / 2 is done by some following NOR-gates.



Exact timing of pulsed GETO-Line address logic is shown in following diagram. Using other handheld computers like HP-41 for controlling the I/O-Board, for example the HP-71, you must analyze their actual timing and then alter address circuit of I/O-Board for correct timing function.



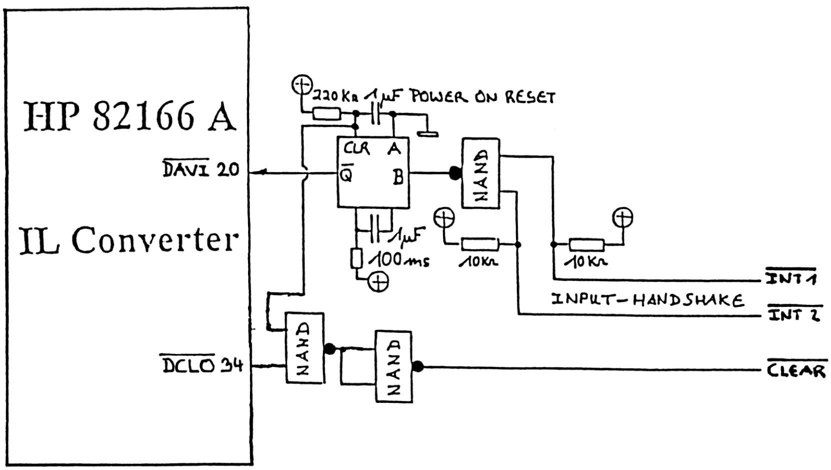
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Power-On-Reset and Clear-Function :

When I/O-Board is waked up from POWER DN to active POWER UP state, input signals of INT1 and INT2 lines must locked a short moment, reaching not DAVI port (Pin 20) of IL-Converter.

This is realized by wiring the CLR line of 100 ms input pulse expanding monostable multivibrator 74HC123 to small Power-On-Reset circuit (R=220kΩ/C=1μF).

If no input modules are inserted to I/O-Board, two 10 kΩ pull up resistors from INT1 and INT2 lines to ⊕ 5V prevent system from unknown logic input levels or spikes.



Also Power-On-Reset signal is wired to nand-gate transfering the DCLO signal (Pin 34) from IL-Converter to plug in modules.

If inserted modules have clear-capability, reset is activated always when system powers up, or when IL-controller send CLRDEV command (I/O-Module) or run DCLR routin (Development-Module).

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Power Up / Down and MSRQ-Logic :

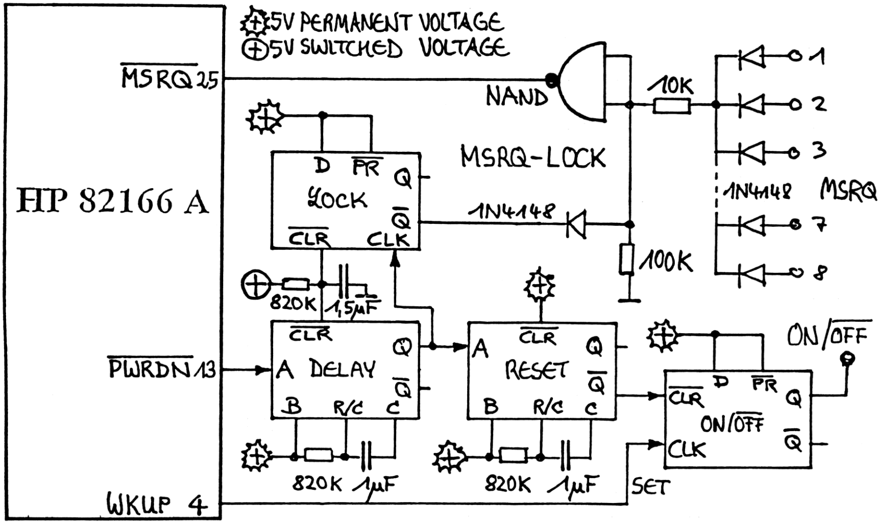
The Power Up/Down function of HP Interface Loop Devices is an important feature for mobile and battery powered applications in the field. Consequentely this ability is added to I/O-Board !

Extern Power Supply of I/O-board is controlled by On/Off signal. This signal is generated by a permanent powered D Flip Flop 74HC74, using WAKUP and delayed PWRDN lines of IL-Converter. Supply current for this circuit is lower than 10 µA. Therefore consume of electric energy is minimal in Power Down mode. Furthermore I/O-Board needs four supply voltages, generated by the extern Power Supply only in Power Up mode.

Another feature of HP Interface Loop Devices is their ability of sending service request messages to the IL-Controller. The I/O-board uses this option to detect Manual Service Request signals of inserted modules.

When MSRQ signal is active, IL-Converter can not Power Down correctly. To exclude this limitation if a Power Down command occurs, the I/O-Board has a MSRQ-Lock. A diode switches to GND and disables activ MSQR signal, driven by a dual monostable multivibrator 74HC123 and D Flip Flop 74HC74, which delays Power Down signal of IL-Converter.

The timing of following Power UP / Down and MSRQ-Lock circuit is not critical. You can use given resistance values.



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

I/O-Board Power Supply Voltages :

Power supply is no part of I/O-Board. An external power supply is wired to existing power connector on motherboard. This feature enabels user to change power supply flexible to actual application of system. The I/O-Board needs five different supply voltages :

- ⚙ 5V = PERMANENT VOLTAGE FOR SWITCHING ON/OFF
- ⊕ 5V = IL-CONVERTER AND MOTHERBOARD HARDWARE
- ⊞ 5V = PLUG IN MODULES (DIGITAL SUPPLY VOLTAGE)
- ◈ 15V = PLUG IN MODULES (ANALOG SUPPLY VOLTAGE)
- ◇ 15V = PLUG IN MODULES (ANALOG SUPPLY VOLTAGE)

To get a maximum of safety to interface system, IL-Converter and I/O-Board hardware are powered by an own +5V digital supply voltage. Trouble of plug in modules do not affect expensive HP 82166 A IL-Converter !

The ⚙ 5V permanent supply voltage is used only for Power Up/Down circuits. I/O-Board hardware including IL-Converter and plug in modules are powered by the switched supply voltages, activated by On/Off signal.

Digital-GND ⏊ and Analog-GND ⏚ are connected together on power supply unit, not on I/O-Board.

I/O-Board Reference Voltage :

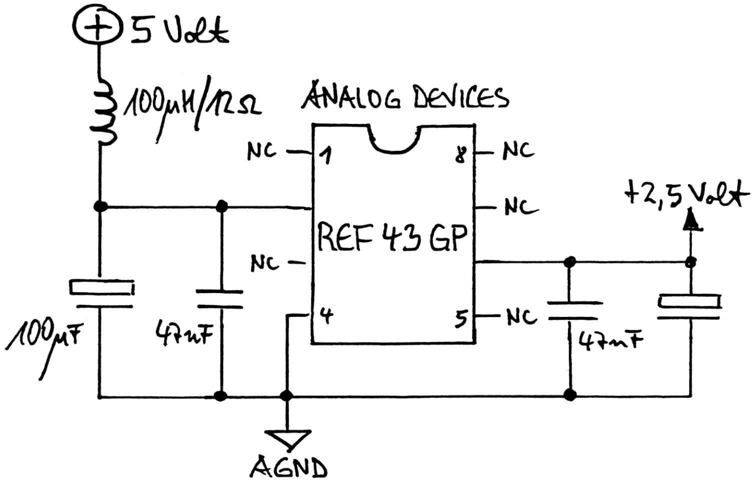
The I/O-Board supplies plug in modules with 2,5V reference voltage, generated by Analog Devices REF43 low power precision voltage reference. For example 8 bit ADC and DAC-Modules need the reference voltage.

A better solution is to generate local reference voltages on belonging modules. The 12 bit ADC and DAC dispose of reference voltages direct on chip !

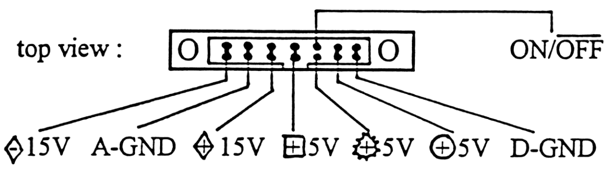
You can plug in such advantage modules in other I/O-Boards (with little different reference voltage) without changing your software. This can have effects, if software compensates the nonlinear characteristic of an adapted sensorelement.

HP 82166 A Input / Output Board :

+2,5 Volt Low Power Precision Reference :

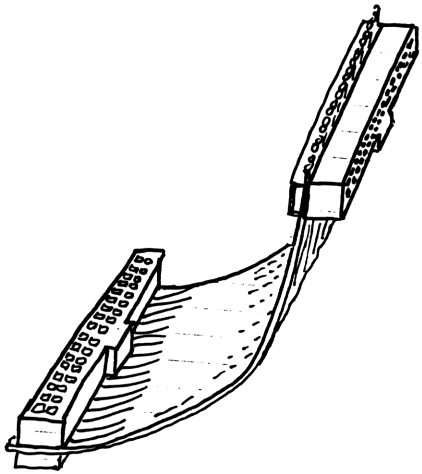


I/O-Board Power Supply Connector :

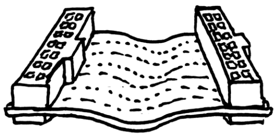


HP 82166 A 16 BIT INPUT / OUTPUT BOARD

I/O-Board Extern Wiring :



Extern Wiring
I/O-Board ↔ IL-Converter
flat ribbon cable length = 55 mm



Extern Wiring
Power Supply ↔ I/O-Board
flat ribbon cable length = 35 mm

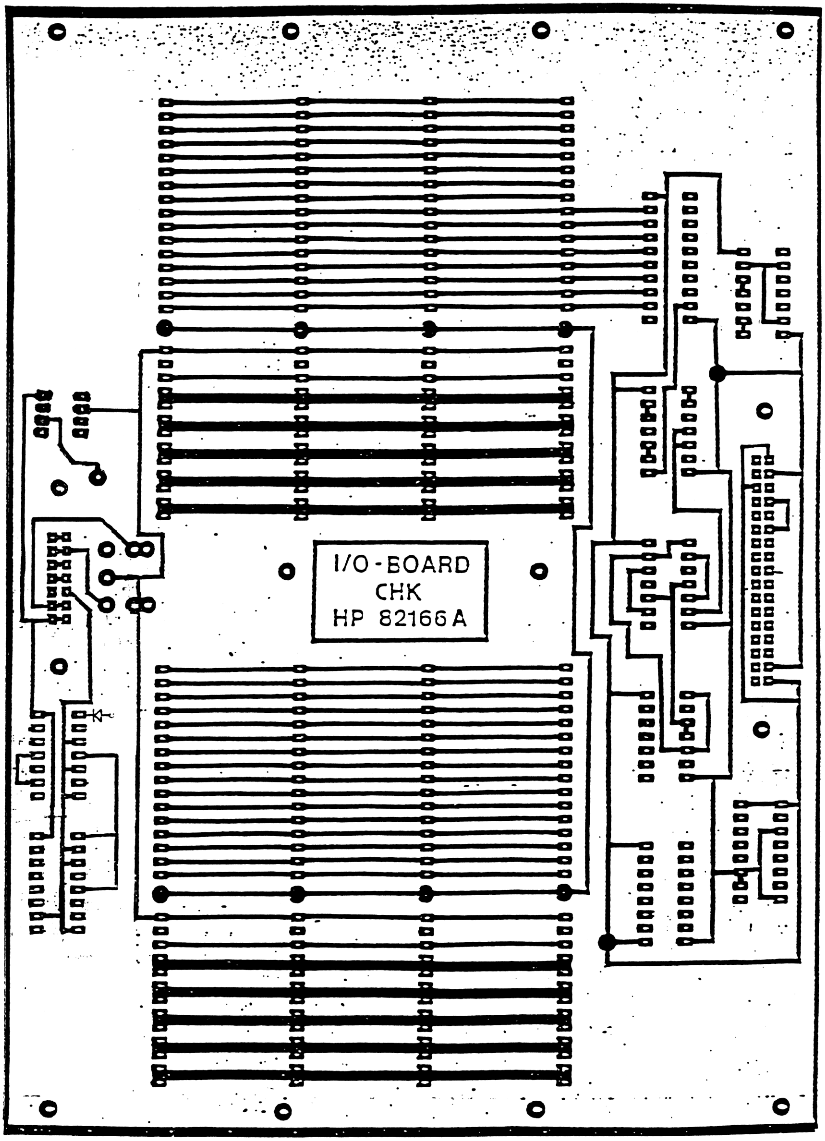
I/O-Board Power Supply Currents :

Following list of typical power supply currents are measured for I/O-Board and plug in modules. Given values do not include losses, additionally produced by the connected Power Supply Unit. That is important when using I/O-Board in battery driven applications.

Power supply current consumer	+ 5 Volt	+ 15 Volt	- 15 Volt
I/O-Board Power Down	max 10 µA		
I/O-Board Power UP	70 mA		
8 bit Manual Input Module	4 mA		
8 Bit LED Module	55 mA		
8 bit Input Module	1,5 mA		
8 bit Output Module	1,5 mA		
8 bit Opto Isolated Input Module	1,5 mA		
8 bit Opto Isolat. Output Module	15 mA		
8 bit Open Collector Module			
8 bit ADC	1,5 mA	8 mA	8 mA
8 bit DAC	2,5 mA	10 mA	15 mA
12 bit ADC	5 mA	8 mA	8 mA
12 bit DAC	5 mA	15 mA	10 mA

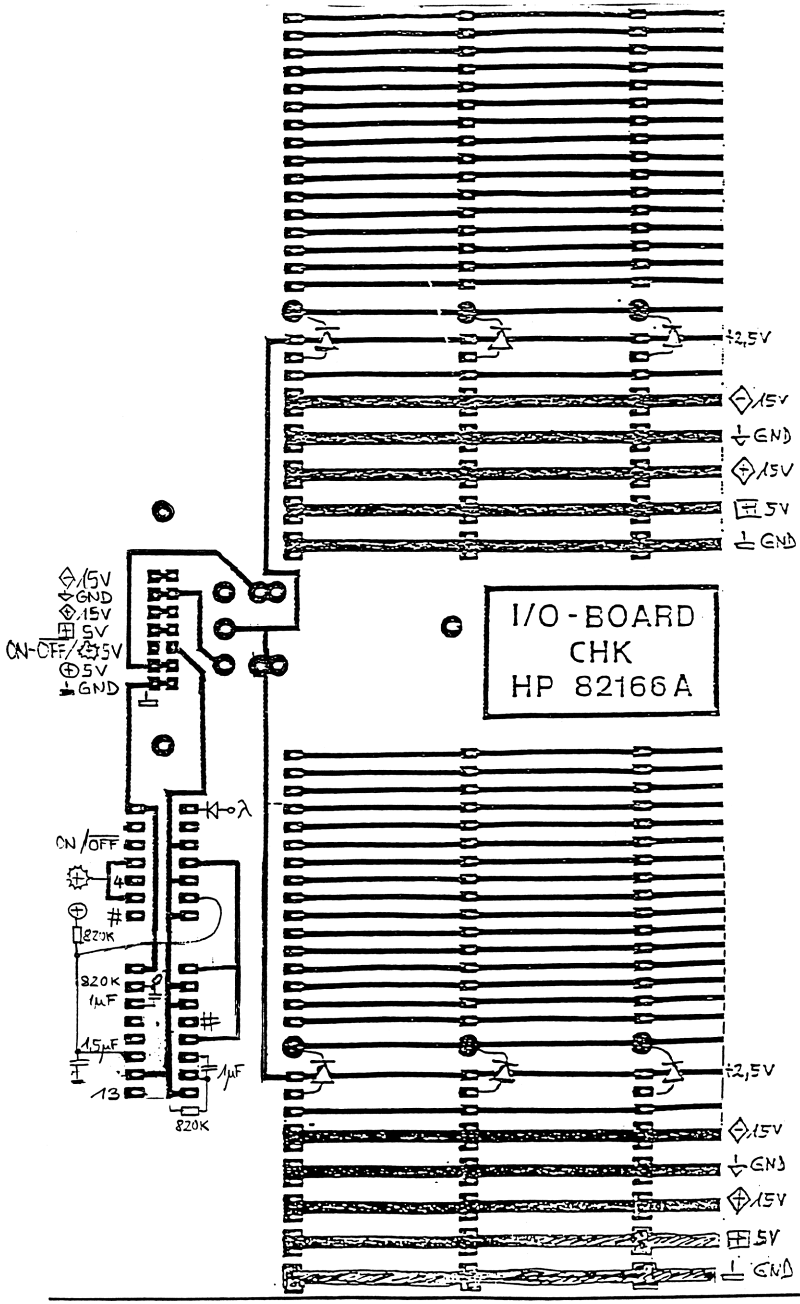
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

I/O-Board Soldering Side :



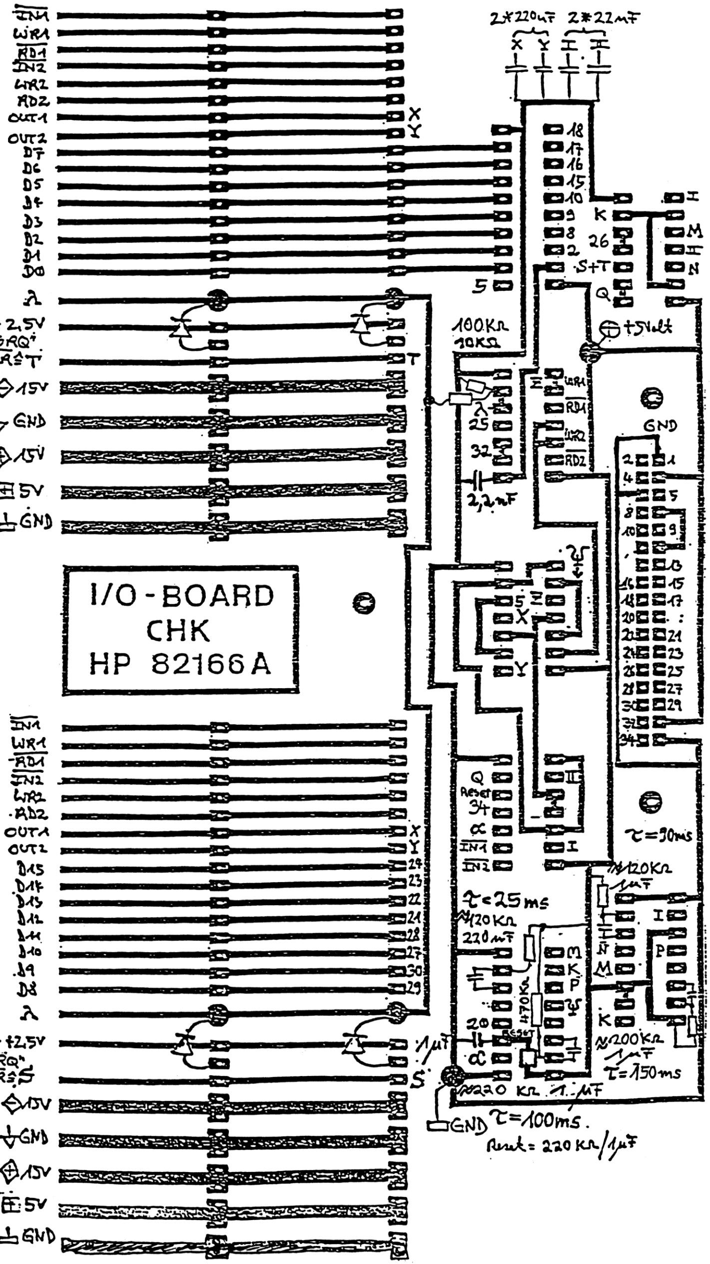
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

I/O-Board Updated Wiring Diagram :



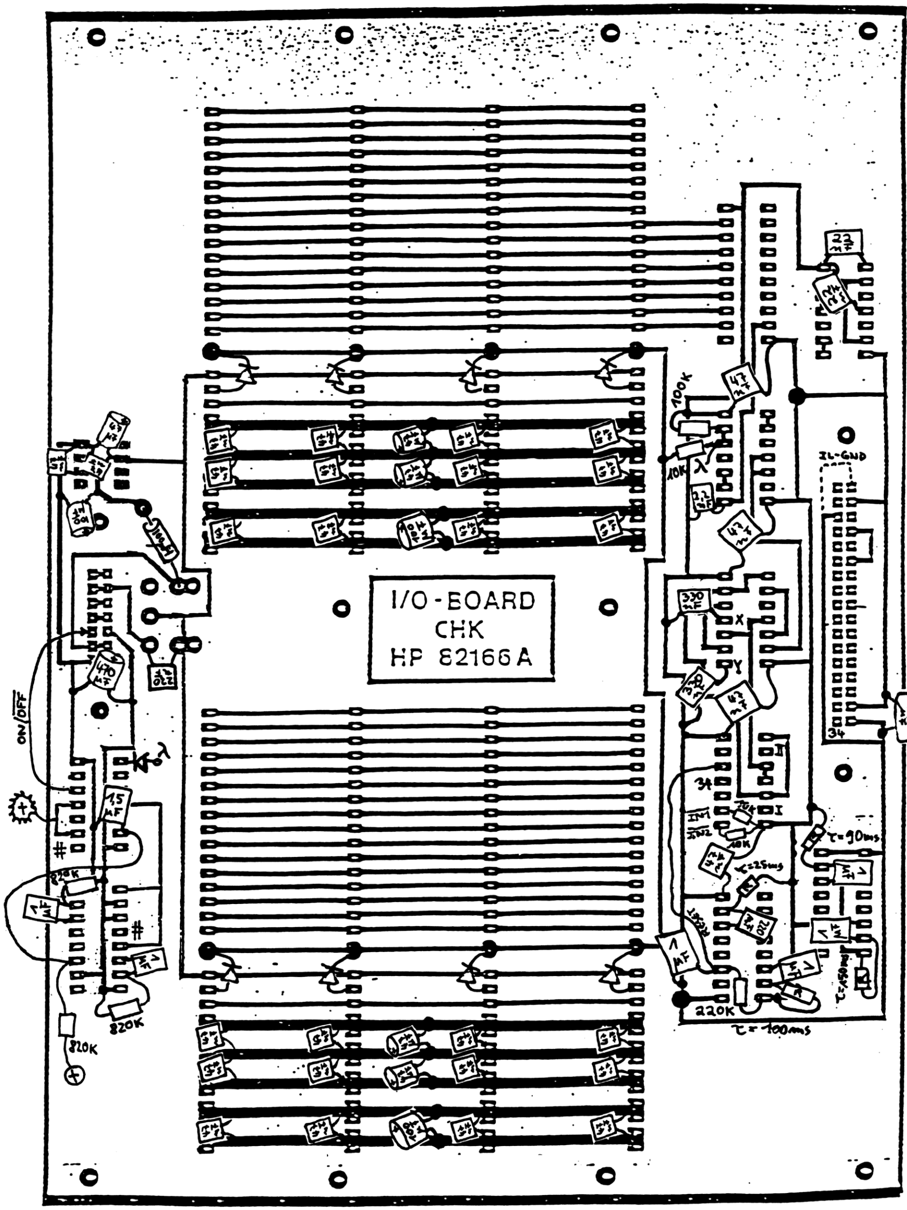
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

I/O-Board Wiring Diagram :



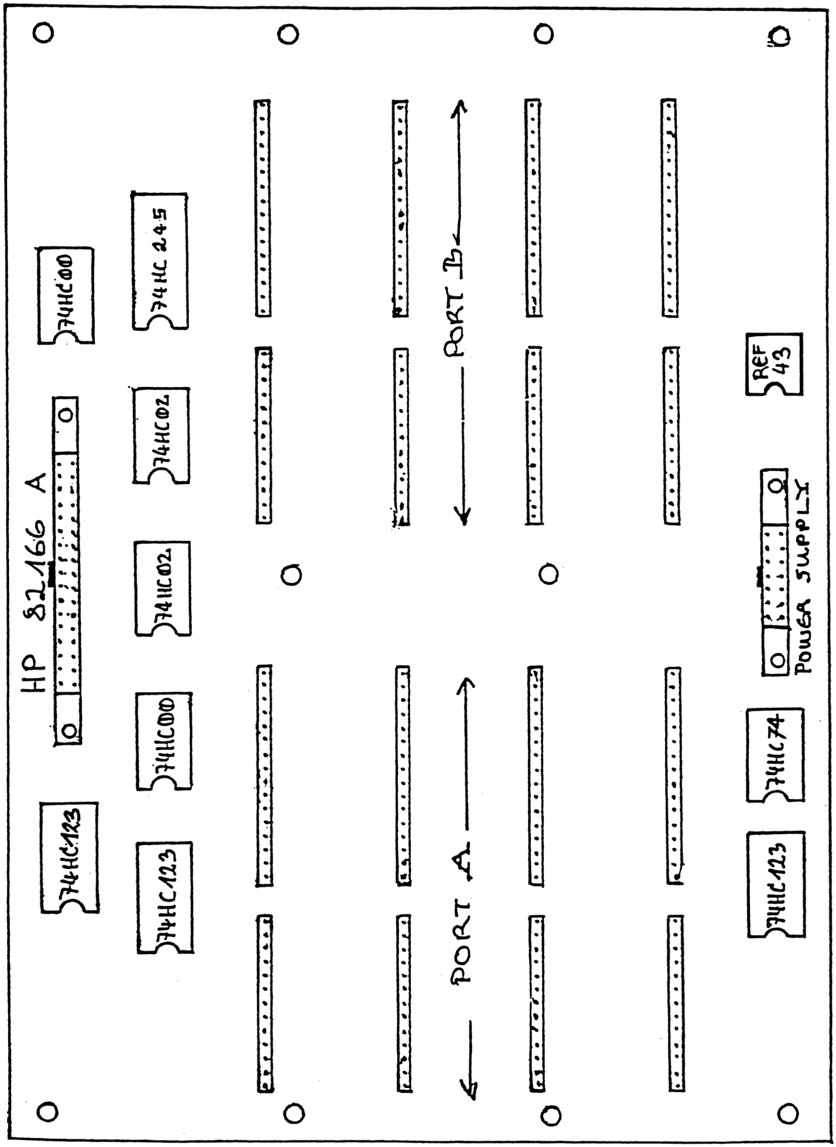
HP 82166 A Input / Output Board :

I/O-Board Soldering Side including Components :



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

I/O-Board Component Side :

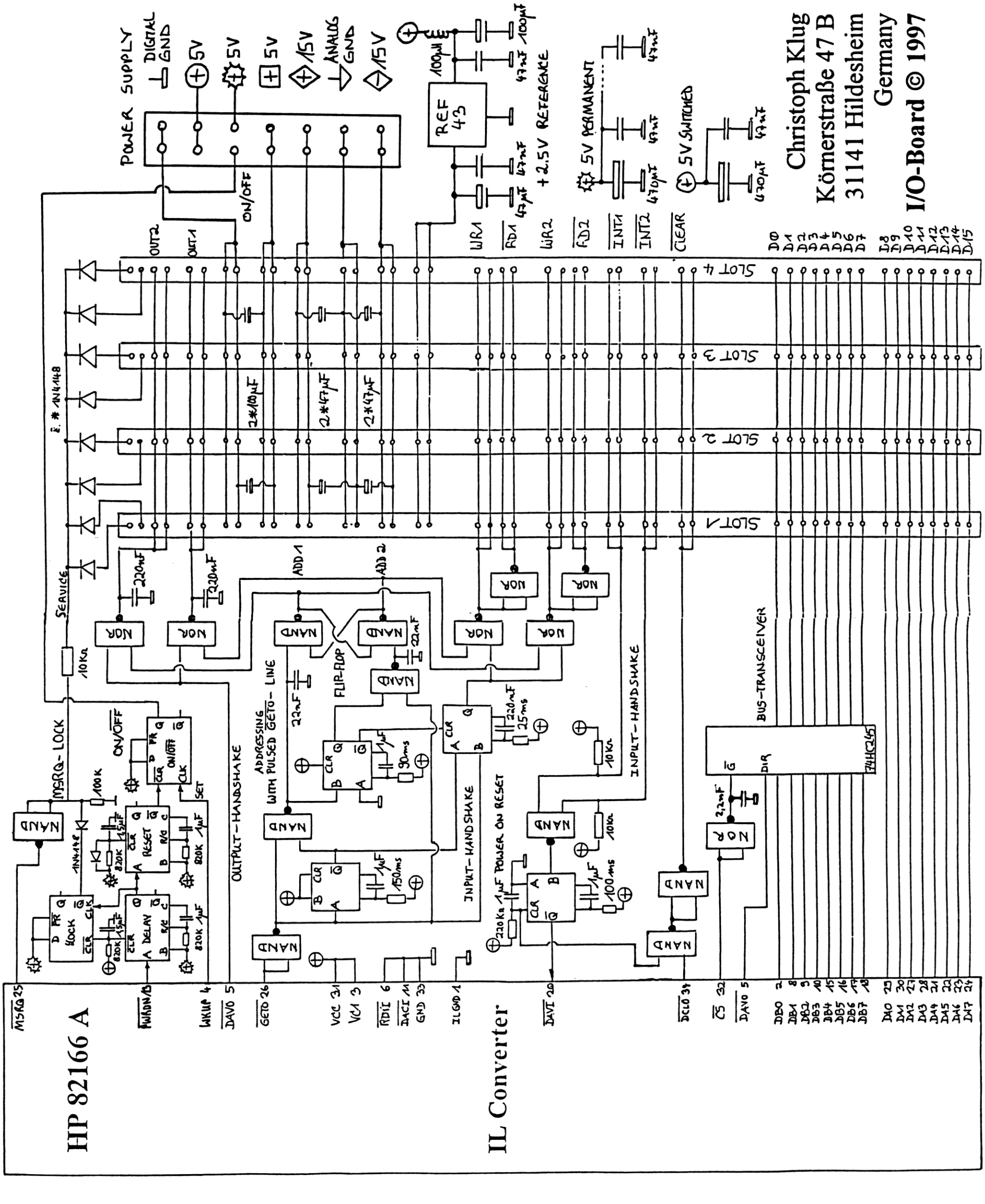


HP 82166 A 16 BIT INPUT / OUTPUT BOARD

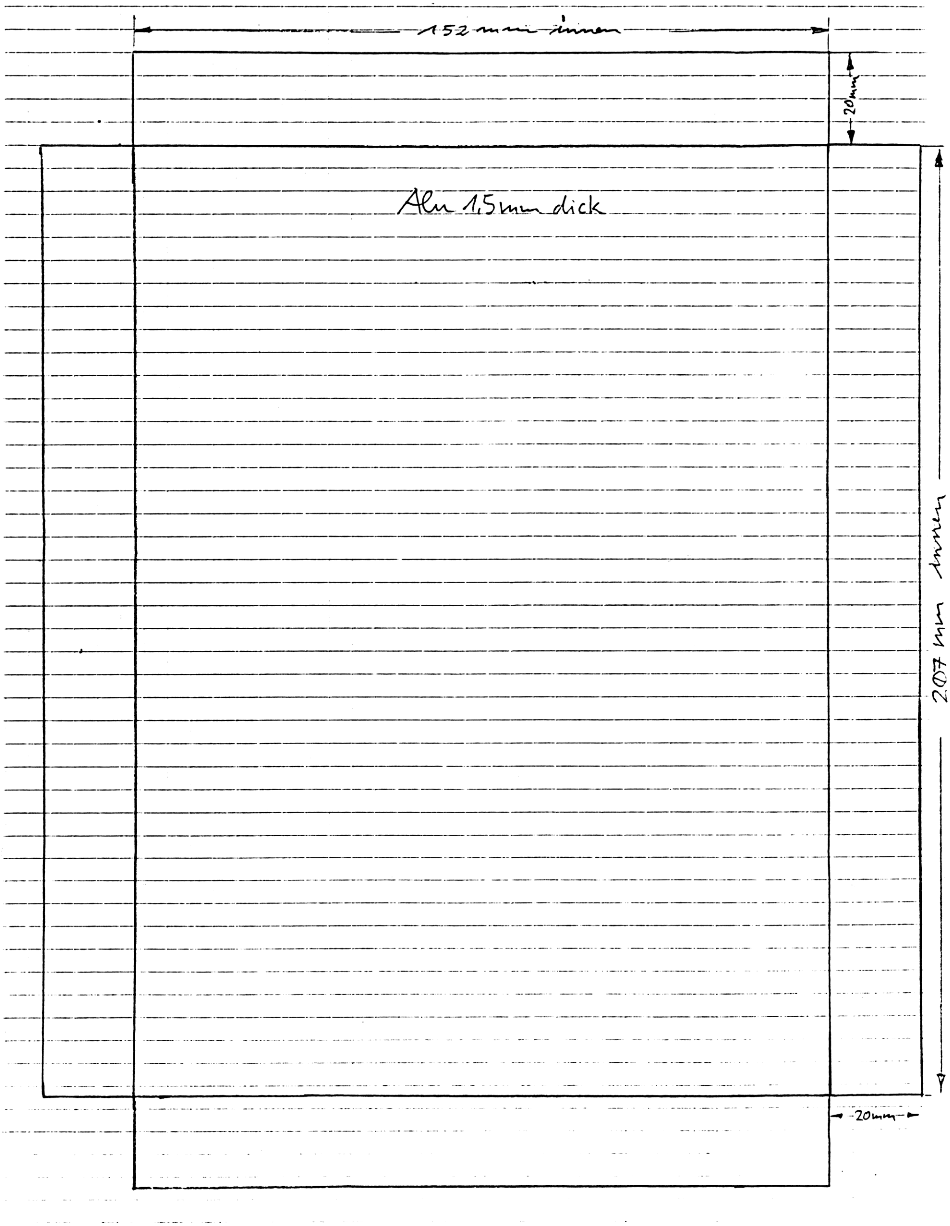
I/O-Board Component List :

3	x	74HC123 Monostable Multivibtaror
2	x	74HC00 Nand Gate
2	x	74HC02 Nor Gate
1	x	74HC74 Dual Flip Flop
1	x	74HC245 Octal Bus Transceiver
1	x	Analog Devices REF 43 Voltage Reference + 2,5 V
9	x	1N4148 Diode
3	x	10 KOhm
1	x	100 KOhm
1	x	220 KOhm
3	x	820 KOhm
4	x	measured resistances in 100 Kohm range (see text)
1	x	2,2 nF MKT Wima
2	x	22 nF MKT Wima
1	x	220 nF MKT Wima
2	x	330 nF MKT Wima
5	x	1 µF MKT Wima
1	x	1,5 µF MKT Wima
1	x	Inductor Coil 100 µH / 12 Ω
19		47 nF ceramics for blocking ⊕ ⊕ ⊞ ⊕ ⊖ to GND
5	x	47 µF Elko low ESR
3	x	100 µF Elko low ESR
2	x	470 µF Elko low ESR
8	x	Female Headers with 13 contacts for square pins
8	x	Female Headers with 16 contacts for square pins
1	x	Strip Line Connector Male Header SVA straight version with extractor 34 contacts
1	x	Strip Line Connector Male Header SVA straight version with extractor 14 contacts

HP 82166 A 16 BIT INPUT / OUTPUT BOARD



I/O-Board Chassis :



CHAPTER IV
POWER SUPPLY

220 Volt AC Power Supply — **IV.01**

- **Component Side** — **IV.02**
- **Soldering Side** — **IV.03**
- **Component List** — **IV.04**

6 Volt DC Power Supply with 10 μA PWRDN Current — **IV.05**

- **Circuit Diagram** — **IV.06**
- **Printed Board** — **IV.07**
- **Component List** — **IV.08**
- **Power Supply Chassis** — **IV.09**

Solar Regulator — **IV.10**

Plug-In Charger — **IV.11**

6 Volt Lead Cell — **IV.12**

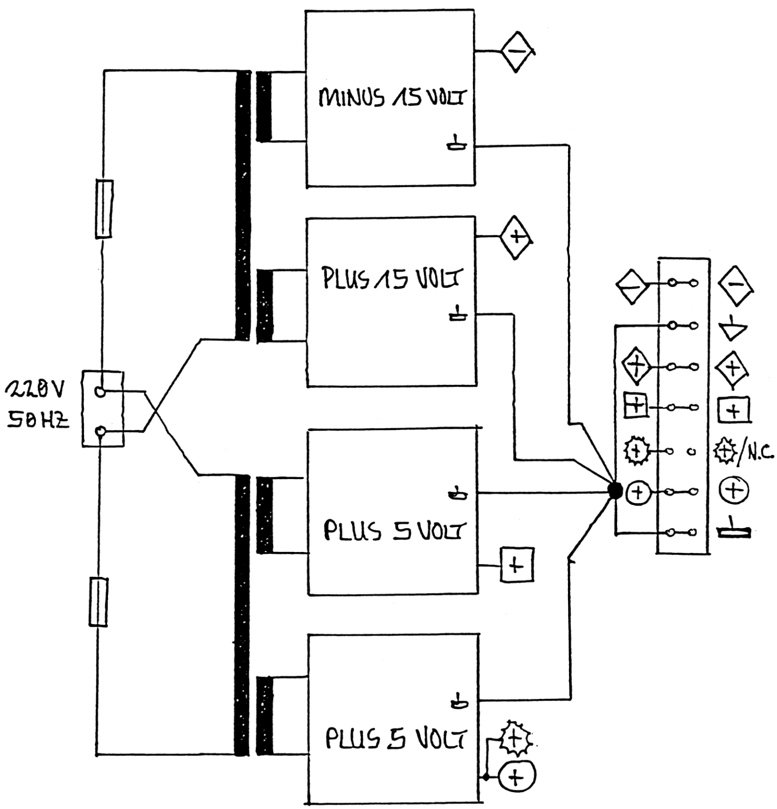
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

220 Volt AC Power Supply :

If using the I/O-Board stationary on your work bench, connect a 220 Volt AC power supply. Insert a HF-Filter-Box between power line and AC power supply to prevent system from spikes and brake down pulses. AC power supply have no ON/OFF switching capability !

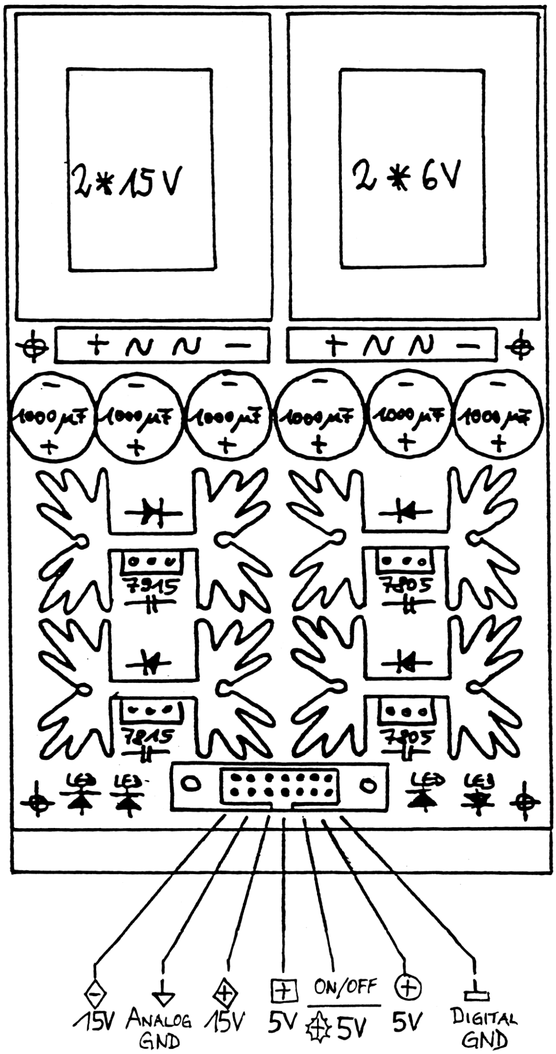
Following low cost circuit supplies I/O-Board with the four needed voltages. Attention ! Danger of death ! Think about dangerous voltage level of 220 Volt AC power line. Therefore mount power supply in an insulated plastic box or case. Insert fuses in supply lines of both transformers. Do not touch high voltage lines !

On power supply board you find the common GND connection of system, Digital-GND and Analog-GND switched together.



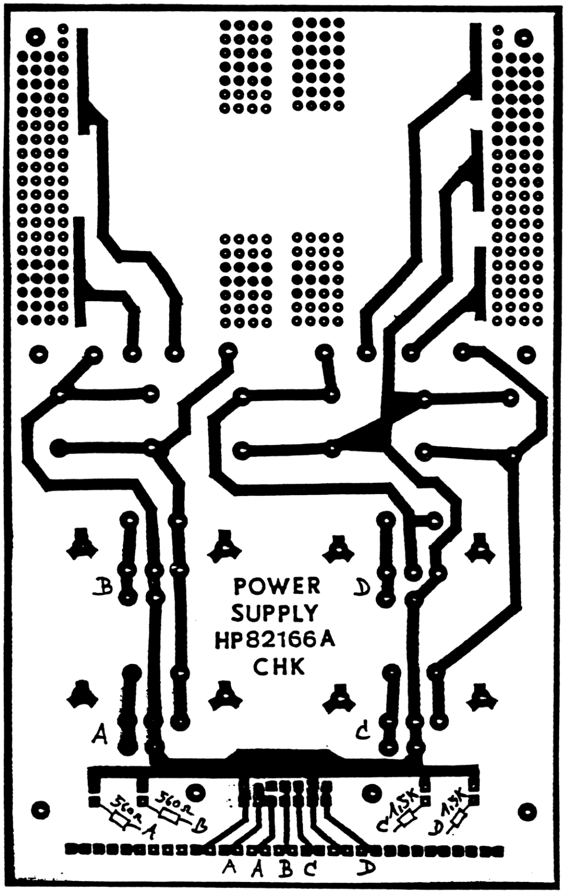
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

220 Volt AC Power Supply Component Side :



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

220 Volt AC Power Supply Soldering Side :



HP 82166 A Input / Output Board :

AC Power Supply Component List :

1	x	transformer 2 x 15V
1	x	transformer 1 x 6V
2	x	bridge rectifier
6	x	electrolytic capacitor 1000 µF/35V
4	x	electrolytic capacitor 47 µF/35V
4	x	ceramic capacitor 100 nF
2	x	560 Ω
2	x	1,5 kΩ
4	x	LED 3 mm Ø red
4	x	diode 4007
2	x	voltage regulator 7805
1	x	voltage regulator 7815
1	x	voltage regulator 7915
4	x	heat sink (Conrad 188301-22)
1	x	strip line connector male header SVA straight version with extractor 14 contacts

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

6 Volt DC Power Supply :

The presented 6 Volt DC Power Supply was developed to make possible mobile applications of I/O-Board. A 6 Volt rechargeable lead-cell is optimal for use with the small DC power supply unit, which is mechanically fixed on backside of I/O-Board.

Input voltage range is from +5,5V to +11V max. Reverse polarity protection diode and L-C Filter circuit are added to input. Stand by current is lower than 10μA.

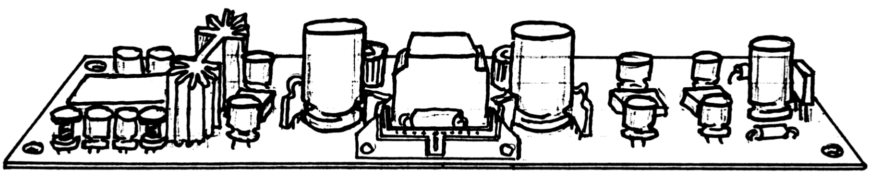
A small regulator-circuit using a 6,8 Volt Z-diod and a 2SC3420 transistor generates ⊕ 5V permanent voltage.

Two low-drop voltage regulators produce ⊕ 5V for motherboard hardware and ⊞ 5V for plug in modules. The used MAX603 regulators have 500 mA output currents and power shutdown pins controlled by ON/OFF signal !

A third low-drop Max603 regulator is wired to a BD605 transistor to expand output current range. Use a small heat sink for BD605. This circuit supplys a standart 24 DIP pinning V 3 W DC/DC-Converter for ◈ 15V and ◇ 15V and ± 100 mA max output current.

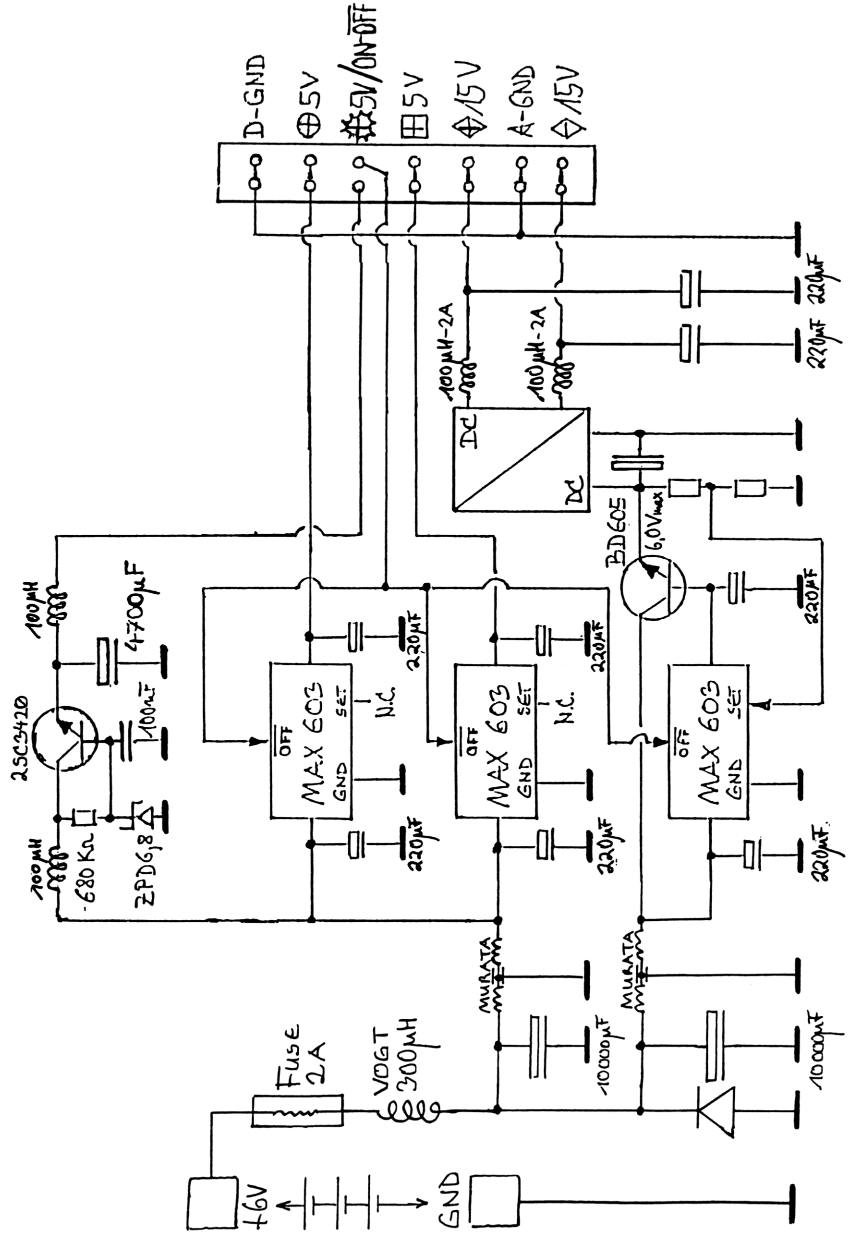
I choose a M+RM 3VRD5W15LC dual DC/DC-Converter with wide input voltage range from + 4,5V to + 6V. No load input current is only 20 mA. Full load input current is 800 mA.

Optionally exists a extern regulator unit to load 6 Volt rechargeable lead-cell by a small solar-panel.



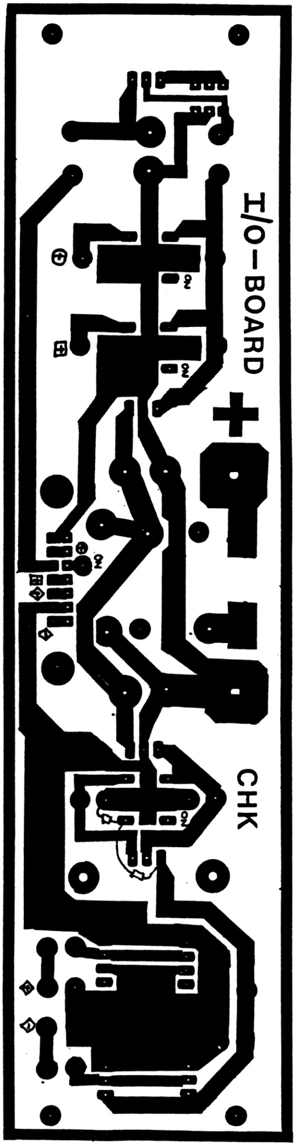
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

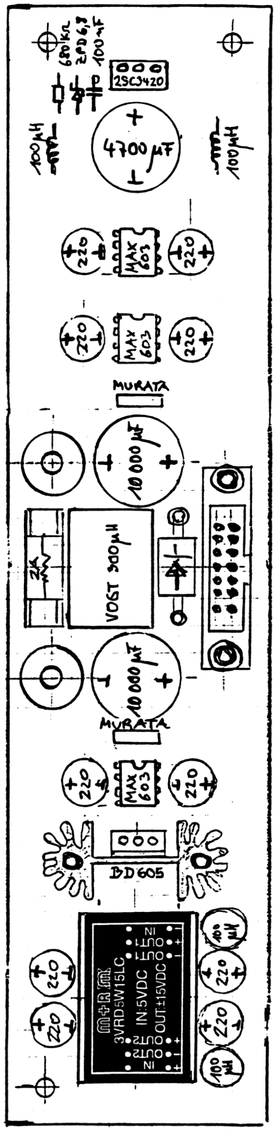
DC Power Supply Circuit Diagram :



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

DC Power Supply Printed Board :



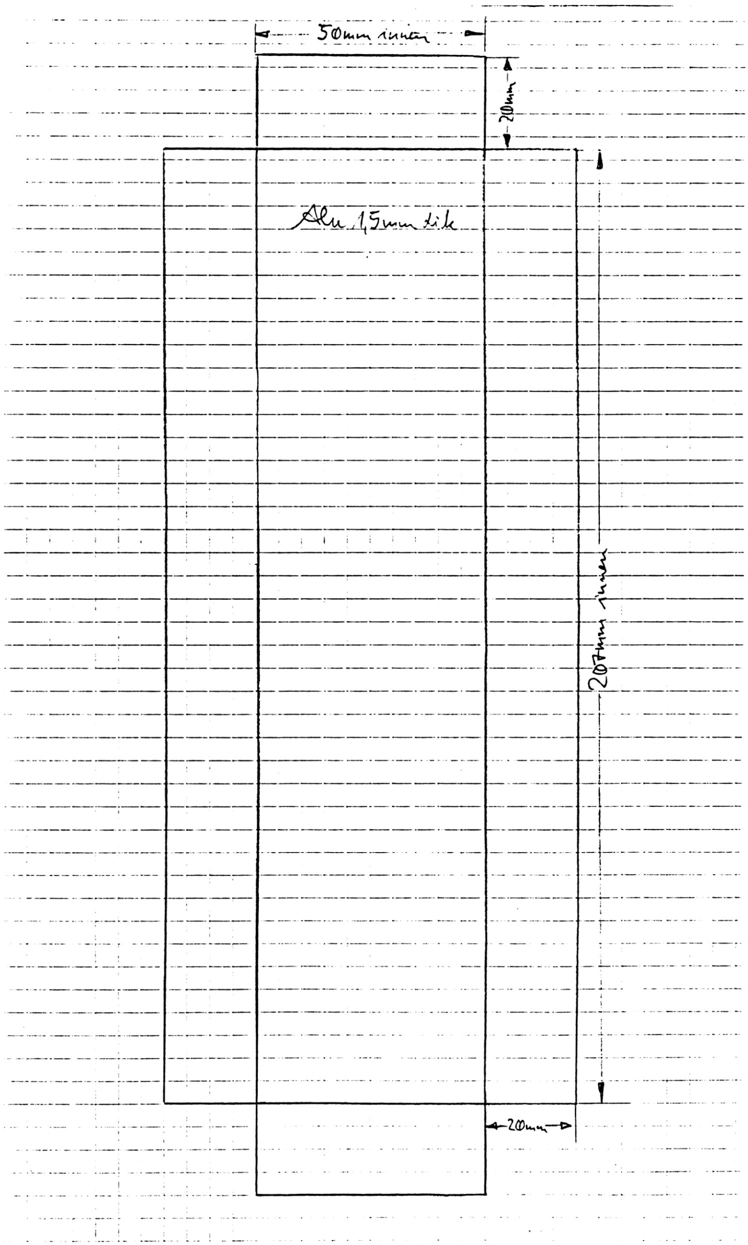


HP 82166 A 16 BIT INPUT / OUTPUT BOARD

DC Power Supply Component List :

3	x	MAX 603	low drop + 5V voltage regulator
1	x	2SC3420	npn transistor
1	x	BD 605	npn transistor
1	x	ZPD 6,8	diode
1	x	1N5401	reverse voltage protection diode
1	x	M+RM	3VRD5W15LC DC/DC-Converter
1	x	300 µH	VOGT
2	x	100 µH	12 Ω
2	x	100 µH	2 Amper
2	x	Murata-Filter	
2	x	10000 µF	Elco with low ESR
1	x	4700 µF	Elco with low ESR
10	x	220 µF	Elco with low ESR
1	x	100 nF	MKT
2	x	resistor for + 6V trim $\Sigma = 250$ KΩ	
1	x	680 KΩ	
1	x	Fuse 2 A	
1	x	heat sink Conrad No. 18 80 93-33	
1	x	Strip Line Connector Male Header SVA straight version with extractor 14 contacts	

DC Power Supply Chassis :



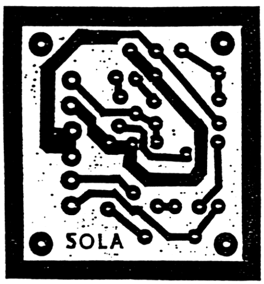
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

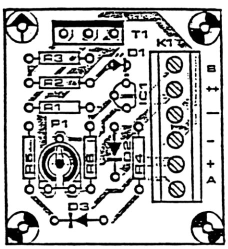
Load Regulator for Solar Panel :

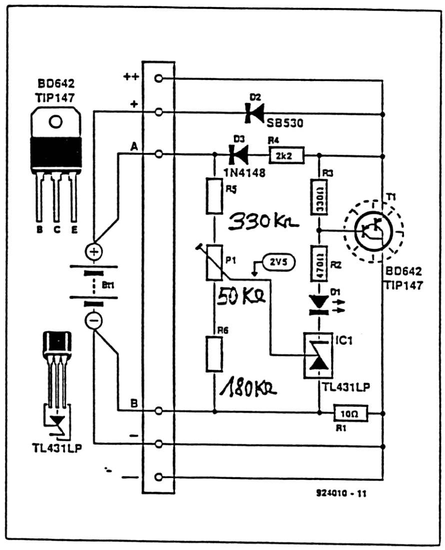
For long time applications with mobile I/O-board you can refresh 6 Volt rechargeable lead-cell by an adapted solar-panel. The given regulator circuit is an application presented by Klaus Schönhoff in the German Elektor-Magazine number 7-8 / 1992.

Values of R5 and R6 are changed to load the 6 Volt lead-cell. Mount power transistor TIP147 to a small heat-sink. The positive output line of solar-panel is connected to the + + pin of regulator circuit.

For the solar-panel I take the Solar-Loader SL 8, originally used for loading batterys of BOSCH drilling machines (part number 2 607 224 182). Charging voltage range =7,2...12V, max current =248mA, power =3W, overall dimensions =230mm x 305mm, weight =1.1 kg.





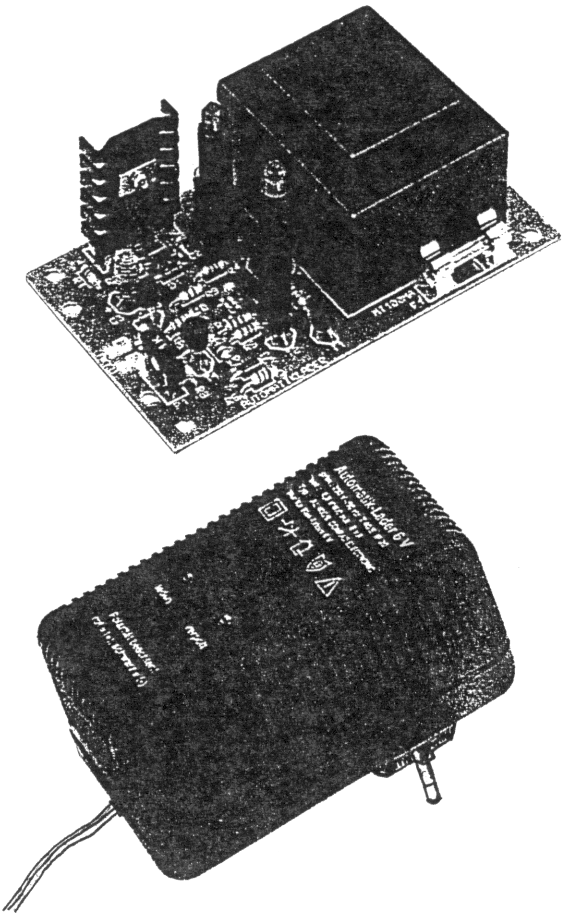


HP 82166 A 16 BIT INPUT / OUTPUT BOARD

6V Lead-Cell Charger Plug-In-Unit :

Alternative to the solar pannel, use a charger for loading lead-cell for stationary applications with DC Power Supply. Realize a no-breaking or uninterruptible power system (UPS) for I/O-Board !

From Conrad Electronic exist a special charger for permanent loading 6V lead-cells, mounted inside a 220 V AC plug-in-unit. Because transformer and charger electronic are totally insolated (Class II applicance), there is no risc for danger of life by voltage hazard ! Charger is available by Conrad Electronic (92240 Hirschau / Germany), oder number = 24 22 25-99, price = 54,- DM.



6V Lead-Cell for I/O-Board :

General Data :

Solar Panel max output current	= 248 mA
Plug In Charger max current	= 400 mA

lead cell charging current = 10 % of battery capacity
lead cell permanent charging voltage = 6,9 V

Panasonic Lead Cell :

6V / 4 Ah battery capacity. Size	= 108 x 48 x 70 mm
Weight	= 830 g
Conrad Electronic Order Number	= 25 54 91-99
Price	= 31,50 DM

Sonnenschein Lead Cell :

6V / 4,2 Ah battery capacity. Size	= 98 x 62 x 52 mm
Weight	= 900 g
Conrad Electronic Order Number	= 25 40 37-99
Price	= 39,80 DM

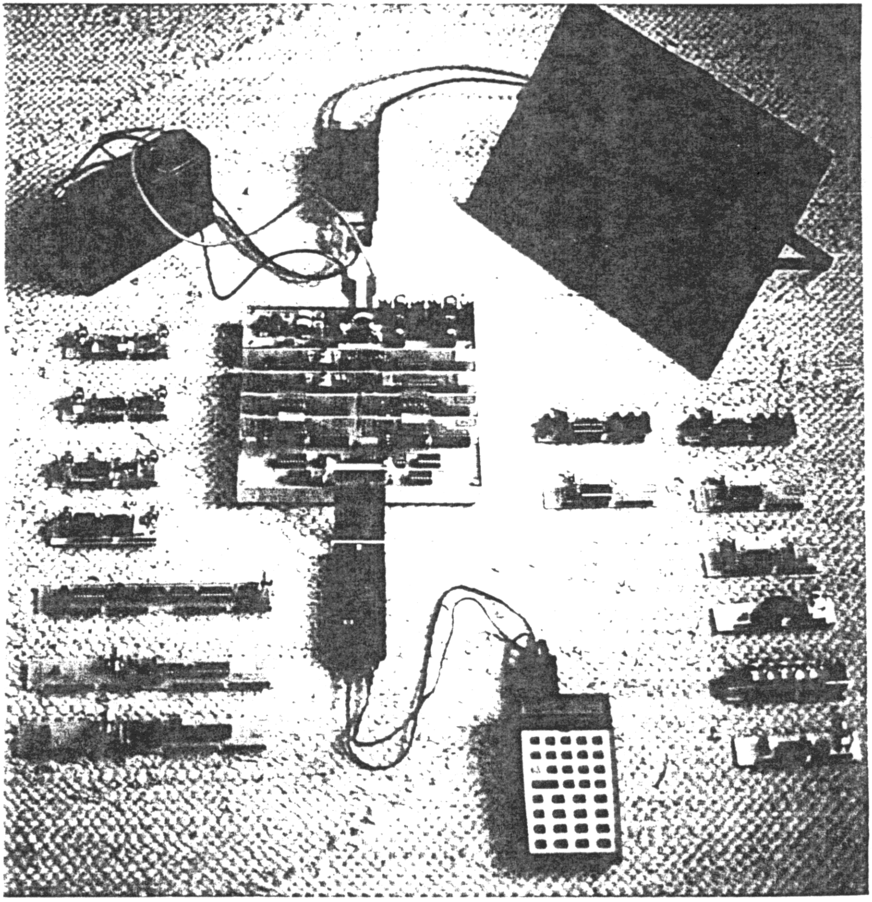
CHAPTER V
I/O-BOARD MODULES

I/O-Board and Accessories	V.01
8 Bit Module Pin Configuration	V.02
Diagnose Module	V.03
8 Bit Test I/O-Modules	V.04
8 Bit Digital I/O-Modules	V.05
8 Bit Opto Isolated Modules	V.09
8 Bit Open Collector Module	V.11
8 Bit ADC and DAC	V.12
12 Bit ADC and DAC	V.16
16 Bit Counter-Module	V.21
Quad Multiplexer Module	V.24

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

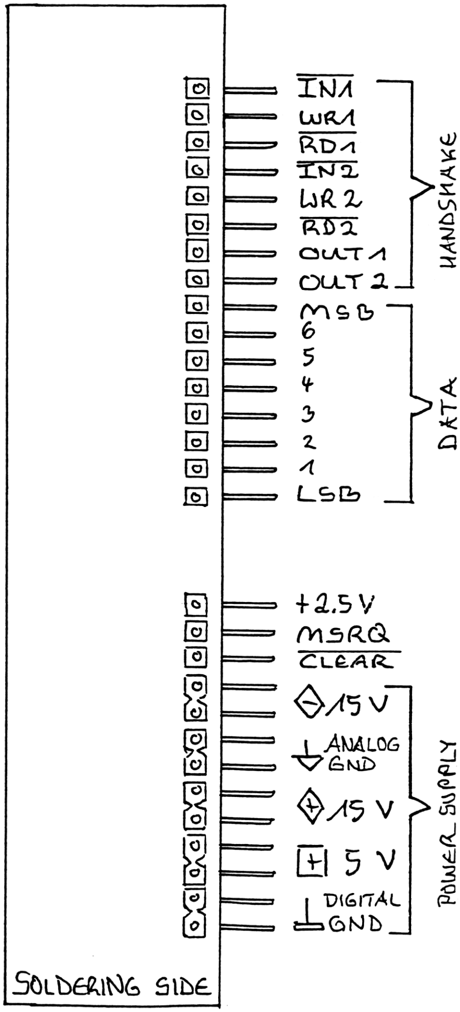
I/O-Board and Accessories :

Picture shows 16 bit I/O-Board with connected HP 82166 A IL-Converter. Interface-Loop-Controller is HP-41 CX handheld computer. I/O-Board is powered by +6V DC power supply unit, mounted direct to the backside of I/O-Board. Above you see rechargeable lead-cell, load-regulator and solar-pannel. Left beside of I/O-Board are shown some analog modules like filter, log-amp, and vca-module. In left corner you see 16 bit ADC-, DAC- and Counter-Module. Some 8 bit modules shown on right side : Multiplexer-module, ADC-, DAC-Module and several digital I/O-modules.



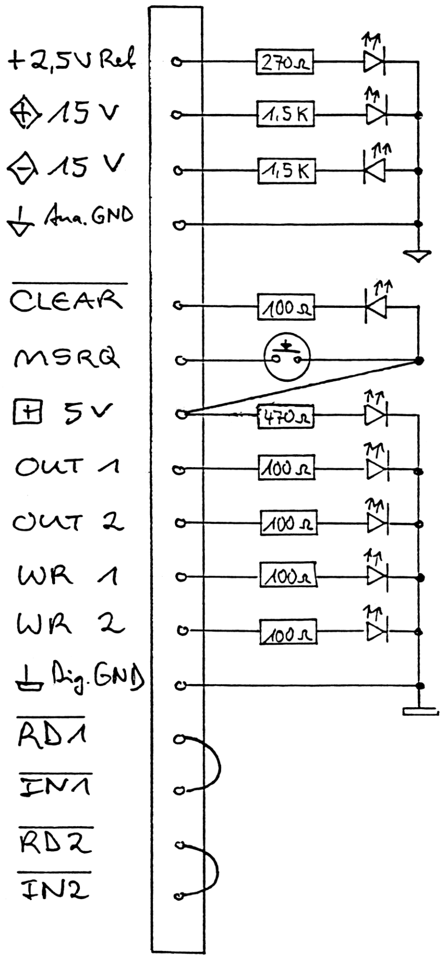
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

8 Bit Module Pin Configuration :



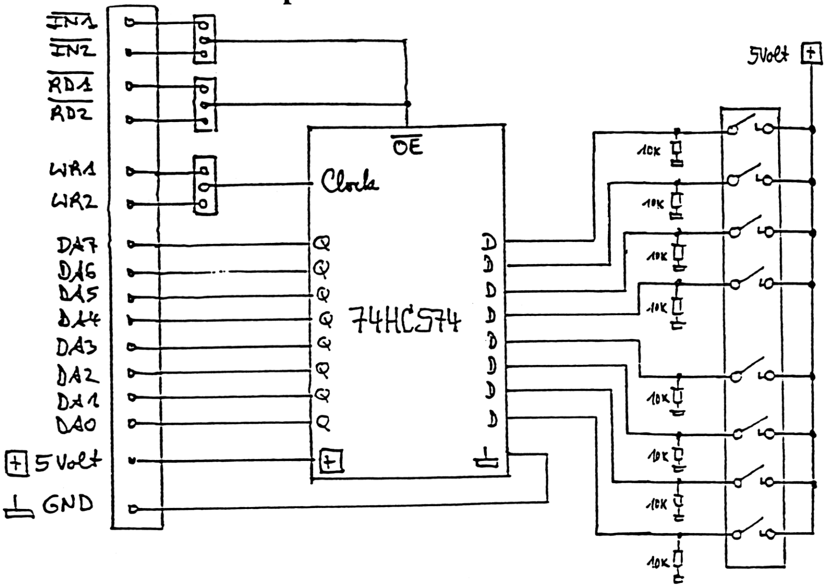
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Diagnose Module :

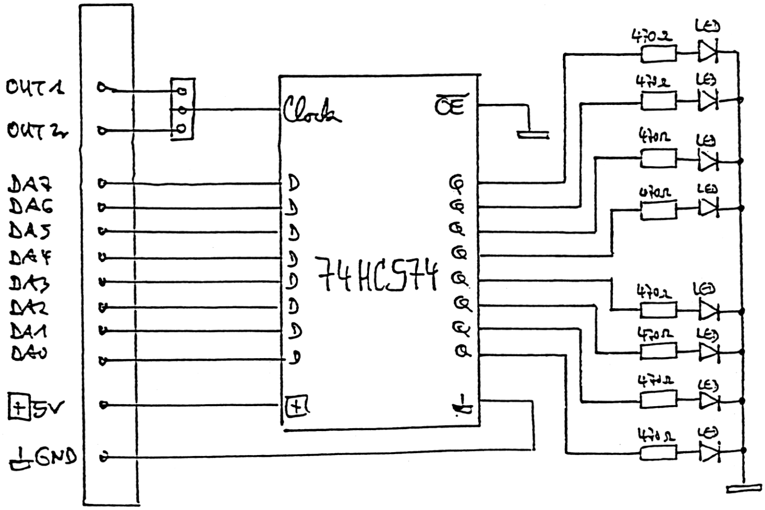


HP 82166 A 16 BIT INPUT / OUTPUT BOARD

8 Bit Input Test DIL Switch Module :

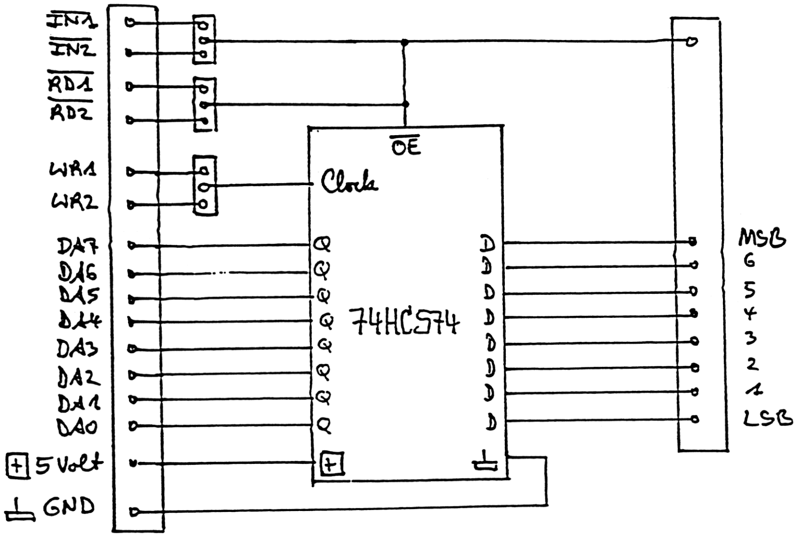


8 Bit Output Test LED Module :

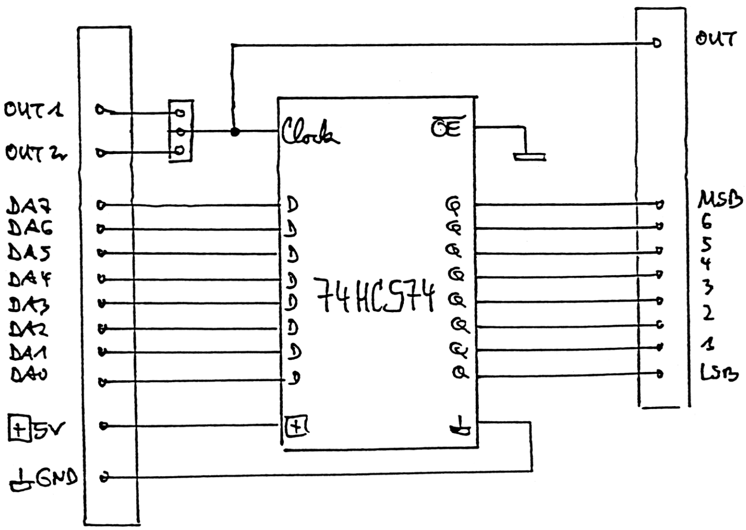


HP 82166 A 16 BIT INPUT / OUTPUT BOARD

8 Bit Digital Input Module :

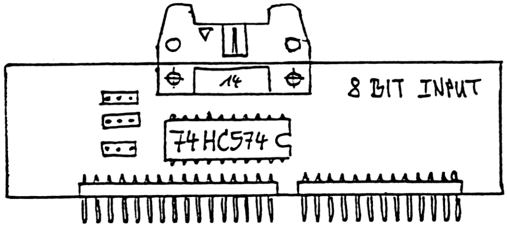


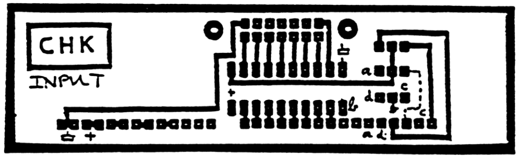
8 Bit Digital Output Module :



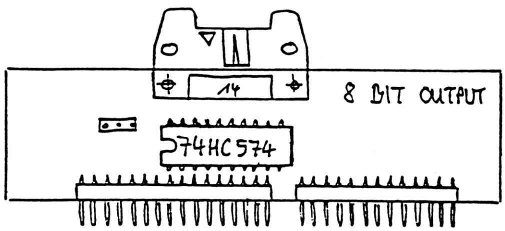
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

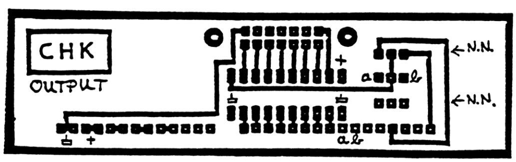
8 Bit Digital Input Module :





8 Bit Digital Output Module :





HP 82166 A Input / Output Board :

8 Bit Digital Input Module Component List :

1	x	74HC574
1	x	14 pin strip line connector with extractor
3	x	Jumper
3	x	male strip line connector 3 Pin
1	x	male strip line connector 13 Pin 90 ° ∠
1	x	male strip line connector 16 Pin 90 ° ∠

8 Bit Digital Output Module Component List :

1	x	74HC574
1	x	14 pin strip line connector with extractor
1	x	Jumper
1	x	male strip line connector 3 Pin
1	x	male strip line connector 13 Pin 90 ° ∠
1	x	male strip line connector 16 Pin 90 ° ∠

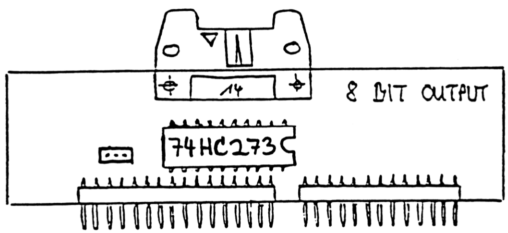
HP 82166 A Input / Output Board :

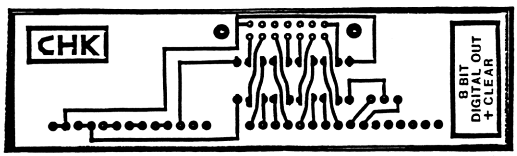
Power On Reset for 8 Bit Digital Output Modules :

When I/O-Board is waked up by IL-Controller, outputlines of inserted 8 Bit Digital Output Modules have indefinable logic state ! Used 74HC574 circuit on Output Module have no power on reset or clear function. This accidental power on state can be a problem for interfaced hardware, for example extern switches toggels to failure mode !

Wake up I/O-Board and reading out zero bytes sets Output Modules to known state, but this software solution need some time delay. An optimal hardware solution to prevent I/O-Board and extern hardware from indefinable power on states is changing from 74HC574 chip to 74HC273 chip, which includes a clear function. Belonging printed board layout is presented :

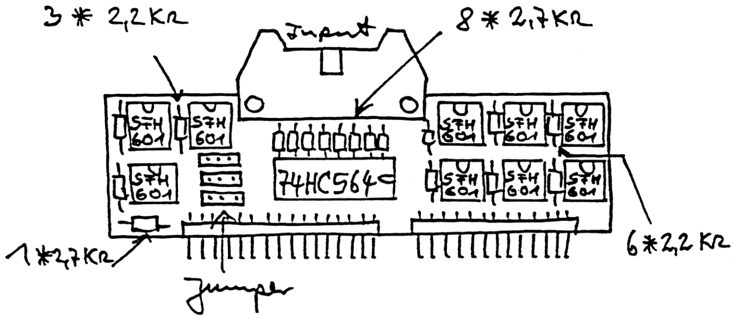
8 Bit Digital Output Module :



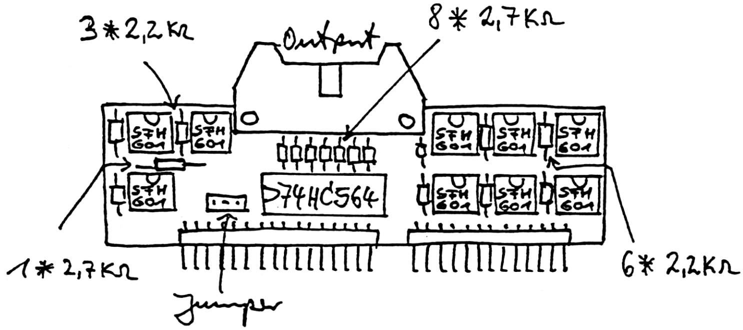


HP 82166 A 16 BIT INPUT / OUTPUT BOARD

8 Bit Opto Isolated Input Module :

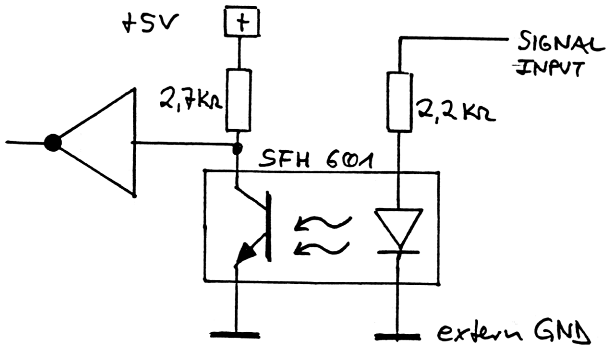


8 Bit Opto Isolated Output Module :

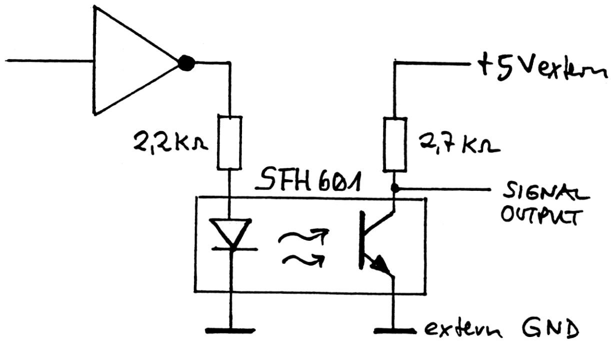


HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Opto Isolated Input :

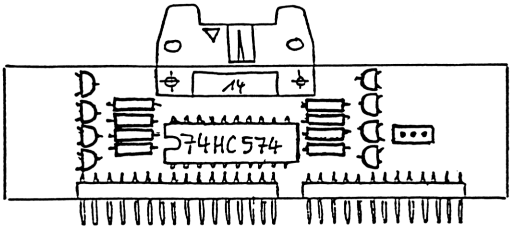


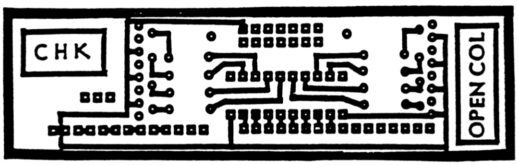
Opto Isolated Output :

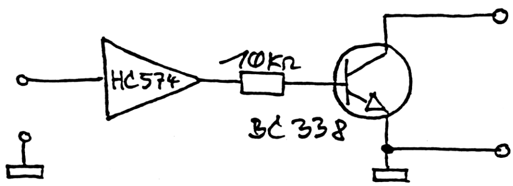


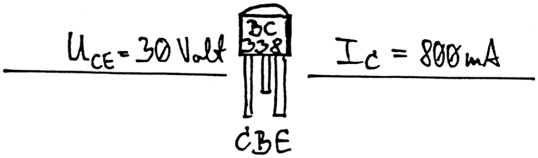
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

8 Bit Open Collector Module :



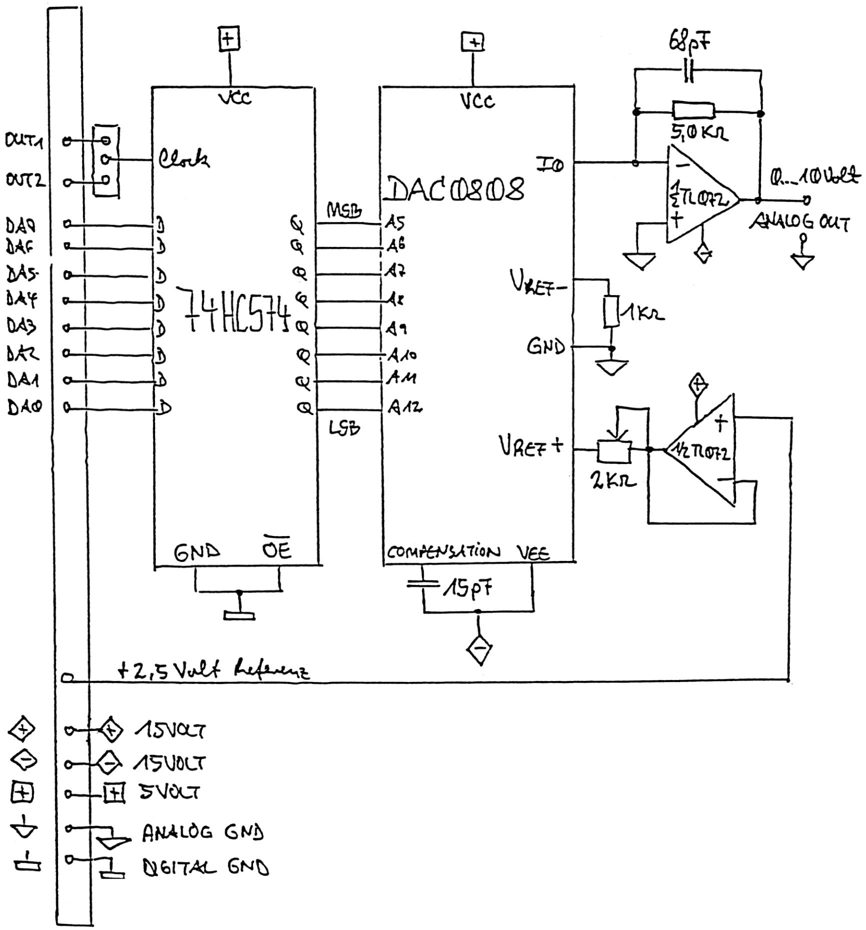






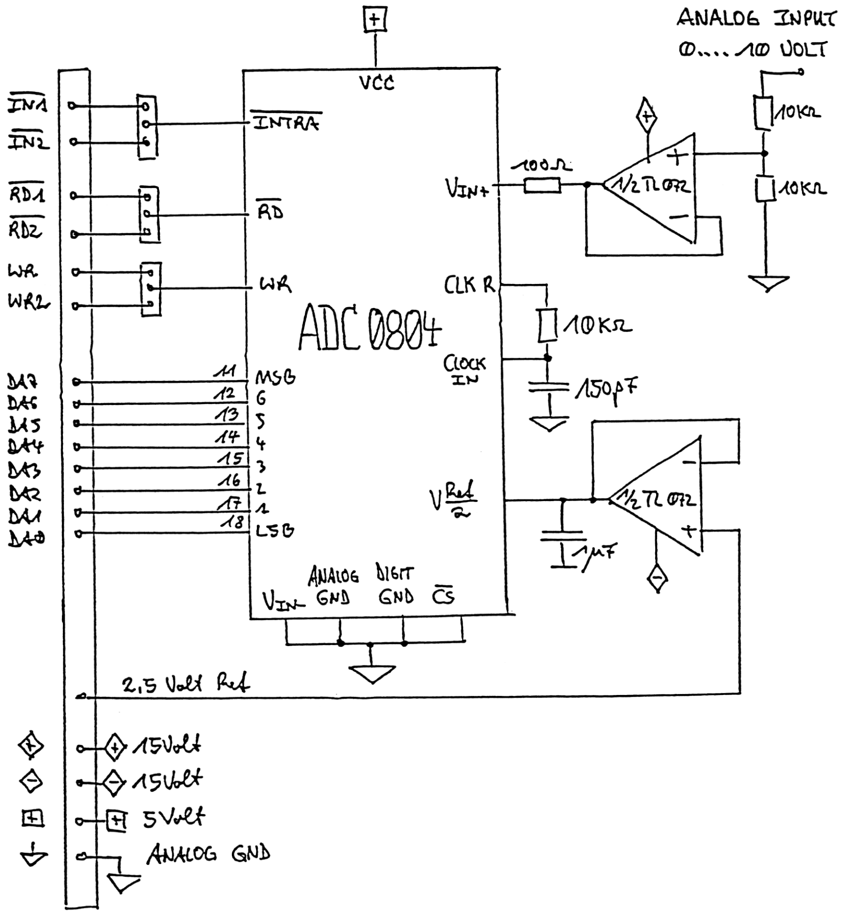
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

8 Bit Digital Analog Converter 08DAC :

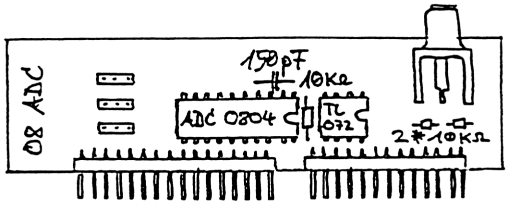


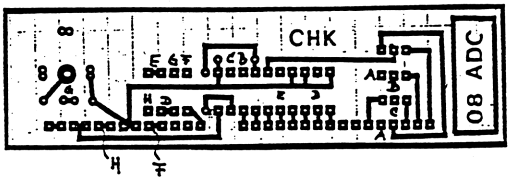
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

8 Bit Analog Digital Converter 08ADC :

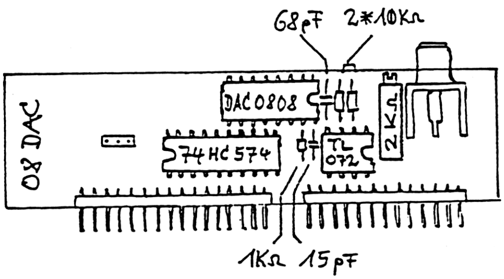


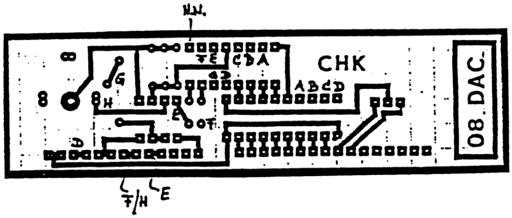
8 Bit Analog Digital Converter 08ADC :





8 Bit Digital Analog Converter 08DAC :





HP 82166 A Input / Output Board :

8 Bit ADC Component List :

1	x	ADC 0804 (National)
1	x	TL 072 Dual Op-Amp
3	x	10 KΩ 1 %
1	x	150 pF ceramic
1	x	female Chinch connector for print mounting
3	x	Jumper
3	x	male strip line connector 3 Pin
1	x	male strip line connector 13 Pin 90 ° ∠
1	x	male strip line connector 16 Pin 90 ° ∠

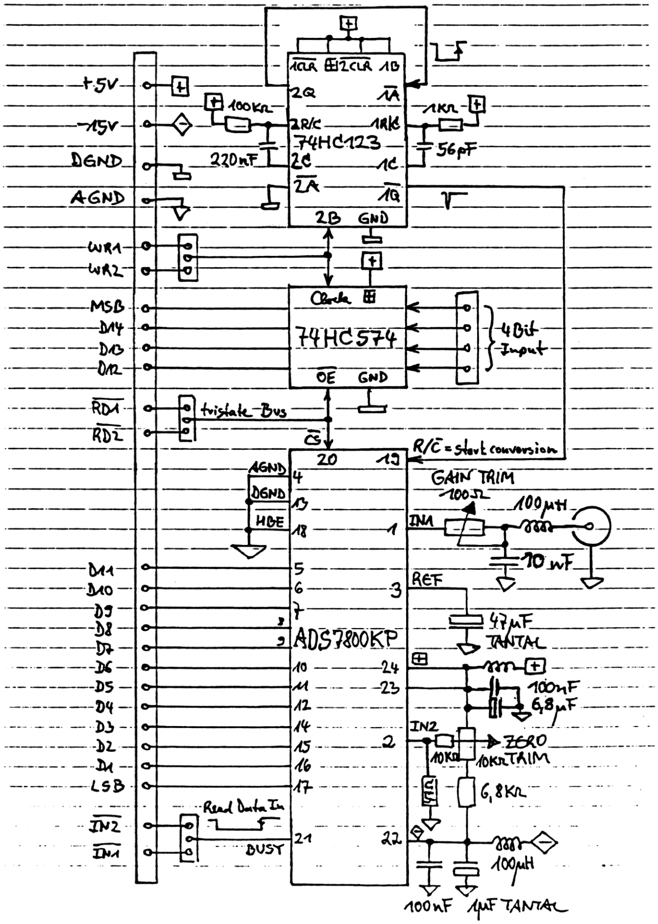
8 Bit DAC Component List :

1	x	DAC 0808 (National)
1	x	74HC574
1	x	TL 072 Dual OP-Amp
1	x	spindle potentiometer 2 KΩ
1	x	1 KΩ 1 %
2	x	10 KΩ 1 %
1	x	68 pF ceramic
1	x	15 pF ceramic
1	x	female Chinch connector for print mounting
1	x	Jumper
1	x	male strip line connector 3 Pin
1	x	male strip line connector 13 Pin 90 ° ∠
1	x	male strip line connector 16 Pin 90 ° ∠

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

12 Bit Analog Digital Converter 12ADC :

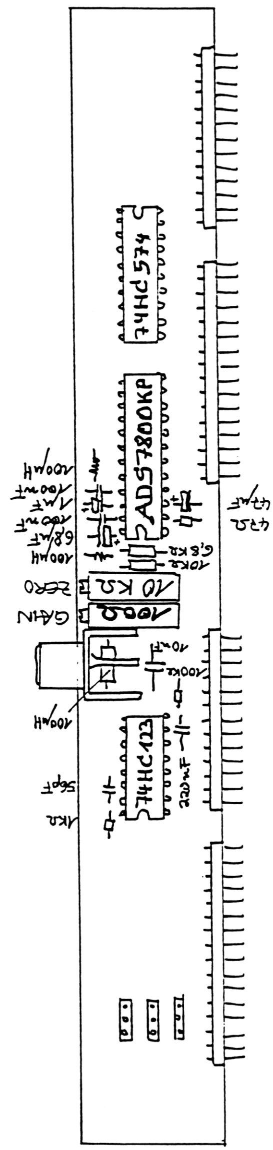
Used Burr&Brown chip ADS7800KP have internal sample/hold, reference voltage, clock and tristate outputs. Circuit needs less external components for analog input section. Zero-trim and gain-trim are available : Connect input to GND, and tune zero-trim until reading in dataword = 1000 0000 0000 = 2048. Now input exact + 10 Volt analog voltage to ADC. Tune gain-trim until reading in full scale dataword = 1111 1111 1111 = 4095. Analog input voltage range is ± 10 Volt. Converter have high accuray (1/2 LSB) and no missing codes. The most significant 4 bits of 16 Bit input dataword can be used as additional 4 bit digital input.



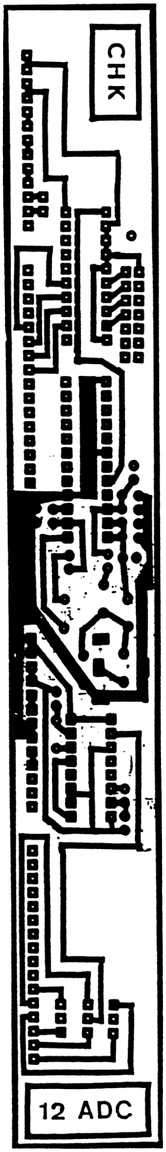
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

12 Bit Analog Digital Converter 12ADC :

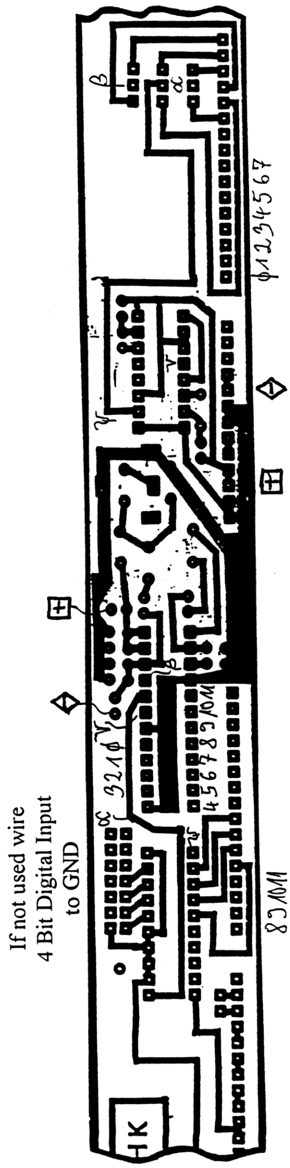
Component Side



Soldering Side

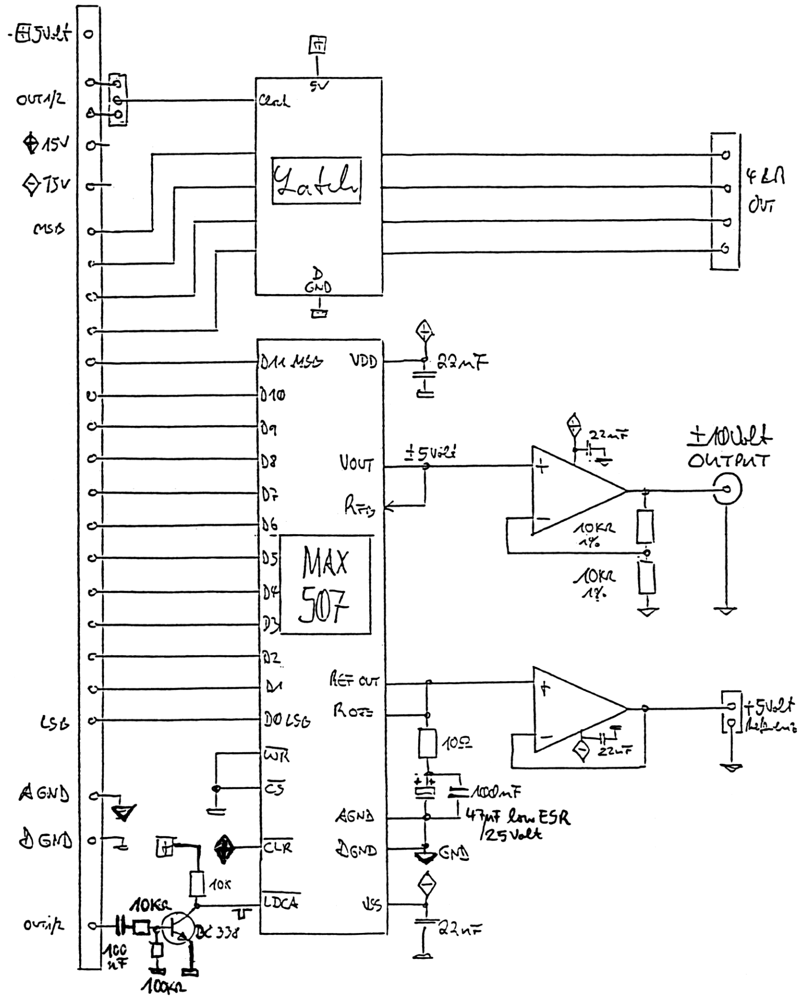


Wiring Diagram



12 Bit Digital Analog Converter 12DAC :

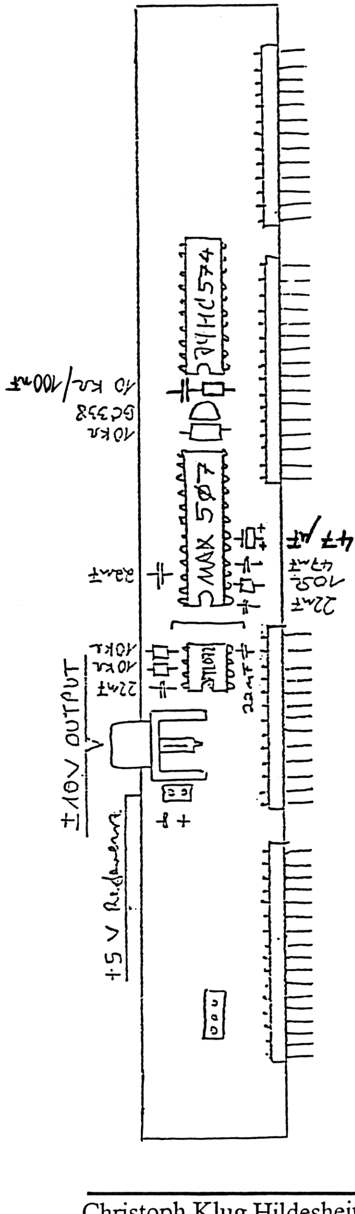
Advantage of MAX507 DAC is internal reference voltage and output amp. The presented circuit need no trimming components, use 1 % or 0,1 % resistances for output buffer Op-Amp. Analog output voltage range is ± 10 Volt. The most significant 4 bits of controlling dataword can address an additional 4 bit digital output.



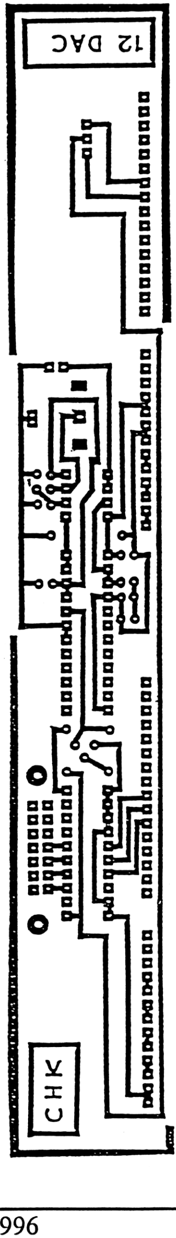
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

12 Bit Digital Analog Converter 12DAC :

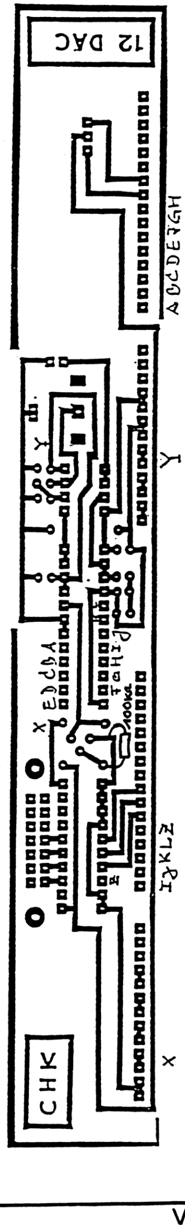
Component Side



Soldering Side



Wiring Diagram



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

12 Bit ADC Module Component List :

1	x	74HC574
1	x	74HC123
1	x	ADS7800KP 12 Bit ADC Burr&Brown
1	x	Spindle Trimm 10 kΩ (Zero Trim)
1	x	Spindle Trimm 100 Ω (Gain Trim)
1	x	6,8 kΩ
1	x	10 kΩ
1	x	47 Ω
1	x	100 kΩ
1	x	1 kΩ
1	x	56 pF Ceramic
2	x	100 nF Ceramic
1	x	220 nF MKT
1	x	10 nF MKT
1	x	1 µF Tantal
1	x	6,8 µF Tantal
1	x	47 µF Tantal
3	x	100µH/12Ω coil
3	x	Jumper
1	x	Chinch connector
2	x	13 pin contact strip with square pins
2	x	16 pin contact strip with square pins

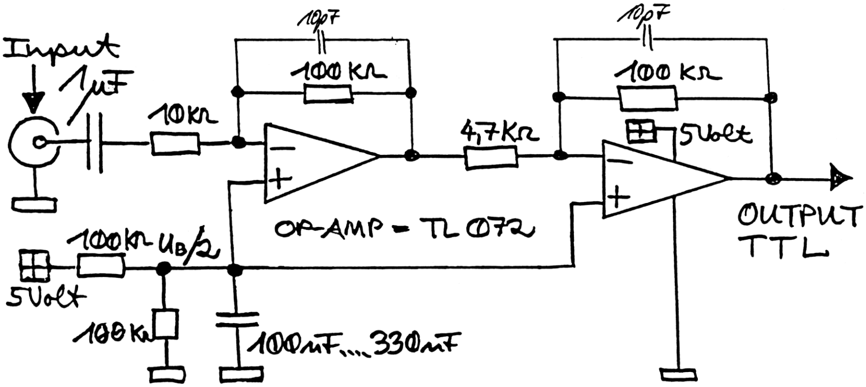
12 Bit DAC Module Component List :

1	x	74HC574	
1	x	MAX 507	12 Bit DAC with intern reference
1	x	TL 072	dual Op-Amp
1	x	BC 338	npn transistor
2	x	10 kΩ	1 % tolerance
1	x	10 Ω	
2	x	10 kΩ	
1	x	100 kΩ	
4	x	22 nF Ceramic	
2	x	100 nF MKT	
1	x	47 µF Elco with low ESR !!!	
1	x	Jumper	
1	x	Chinch connector	
2	x	13 pin contact strip with square pins	
2	x	16 pin contact strip with square pins	

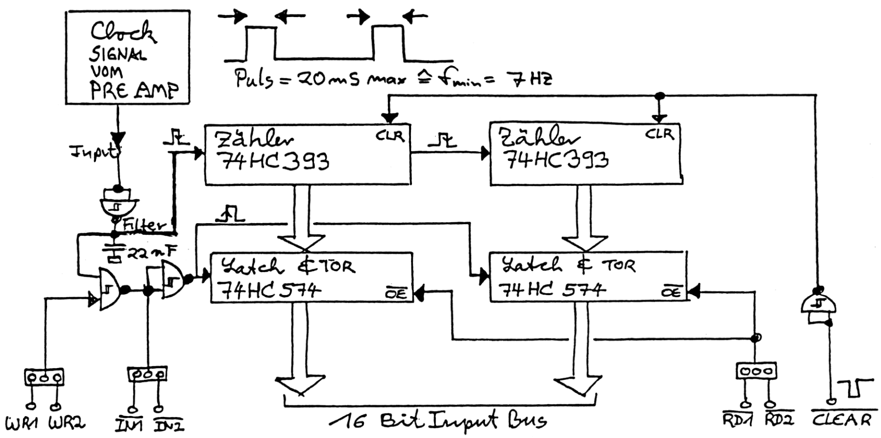
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

16 Bit Counter Module :

Presented 16 bit Counter Module consists of an analog pre-amplifier and following digital counter logic. The pre-amp works with inverting TL072 Op-Amps. Input voltage range is from 3,5 mV_{eff} to 5,3 V_{eff} . Output voltage is a TTL signal because OP-Amps are powered unipolar by +5V.



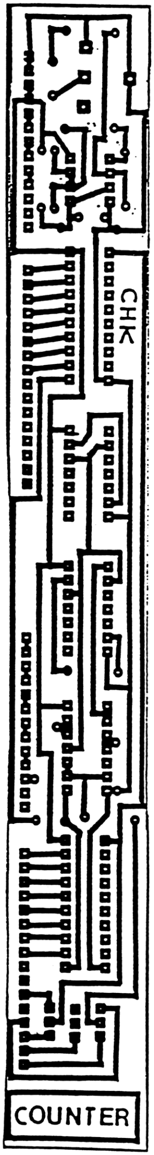
Digital 16 bit counter logic uses two 74HC393 binary counter. Input TTL signal is improved by 74HC132 schmitt nand gate. Maximum input pulse lenght of circuit is 20 mS. This corresponds to a minimum input signal frequency of 7 Hz. For lower counting time intervals insert additional puls former between pre-amp and counter logic. I/O-Board detects first falling edge of IN1/2 signal for reading data from Counter Module.



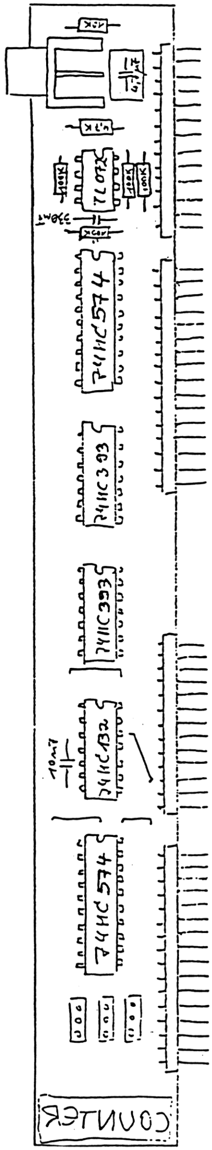
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

16 Bit Counter Module :

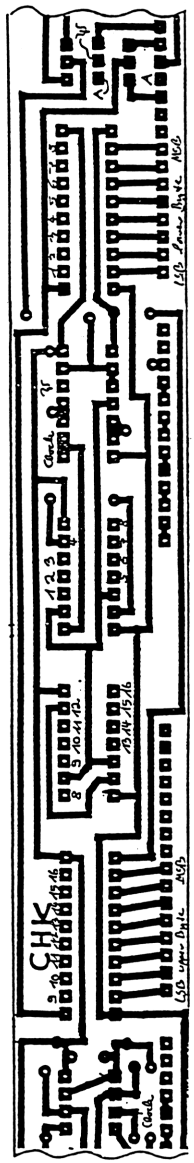
Soldering Side



Component Side



Wiring Diagram



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

16 Bit Counter Module Component List :

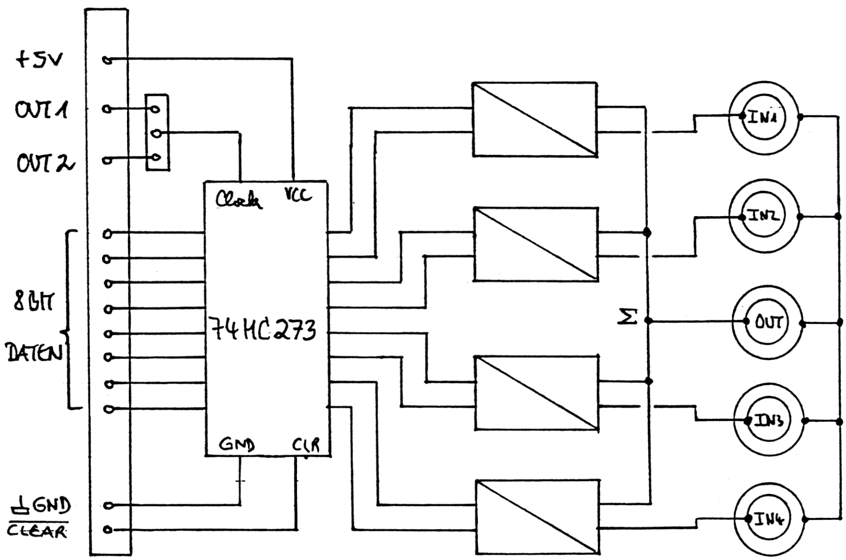
1	x	TL 072 OP-Amp
1	x	74HC132
2	x	74HC393
2	x	74HC574
1	x	4,7 kΩ
1	x	10 kΩ
4	x	100 kΩ
2	x	10 pF ceramic
1	x	10 nF MKT
1	x	330 nF MKT
1	x	4,7 µF MKT
3	x	Jumper
1	x	Chinch connector
2	x	13 pin contact strip with square pins
2	x	16 pin contact strip with square pins

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Quad Multiplexer Module :

This module you can use for measuring four different voltages with 8 Bit ADC or 12 Bit ADC. Or for multiplexing other signals to your own hardware. Switching is done by bistable relais. Using mechanic relais have some advantages which not attributes of electronic cmos-switchers :

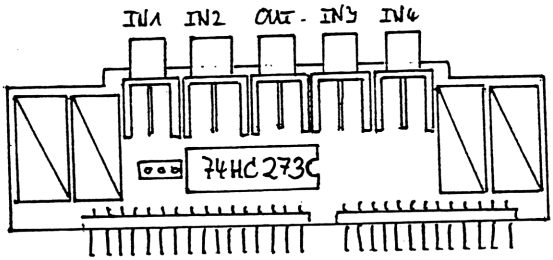
Signals are completely isulated from I/O-Board hardware. Signal amplitude not limited to power supply level. State or bistable relais is stored also when system is in power down mode !

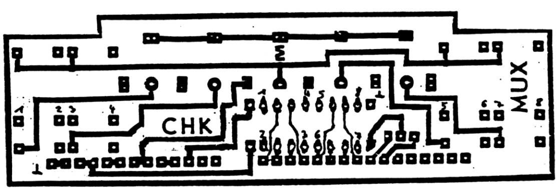


4 * BISTABIL RELAIS

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Quad Multiplexer Module :





Quad Multiplexer Module :

Software :

Bistable relais are controlled by set- and reset pulses. This pulses are generated by software sending binary pattern with $OUT1A command :

Command	Dez	Bin
Rel 1 On	128	1000 0000
Rel 1 Off	064	0100 0000
Rel 2 On	032	0010 0000
Rel 2 Off	016	0001 0000
Rel 3 On	008	0000 1000
Rel 3 Off	004	0000 0100
Rel 4 On	002	0000 0010
Rel 4 Off	001	0000 0001
no current	000	0000 0000

For example for setting Rel 2 to On state output Dez 032 followed by Dez 000.
For resetting Rel 2 to Off state output Dez 016 followed by Dez 000.

Quad Multiplexer Module :

Component List

5	x	Chinch connector
4	x	5 Volt Bistable Relais
1	x	74HC273
1	x	Jumper
1	x	13 pin contact strip with square pins
1	x	16 pin contact strip with square pins

CHAPTER VI
PRACTICAL TIPS

Practical Tips for Building	VI.00
HP 82166 A IL-Converter Signal Description	VI.01
Digital Integrated Circuits	VI.02
Analog Integrated Circuits	VI.03
Practical Tips for Installing	
Part 1 Software	VI.04
Part 2 Hardware	VI.05
Practical Tips for Testing	VI.06
Practical Tips for Starting	VI.07

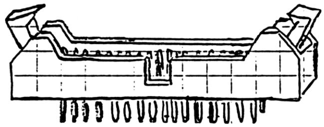
HP 82166 A Input / Output Board :

Practical Tips For Building I/O-Board :

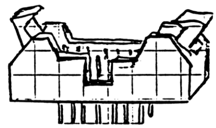
For I/O-Board exist a set of some printed boards. But only with one side layout, therefore you must wire a lot of additional connections on soldering side using wiring diagram. This is easy for most presented printed boards of I/O-Board manual. Only the I/O motherboard is a little bit more complex, therefore here are given some practical tips and tricks for you to finish building with positiv result !

Start with drilling holes for components (0,8 mm ∅) and for mounting (3,2 mm ∅). Now check complete layout to reach actual design level. Because there were some small updates. Use sharp cutter knife to break track conducters or add new conducters using short wire !

Now insert high quality IC sockets (right polarity), 34 pin connector (IL-Converter), 14 pin connector (power supply) and 13/16 pin connectors (plug in modules) to component side and solder them. General work accurat and without uncleanness !

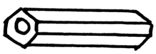


34 pin connector

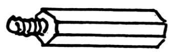


14 pin connector

Mount ten 15 mm bolts to soldering side to reach stability stand of I/O-Board. Additionally use four 15 mm winding bolts to fix 34 pin and 14 pin connector :



15 mm bolt



15 mm winding bolt

Solder electronic components like diodes, resistors, capacitors and R/C networks to corresponding positions on soldering side (On component side therefore no positions exist). The R/C networks must be aligned to get right function, see chapter "Port Addressing by Pulsed GETO-Line" in I/O-Board manual ! Picture on page III.13 shows you I/O-Board soldering side including electronic components..

Now start with wiring additional connections on soldering side following wiring diagram of manual. First begin with short wiring connections, than add longer wiring on "second floor" above and finish with long wiring to power supply connector. Generall realize clean and short connections, don't leave out any !

Last insert TTL High Speed CMOS circuits to corresponding sockets, followed by a visual test about your correct work. Now your I/O-Board is finished !

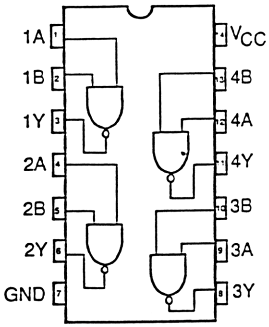
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP 82166A IL-Converter Signal Description :

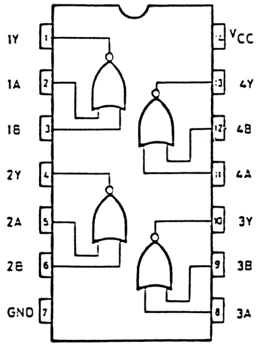
Description	Signal	Pin	Pin	Signal	Description
Device Clear Output	$\overline{DCLO}$	34	33	GND	Ground
Internal Chip Select	$\overline{CS}$	32	31	VCC	Supply Voltage
Data Bus A	DA1	30	29	DA0	Data Bus A
Data Bus A	DA3	28	27	DA2	Data Bus A
Group ExecTrigg Output	$\overline{GETO}$	26	25	$\overline{MSRQ}$	Manual Service Request
Data Bus A	DA7	24	23	DA6	Data Bus A
Data Bus A	DA5	22	21	DA4	Data Bus A
Data Valid Input	DAVI	20	19	DACO	Data Accepted Output
Data Bus B	DB7	18	17	DB6	Data Bus B
Data Bus B	DB5	16	15	DB4	Data Bus B
Handsh Line Logic Out	HLLO	14	13	$\overline{PWDN}$	Power Down
Ready Output	RDYO	12	11	DACI	Data Accepted Input
Data Bus B	DB3	10	9	DB2	Data Bus B
Data Bus B	DB1	8	7	GND	Ground
Ready Input	RDYI	6	5	DAVO	Data Valid Output
Wake Up	WKUP	4	3	VC1	Supply Voltage
Data Bus B	DB0	2	1	GND	Ground

HP 82166 A Input / Output Board :

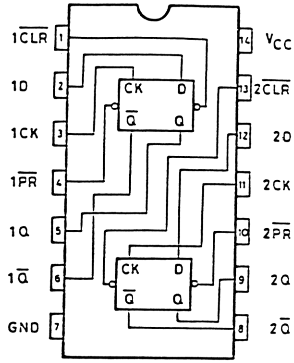
I/O-Board Digital Integrated Circuits :



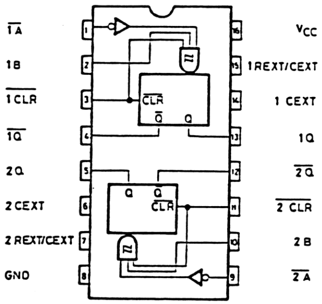
74HC00



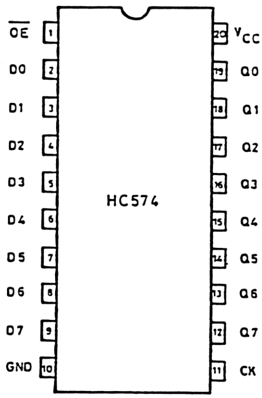
74HC02



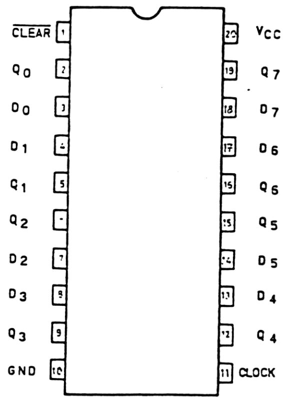
74HC74



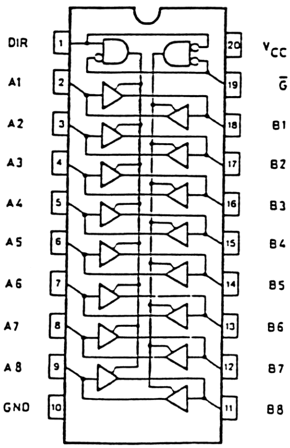
74HC123



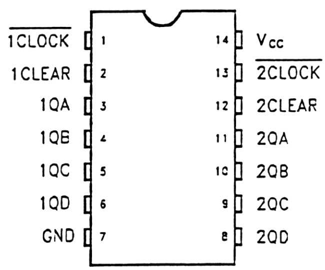
74HC574



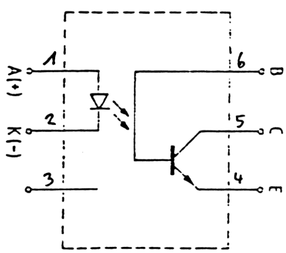
74HC273



74HC245



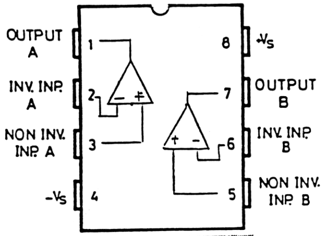
74HCT393



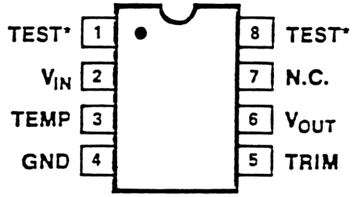
SFH 601

HP 82166 A Input / Output Board :

I/O-Board Analog Integrated Circuits :

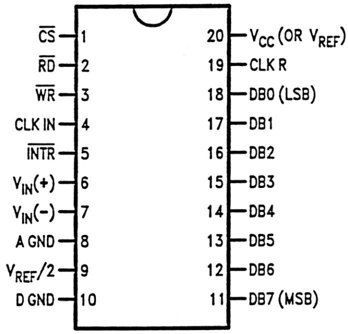


TL072

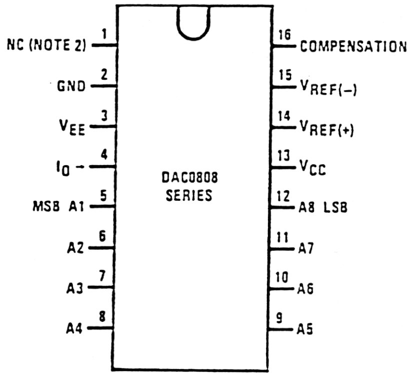


REF-43

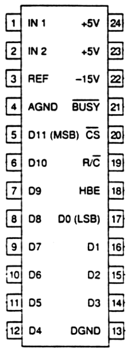
*RESERVED FOR FACTORY TESTING.
MAKE NO ELECTRICAL CONNECTION TO THESE PINS.



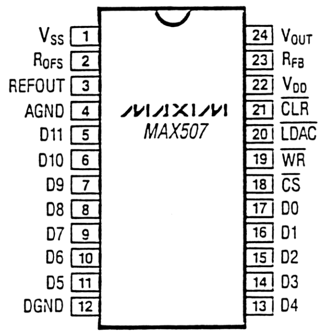
ADC0804



DAC0808



ADS7800



MAX507

HP 82166 A Input / Output Board :

Practical Tips For Installing I/O-Board :

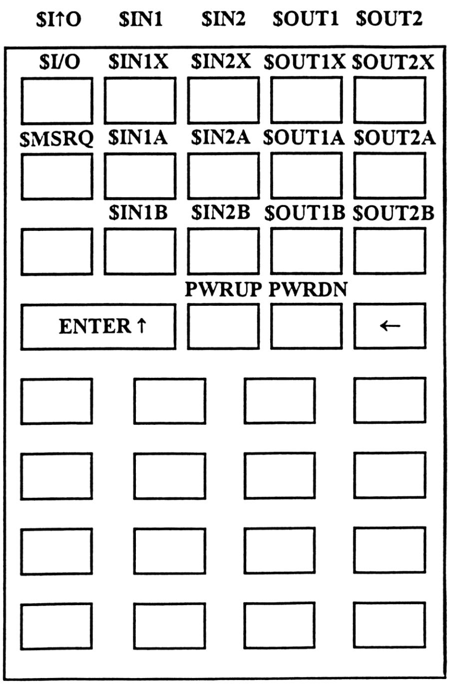
PART 1 :
Software Installation

First switch off HP-41 and install expansion modules to backside slots. If you want to use the CCD-Module place it to slot position 1, followed by I/O-Module or Development-Module, X-Memory or Card-Reader, insert IL-Module to slot position 4 :

CCD-Module	I/O or Devel
X-MEMORY	IL-Module

Now read in I/O-Board control software using Wand and presented barcode plots inside I/O-Board manual. More easy and faster is using the Cassette Drive and Mini Data Cassette availlable from author !

Last assign I/O-Board control functions to USER keyboard as shown. Use SHIFT key to assign second function. Shown keybord presents the command set for I/O-Module. For Development-Module assign a corresponding USER keyboard.



HP 82166 A Input / Output Board :

Practical Tips For Installing I/O-Board :

PART 2 :
Hardware Installation

Start with connecting IL-Converter and Power Supply Unit to I/O-Board. Only use short flat cable connections. Now set jumpers on plug in modules to address 1 or address 2 and insert plug in modules to I/O-Board.

When using DC-Power Supply Unit wire it only with correct polarisation. The red connector is + 6 Volt ! Take a short cable connection between power supply and rechargeable lead-cell.

Do not change any hardware configuration, or plug in and plug out any modules or the IL-Converter when power supply is active or switched to PWRUP !!!

Now close Inferface-Loop by inserting IL-Module plugs to IL-Converter terminals. When I/O-Board and Power Supply Unit is connected to AC- or DC source, system frequently switch to PWRUP state. That is a normal effect of hardware.

Switch on HP-41 Interface-Loop Controller. HP-41 than automatically sends a PWRUP command when switched on. If I/O-Board do not wake up same time send once more PWRUP command to activate system. Now run I/O-Board initialisation software $I/O or DI/O. Now your system can work ! When job finished than deactivate I/O-Board by using PWRDN and switch off handheld computer.

!! ATTENTION !!

The IL-Converter is the most expensive and valuable component of I/O-Board system ! Today for this exotic IL-Device no repair service exists from Hewlett-Packard or any other known company ! Therefore prevent IL-Converter from any damange, do not touch hardware or connector pins ! When using a OEM IL-Converter board than mount it inside a small case. Normally no problems occure when IL-Converter is used correct with I/O-Board.

HP 82166 A Input / Output Board :

Practical Tips For Testing I/O-Board :

If you have finished building of I/O-Board and your work is acurat, add a visual test of wiring and soldering. Test components about their right polaristion ! Is wiring complete and positions right ? Avoid uncleanliness and remove short circuits !

Now you can start first function test, supply I/O-Board only with digital ⊕ 5 V, ⊕ 5V and ⊞ 5 V ! Insert current limiting fuses to power supply lines to prevent expansive IL-Converter from damange ! Alternatively use a current limiting labor power supply :

⊕ 5 V typical supply current = 10 µA !

⊕ 5 V maximal supply current = 200 mA !

⊞ 5 V maximal supply current = 500 mA !

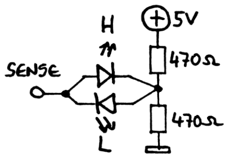
If supply currents are to high, find out reasons ! But normally there are no problems and you can test I/O-Board. If Power Up mechanusmus is locked, wire On/Off line of DC power supply to high level to reach On state for further tests.

Handshake lines are checked by using the Diagnose Module. For digital data input and output test use Test DIL Switch Module and Output Test LED Module.

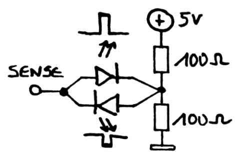
If any hardware function is not correct, analyze belonging circuits step by step. For example, if port addressing circuit have a failure, test output signals of Flip-Flop, than signals of pulsed address hardware.

Measure IL-Converter lines only with high input impedance voltmeter or oszilloscope !!! Normally there is no reason to analyze IL-Converter lines direct, and measuring is more complex !

Better and without risc for the IL-Converter is measuring of I/O-Board circuit signals. You can use a simple Resistor/LED probe, analyzing digital logic levels and a modified probe for pulsed digital signals :



static probe



pulsed probe

Finish first I/O-Board test with measuring + 2,5 V Reference Voltage and ⊕ 15 V and ⊖15 V analog power supply. When complete function test result is OK than remove fuses between I/O-Board and Power Supply.

HP 82166 A Input / Output Board :

Practical Tips For Starting with I/O-Board :

Reading this chapter you will find some systematic tips for using I/O-Board first time and effectively learn something about HP-41 software command set :

Easiest way is to plug in four 8 Bit Input Test DIL Switch Modules and four 8 Bit Output Test LED Modules. Set Jumpers to Add 1 and Add 2. Actual switch position shows you two 16 Bit data inputs and lighting LED shows you two 16 Bit data outputs witout need of measurement equipment.

Power up I/O-Board and initiate it by $I/O. Now execute 16 Bit data output commands from X-Register like $OUT1X, or from ALPHA (write dummy byte D and two databytes to Alpha using XTOA or CCD-Module) and run $OUT2. Create X-Memory file using $CRFL and execute 8 Bit data output commands from X-Register like $OUT1A or $OUT2B. Another short test is running $LIGHT or to start the binary counter program $DAC.

Now go on with 16 Bit data input to X-Register using $IN1X, or to Alpha using $IN2 (switch to Alpha mode and you will see received result. Transfer data bytes to X-Register using ATOXR). Read in 8 Bit data to X-Register using $IN1A or $IN2B.

Generally you can convert 8 Bit binary numbers to decimal values executing B↑D and D↑B. If you like the hexadecimal data format use $IN1H, $IN2H and $OUT1H, $OUT2H for data input and output.

Finish digital I/O test session with an complete data transfer from HP-41 (software) to I/O-Board (hardware) and than back to handheld : Instead of test modules insert 8 Bit digital I/O plug in modules to Jumper Add 1 and connect them together using flat cable. Now transmit data from X-Register to output module using $OUT1X. Receive data from input module to X-Register using $IN1X. Transfer is OK when values are identic. Same job is done by $ADC routine. Enter 12 bit data in decimal format, than program displays transmited and received data at same time.

Last test analog voltage I/O, insert and address 8 Bit or 12 Bit ADC and DAC plug in modules to I/O-Board. Now read out data from X-Register executing $OUT1A for 8 Bit DAC or $OUT2X for 12 Bit DAC, and measure resulting DAC analog output voltage using a voltmeter.

When analog output function is OK than connect ADC module to DAC module by chinch cable. Like above execute a complete data transfer now to analog area using $ADC. Received data depends on zero and gain trimming of ADC and corresponds not exactly to transmitted data. Difference must be constant. Existing error of ADC is typically one digit = 1 LSB.

CHAPTER VII
ADVANCED PROGRAMMING

HP-41 Error Ignore Flag 25	VII.01
Updated Program $SAMP	VII.02
Hex Input / Output Software	VII.03
Four Digit BCD-Number Input	VII.04
Fast $OUT1X and $OUT2X with CCD-Module	VII.05
X-Memory Data File $I/O-FL	VII.06
Bit-Testing with CCD-Module	VII.07
Bit-Setting with CCD-Module	VII.08
Decimal ↔ Byte Conversation	VII.09
Decimal ↔ Hex Conversation	VII.10
I/O-Board Alarm Functions	VII.11
I/O-Board as Data Logger	VII.13

HP 82166 A Input / Output Board :

Advanced Programming using HP-41 Error Ignore Flag 25

If you run HP-41 control software for I/O-Board and some hardware failure occur, program will stop and error message is displayed. This program interruption is an disadvantage for automatic and stand alone use of system without human intervention !

For example if you start $SAMP routine from I/O-Board manual for testing power on hardware and switch off power supply, HP-41 hang up and displays TRANSMIT ERR message. This malfunction is not stored inside HP-41 register, and program ends without setting new timer alarm.

Use error ignore Flag 25 to overcome such limitations : Set Flag 25 before running any risk command and test Flag 25 after command is finished for brunching to label without program stop ! The following short program example check I/O-Board status, including hardware failure :

```
01 LBL $CHK
02 SF 25
03 PWRUP
04 FC?C 25
05 GTO 02
06 XEQ $I/O
07 XEQ $MSRQ
08 RTN
09 LBL 02
10 "$ERR"
11 ASTO X
12 CLA
13 END
```

The following updated version of $SAMP uses same advanced programming technique to prevent software interruption if power supply is disconnected from I/O-Board. Misfunction is stored by Label 99 in HP-41 memory and new timer alarm is programmed. If break down circumstances fade away system works correct without human invention !

For that reason also use error ignore Flag 25 when programming your own software like watchdog routines which include time module commands. For example, your program can set a timer alarm used as time out counter if an extern hardware device do not input any data to I/O-Board using IN1 / IN2 lines.

HP 82166 A Input / Output Board :

Updated Program Version of $SAMP :

Complete marked program lines to existing I/O-Board Manual software routine $SAMP to get updated version including advanced programming technique using Error Flag 25 :

```
01*LBL "$SAMP"
02 SF 25
03 PWRUP
04 FC?C 25
05 GTO 99
06 XEQ "$I/O"
07 "D⊕⊕"
08 XEQ "$OUT1"
09 XEQ "$OUT2"
10 101
11 RCL 00
12 X=Y?
13 PWRDN
14 X=Y?
15 OFF
16 FS? 49
17 PWRDN
18 FS? 49
19 OFF
20 CLX
21 ENTER^
22 ENTER^
23 DATE
24 TIME
25 0,003
26 HMS+
27 "^^$SAMP"
28 XYZALM
29 1
30 ST+ 00
31 XEQ "$IN1"
32 ATOXR
33 ATOXR
34 256
35 *
36 +
37 STO IND 00
38 "DZZ"
39 XEQ "$OUT1"
40 XEQ "$OUT2"
41 RCL 00
42 PSE
43 PWRDN
44 OFF
45 RTN
46*LBL 99
47 FS? 49
48 OFF
49 CLX
50 ENTER^
51 ENTER^
52 DATE
53 TIME
54 ,003
55 HMS+
56 "^^$SAMP"
57 XYZALM
58 1
59 ST+ 00
60 CLX
61 STO IND 00
62 RCL 00
63 PSE
64 OFF
65 END
```

HP 82166 A Input / Output Board :

Hex - Input / Output Software :

Using hex commands of CCD-Module you can realize easy hexadecimal data I/O. Value of Nibble = 4 Bit ranges from 0 to 9 and A to F. Hex format is optimal for fast testing and prototyping plug in modules. Program use 16 Bit wordsize of CCD-Module.

```
01♦LBL "$OUT1H"
02 16
03 WSIZE
04 "OUT1H="
05 PMTH
06 "D"
07 XTOAH
08 XEQ "$OUT1"
09 RTN
10♦LBL "$OUT2H"
11 16
12 WSIZE
13 "OUT2H="
14 PMTH
15 "D"
16 XTOAH
17 XEQ "$OUT2"
18 RTN
19♦LBL "$IN1H"
20 16
21 WSIZE
22 XEQ "$IN1X"
23 "IN1H="
24 ARCLH
25 CLX
26 PROMPT
27 RTN
28♦LBL "$IN2H"
29 16
30 WSIZE
31 XEQ "$IN2X"
32 "IN2H="
33 ARCLH
34 CLX
35 PROMPT
36 END
```

HP 82166 A Input / Output Board :

Four Digit BCD-Number Input :

With following program you can read in a four digit BCD-Number (16 Bit) to X-Register. Range of BCD-Number for presented software is only from 0 to 9, exclusive expanded range A to F. Program uses the CCD-Module !

For example 7-Segment Decoders like 74HC4511 for driving LED 7-Segment Displays have BCD coded input lines (4 Bit = 1 Nybble). Four BCD-Digits correspond to 16 Bit. Therefore you can transfer in data of a four digit 7-Segment Display to X-Register :

BCD	BCD	BCD	BCD
Port A		Port B	
MSB			LSB

Wire BCD lines to two 8 Bit digital input modules. Read in BCD-Numbers to Alpha-Register using **$IN1** or **$IN2** command. Than execute **$BCD** to decode Alpha-Register content as a decimal number to X-Register.

Synthetic Alpha-Text of program line 02 have the following decimal values, use CCD-Module commands User-Off, Shift, Enter↑ = :_ _ _ for easy Alpha input :

02 "APPEND; 000; 000; 000; 004 "

```
01♦LBL "$BCD"
02 "├♦♦♦α"
03 5,6
04 0
05 POKEB
06 RCL M
07 1
08 *
09 CLA
10 END
```

HP 82166 A Input / Output Board :

Fast $OUT1X and $OUT2X with CCD-Module :

Using the XTOAH command of CCD-Module you realize fast 16 Bit data output from X-Register. Program set wordsize of CCD-Module to 16 Bit. Compared to identic program without using CCD-Module (43 bytes program length) following version saves 14 bytes of program code :

```
01◆LBL "$OUT1X"
02 16
03 WSIZE
04 "D"
05 X<>Y
06 XTOAH
07 XEQ "$OUT1"
08 RTN
09◆LBL "$OUT2X"
10 16
11 WSIZE
12 "D"
13 X<>Y
14 XTOAH
15 XEQ "$OUT2"
16 END
```

X-Memory data File $I/O-FL :

The I/O commands for 8 Bit transfer like $IN1A or $OUT2B use X-Memory data file $I/O-FL. The decimal values of every I/O port are stored in one file register. Following diagram shows you the complete data file content if you want to read and write registers for own program applications :

00	OUT1A
01	OUT1B
02	OUT2A
03	OUT2B
04	IN1A
05	IN1B
06	IN2A
07	IN2B

X-Mermory Data File
$I/O-FL

Use X-Functions like SEEKPTA and SAVEX or GETX for datatransfer between X-Memory File and X-Register. An example for using $I/O-FL is given on following pages.

Bit-Testing with CCD-Module :

Testing individual Bit states from Port IN1A, IN2A or IN1B, IN2B can programmed easy by using $Tb1A, $Tb1B or $Tb2A, $Tb2B commands followed by CCD-Module functions bS? and bC?. For example you want to check if Bit 0 from Port IN1A is set to high level :

20 :	
21 :	
22 ↓	
23 0	**bit number**
24 XEQ $Tb1A	**read port 1A**
25 bS?	**is bit 0 high ?**
26 GTO 01	**yes → skip to 01**
27 :	**no → this line**
28 :	
29 ↓	

Bit numbers range from 0 (= LSB) to 7 (= MSB). For bit testing about active low level use bC? command.

```
01♦LBL "$Tb1A"
02 STO L
03 8
04 WSIZE
05 XEQ "$IN1A"
06 RCL L
07 RTN
08♦LBL "$Tb1B"
09 STO L
10 8
11 WSIZE
12 XEQ "$IN1B"
13 RCL L
14 RTN
15♦LBL "$Tb2A"
16 STO L
17 8
18 WSIZE
19 XEQ "$IN2A"
20 RCL L
21 RTN
22♦LBL "$Tb2B"
23 STO L
24 8
25 WSIZE
26 XEQ "$IN2B"
27 RCL L
28 END
```

If you want to test more bit states corresponding to identic sampling time, work with data from X-Memory File $I/O-FL : Set file pointer and recall input port data with GETX. Now enter bit number and execute bS? or bC? command.

Bit-Setting with CCD-Module :

Setting individual bit states from Port OUT1A, OUT1B or OUT2A, OUT2B is realized by following routines using CCD-Module functions Sb and Cb. Key in bit number ranging from 0 to 7 and run $Sb1A, $Sb1B, $Sb2A, $Sb2B for setting bit, or $Cb1A, $Cb1B, $Cb2A, $Cb2B for clearing bit. For example you want to set Bit 0 from Port OUT1A to high level :

```
60  :
61  :
62 ↓
63 0                bit number
64 $Sb1A            set Bit 0
65  :
66  :
67 ↓
```

Note that other Bit´s are not affected in their individual states ! If you want to clear Bit to low level use $Cb1A command. Program works with X-Memory Data File $I/O-FL. After powering up system clear file contens with $CLFL to reach known data output.

```
01♦LBL "$Sb1A"
02 0
03 XEQ 01
04 Sb
05 XEQ "$OUT1A"
06 LASTX
07 RTN
08♦LBL "$Sb1B"
09 1
10 XEQ 01
11 Sb
12 XEQ "$OUT1B"
13 LASTX
14 RTN
15♦LBL "$Sb2A"
16 2
17 XEQ 01
18 Sb
19 XEQ "$OUT2A"
20 LASTX
21 RTN
22♦LBL "$Sb2B"
23 3
24 XEQ 01
25 Sb
26 XEQ "$OUT2B"
27 LASTX
28 RTN
29♦LBL "$Cb1A"
30 0
31 XEQ 01
32 Cb
33 XEQ "$OUT1A"
34 LASTX
35 RTN
36♦LBL "$Cb1B"
37 1
38 XEQ 01
39 Cb
40 XEQ "$OUT1B"
41 LASTX
42 RTN
43♦LBL "$Cb2A"
44 2
45 XEQ 01
46 Cb
47 XEQ "$OUT2A"
48 LASTX
49 RTN
50♦LBL "$Cb2B"
51 3
52 XEQ 01
53 Cb
54 XEQ "$OUT2B"
55 LASTX
56 RTN
57♦LBL 01
58 X<>Y
59 STO L
60 RDN
61 "$I/O-FL"
62 SEEKPTA
63 8
64 WSIZE
65 GETX
66 LASTX
67 END
```

HP 82166 A Input / Output Board :

Decimal ↔ Byte Conversation Software :

Following HP-41 conversating routines change decimal numbers (ranging from 0 to 255) to binary values (8 Bit = 1 Byte) or conversely. Routines only use stack registers and reconstruct original state of user Flag 00 to Flag 07.

For example enter 15 to X-Register and execute D↑B. Than X-Register displays you the binary result 1111. The Alpha-Register contains result 00001111 including leading nulls. Now enter 11000011 and execute B↑D. The decimal result is 195 in X-Register.

You can use both routines for easy binary digital input and output, and for testing I/O-Board using LED-Output Module and DIL Switch Input Module !

```
01♦LBL "D↑B"
02 X<>F
03 STO L
04 CLA
05 7
06♦LBL 01
07 FS? IND X
08 "├1"
09 FC? IND X
10 "├0"
11 DSE X
12 GTO 01
13 FS? IND X
14 "├1"
15 FC? IND X
16 "├0"
17 LASTX
18 X<>F
19 ANUM
20 RTN
21♦LBL "B↑D"
22 1 E7
23 /
24 ENTER↑
25 CLX
26 X<>F
27 7
28 RCL Z
29♦LBL 02
30 INT
31 X≠0?
32 SF IND Y
33 RDN
34 LASTX
35 FRC
36 10
37 *
38 DSE Y
39 GTO 02
40 X≠0?
41 SF 00
42 RCL Z
43 X<>F
44 END
```

HP 82166 A Input / Output Board :

Decimal ↔ Hex Conversation Software :

Following HP-41 conversating routines change decimal numbers to the hex representation or conversely. First set wordsize of CCD-Module.

You can use D↑H and H↑D as subroutines in your own programs. Similar VIEWH and PMTH command of CCD-Module needs manual user input from keyboard or result is shown only in display.

The H↑D routin is programmed by Gerhard Kruse, presented in his book "Optimales Programmieren mit dem HP-41" and uses X-Funktions. ALENG command detects wordsize of hex number in Alpha-Register.

For example set 16 Bit wordsize, enter 54321 to X-Register and execute D↑H. Now Alpha-Register contains the hex result D431. Than enter FEDC to Alpha-Register and execute H↑D.The decimal result in X-Register is 65244.

```
01♦LBL "D↑H"
02 CLA
03 ARCLH
04 CLX
05 RTN
06♦LBL "H↑D"
07 ALENG
08 0
09♦LBL 00
10 16
11 *
12 ATOX
13 57
14 -
15 X>0?
16 2
17 X<=0?
18 9
19 +
20 +
21 DSE Y
22 GTO 00
23 X<0?
24 CLX
25 END
```

I/O-Board Alarm Functions :

This command set is programmed to give an advanced sample of using Time-Module functions for general controlling I/O-Board. Data stored in X-Memory file ALM-FL. Common sign of these commands are the leading $A characters. Program length of $A command set is 539 Bytes ≈ 77 Register.

$ALOAD Load alarm data in X-Memory. Enter Start-Date, Stop-Date and Delta-Days. Now enter Start-Time, Stop-Time and Delta Time.

$ADATA Shows you alarm data stored in X-Memory : Start-Date, Stop-Date, Delta Days, Start-Time, Stop-Time and Delta-Time.

$ASET Calculates alarm data for next alarm. Results are stored in X-Memory file ALM-FL. Activates time alarm ↑$ALM in Catalog 5. When Date = 0 no time alarm is activated.

$ALM The program LBL of your own alarm routine. For example start with executing $CHK.

$AVIEW Stores actual alarm time and date in X-Register. Format is hhmm,DDMMYY (DMY and FIX 6). You can use it for Data Logging applications. Stores actual time and date in Alpha-Register for printing with Thermal-Printer.

Enter "ALM-FL" in Alpha-Register and 8 in X-Register for creating X-Memory data file by CRFLD command.

00	Date
01	Time
02	Start-Date
03	Stop-Date
04	Delta Days
05	Start-Time
06	Stop-Time
07	Delta Time

```
01*LBL "$ALOAD"
02 "ALM-FL"
03 0
04 SEEKPTA
05 SAVEX
06 SAVEX
07 "START DATE=?"
08 PROMPT
09 SAVEX
10 "STOP DATE=?"
11 PROMPT
12 SAVEX
13 "DELTA DAYS=?"
14 PROMPT
15 SAVEX
16 "START TIME=?"
17 PROMPT
18 SAVEX
19 "STOP TIME=?"
20 PROMPT
21 SAVEX
22 "DELTA TIME=?"
23 PROMPT
24 SAVEX
25 RTN
26*LBL "$ADATA"
27 RCL d
28 STO L
29 FIX 6
30 CF 29
31 "ALM-FL"
32 2
33 SEEKPTA
34 AON
35 GETX
36 "START DATA="
37 ARCL X
38 PSE
39 GETX
40 "STOP DATA="
41 ARCL X
42 PSE
43 FIX 0
44 GETX
45 "DELTA DAY="
46 ARCL X
47 PSE
48 FIX 2
49 GETX
50 "START TIME="
51 ARCL X
52 PSE
53 GETX
54 "STOP TIME="
55 ARCL X
56 PSE
57 GETX
58 "DELTA TIME="
59 ARCL X
60 PSE
61 AOFF
62 CLA
63 LASTX
64 STO d
65 CLX
66 RTN
67*LBL "$ASET"
68 "ALM-FL"
69 0
70 SEEKPTA
71 GETX
72 X=0?
73 GTO 01
74 GETX
75 6
76 SEEKPT
77 X<>Y
78 GETX
79 X>Y?
80 GTO 02
81 0
82 SEEKPT
83 GETX
84 3
85 SEEKPT
86 X<>Y
87 GETX
88 X>Y?
89 GTO 03
90 CLA
91 CLX
92 RTN
93*LBL 03
94 0
95 SEEKPT
96 GETX
97 4
98 SEEKPT
99 X<>Y
100 GETX
101 DATE+
102 0
103 SEEKPT
104 X<>Y
105 SAVEX
106 5
107 SEEKPT
108 GETX
109 1
110 SEEKPT
111 X<>Y
112 SAVEX
113 GTO 04
114*LBL 02
115 1
116 SEEKPT
117 GETX
118 7
119 SEEKPT
120 X<>Y
121 GETX
122 HMS+
123 1
124 SEEKPT
125 X<>Y
126 SAVEX
127 GTO 04
128*LBL 01
129 2
130 SEEKPT
131 GETX
132 0
133 SEEKPT
134 X<>Y
135 SAVEX
136 5
137 SEEKPT
138 GETX
139 1
140 SEEKPT
141 X<>Y
142 SAVEX
143*LBL 04
144 "ALM-FL"
145 0
146 SEEKPTA
147 GETX
148 GETX
149 "^$ALM"
150 XYZALM
151 CLA
152 CLX
153 RTN
154*LBL "$AVII
155 "ALM-FL"
156 1
157 SEEKPTA
158 CLA
159 GETX
160 FIX 2
161 ATIME
162 "├␣"
163 0
164 SEEKPT
165 GETX
166 FIX 6
167 ADATE
168 "├␣"
169 FIX 4
170 0
171 SEEKPT
172 GETX
173 1 E2
174 *
175 ENTER^
176 INT
177 X<>Y
178 FRC
179 1 E2
180 *
181 FRC
182 +
183 1 E4
184 /
185 GETX
186 1 E2
187 *
188 INT
189 +
190 END
```

I/O-Board as time controlled Data Logger:

This is an example program for I/O-Board hardware working as time controlled Data Logger. Program showes you the advantage use of I/O-Board subroutine $CHK and the $A... alarm command set. First enter complete alarm data using $ALOAD. Then activate alarm manually running $ASET from keyboard. Than PWRDN interface loop and switch off HP-41. Rest is done automatically by $ALM routine.

```
LBL $ALM          time alarm routine
FS? 49            HP-41 battery test
OFF               switch off when low bat
XEQ $CHK          activates I/O-Board and
PSE               shows you status
GTO IND X         branches to $SRQ, $OK or $ERR

LBL $SRQ          Service ReQuest routine
.                 your own programm solution
.                 if you don't use SRQ option
.                 jump to $OK.


LBL $OK           Data logging routine
XEQ $AVIEW        store alarm data in X
PSE               shows you alarm data
STO .....
XEQ $IN1A         your own programm solution
STO ....          for measuring and controlling
XEQ $IN1B
STO .....         data can be stored in X-Memory file
.                 or matrix generated by CCD-Module
.
.
.
XEQ $ASET         calculates and set new alarm
PWRDN             power down I/O-Board
OFF               switch off HP-41
RTN


LBL $ERR          Error routine
BEEP              alternatively you can store error message
OFF               and time using $AVIEW and set new
END               time alarm
```

CHAPTER IIX
REFERENCES

The Author's HP-41 Activities	IIX.01
Book Reviews	IIX.05
History of I/O-Board	IIX.19
HP-41 CX References	IIX.28
IL-Converter References	IIX.29
Advanced Programming	IIX.30
Hewlett Packard Journal	IIX.31
PPC Computer Journal	IIX.32
Interface - Devices	IIX.34
Measurement – Devices	IIX.48
Printer, Plotter, Storage - Devices	IIX.63

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 Activities :

Also today I like working with the "nostalgic" Fourty-One handheld computer system. From this activities results a collection of HP-41 and HP-IL components. My activities are concentrated to the powerfully CX model, belonging software development includes User code and synthetic programming, not mcode programming. For realizing extensive software solutions I work with RSU (Ram Storage Unit) and burn own ZEPROM-Modules (EPROM).

Main subject is interfacing of external electronic hardware to HP-41 handheld by using HP-IL. I developed the battery powered, modular Input/Output-Board for use with the HP 82166A IL-Converter. Belonging I/O-Board manual in English language (presently XVI chapters and over 200 pages) and some analog- and digital-applications for "measurement & controlling" updated permanently. Both, HP-41 and I/O-Board creating an expandably software/hardware system for realizing individual applications.

Connecting HP-41 to I/O-Board make possible data logging applications. For processing measurement-data the transfer to modern PC have a key function for today work with HP-41. By using HP-IL with an own rebuild version of the HP-IL ↔ PC Interface Card I merge mobile HP-41 system and modern PC. Existing transfer software solutions are tested and optimiced for usage with HP-41.

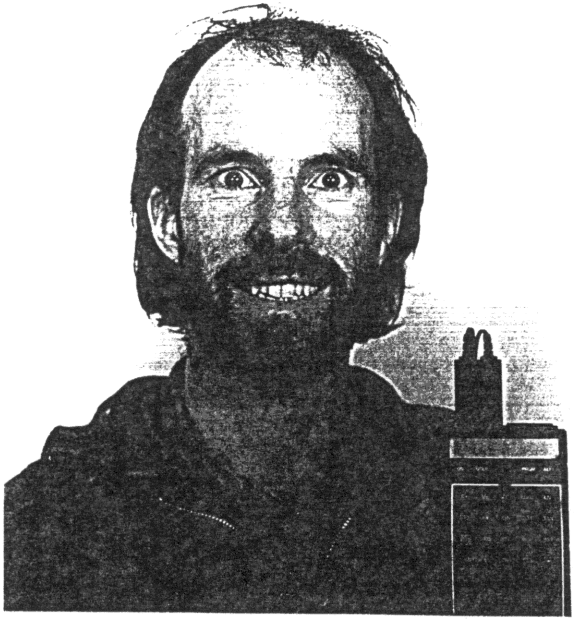
Above activities completed by writing HP-41 articles as author for the Datafile Journal, published worldwide for members of the HPCC Handheld and Portable Computer Club (London).

The collection of HP-41 parts and accessories, HP-IL devices and books and software is an by-product of using HP-41. By trading components with other handheld computer fans I hope to improve existing stock of my collection. My "HP-41 Activies" also including support of today busines of HP-41 users, fans and handheld computer collectors.

Also for today work the "nostalgic" HP-41 is a powerful handheld computer system : With additionally plug in expansion modules you bypass hardware limitations. And by using HP-IL you realize extensive data storage, printing, plotting, interfacing, measurement & controlling and data-transfer to PC.

Christoph Klug Körnerstraße 47 B 31141 Hildesheim Germany

HP 82166 A 16 BIT INPUT / OUTPUT BOARD



Christoph Klug, the author of I/O-Board manual was born 1960 in Fulda / Germany (the native town of Ferdinand Braun, inventor of telegraphy and cathode-ray tube/picture tube). 1984 Christoph completes his engineering studies of electronic/telecommunication on college "Fachhochschule Darmstadt". His special subject is electroacoustics, audio-engineering and consumer electronics. After college he join to Bosch/Blaupunkt company in Hildesheim, working in the department for "Car-Hifi and Loudspeaker Development". 1992 he change to the Bosch/Blaupunkt department "Driver Information Systems and Car Navigation Systems".

Christoph is married with Maria and they have two sons, Jonas and Jeremias. The family like biking and mountain trekking and practise the modern traffic system car sharing. The author´s hobbies are playing pipe organ in church or Hammond Organ B3 and Yamaha electronic grand piano CP80 at home. He realized some special audio electronic projects and digital electronic projects like MIDI or the I/O-Board for the HP-41 handheld computer system. If you want to contact the author write to :

Christoph Klug
Körnerstraße 47 B
31141 Hildesheim
Germany

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Book Reviews :

HPCC Datafile Journal	IIX.06
PROMPT Journal	IIX.10

HP82166A HP-IL Converter 16 Bit Input/Output Board Manual

a book by Christoph Klug, #879

reviewed by Wlodek Mier-Jedrzejowicz, #9

Of Interest to Users of the HP-41 and of HP-IL

Christoph Klug is one of HPCC's most enthusiastic and continuing supporters of the HP-IL system and he has designed a general purpose I/O board for use with the HP82166A HP-IL converter. He has also written a manual for this board, but the manual can be read on its own for the details and programs it gives. I have had two copies of this manual for over 6 months now - Christoph sent them to HPCC for review and for inclusion in the Club library. Since the library is in a state of upheaval because of the former librarian's move out of London I think I should review it briefly here and let anyone who wants to see a copy write to me.

Christoph begins by describing the HP82166A HP-IL Converter and his I/O board for use with it, and then the HP-41 and modules he uses with it. He suggests using an HP-41CX as this has the extra Time and Extended Functions and Memory built in. He uses the CCD module and either an HP-IL I/O module or an HP-IL Development module for greater control of the HP-IL loop and peripherals. Of course an HP-41 HP-IL module is needed too!

The board itself can be used with plug-in 8 bit or 16 bit modules for input, output, and analog-digital converter modules. The next part of the manual describes board control functions, and then provides HP-41CX programs to provide these control functions. Some of these programs contain synthetic HP-41 lines - the CCD module can be used to create these lines - though a Zenrom module would do at least as well! Test programs are included too. The next chapters describe the board hardware (so you could build such a board yourself), and power supply details - there is even a description of a solar panel circuit to refresh the batteries if the board is to be used for a long time with rechargeable batteries. Next, the add-on modules for the board are described. Barcodes are given for the programs, and an appendix provides references, including my book "Extend Your HP-41" - and Gary Friedman's "Control the World with HP-IL" to which Christoph refers many times - indeed Gary's book would be of great interest to anyone who would find this manual interesting. The appendix also contains a detailed circuit diagram of the HP82166A Converter (repeated on the back cover) - and as an added bonus a program to print HP-41 barcodes on an HP DeskJet 500 printer. This program has been developed by Thomas Mareis and Christoph Klug, from the program in the CCD module manual for printing barcodes on the HP ThinkJet Printer - it could be of interest to people who have no use for the rest of this manual! The program needs an HP-41 with HP-IL module, Extended Functions (on a plug-in module or built into an HP-41CX), a CCD module, plus an HP82166A converter to connect to the DeskJet 500, or an HP-IL PC card to print the barcodes to a printer connected to a PC.

Given that few people use HP-IL any longer, this book is of specialist interest - but to anyone who still does use HP-IL and an HP-41, and to newcomers to this very useful low power control system, the book could be a true gift. Christoph has offered to sell copies of his I/O board - write to:

Christoph Klug,
Koernerstrasse 47 B,
31141 Hildesheim,
Germany.

[Editor's note: see also the article about the I/O Board by Christoph Klug on page 16]

HP82166A HP-IL Converter 16 Bit Input/Output Board Manual Update

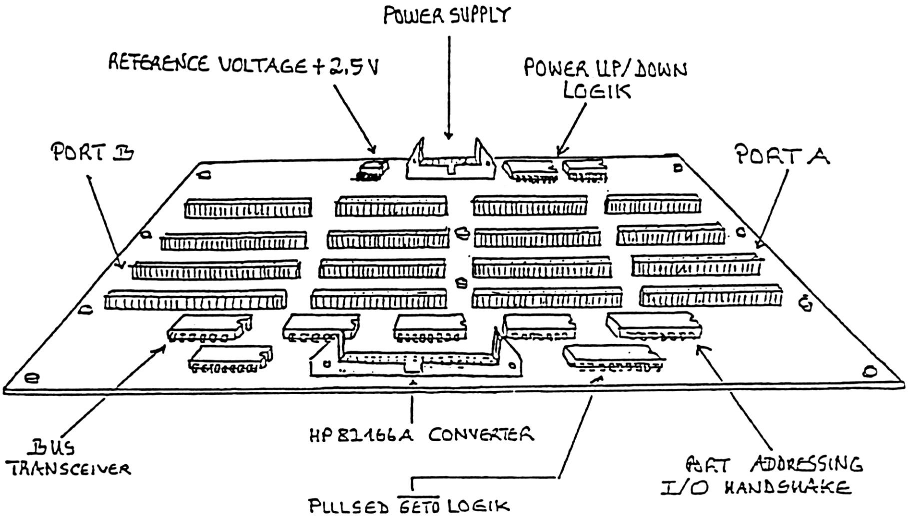
reviewed by Wlodek Mier-Jedrzejowicz

Of interest to users of the HP-41 and of HP-IL

Just a few days after I had sent the review of Christoph Klug's book to Roger Wiley (see previous issue of Datafile), I got an updated version in the post. This new version has more circuits, more tips - and a serious warning about the need to take care of the IL Converter because HP no longer make it or repair it. Just for this one warning I think the new version of the book is worth getting if the topic of HP-IL interfacing interests you! I have only one copy but would be happy to show it to anyone at club meetings. Or order a copy from Christoph directly: Christoph Klug, Körnerstraße 47 B, 31141 Hildesheim, Germany.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP 82166 A 16 BIT INPUT / OUTPUT BOARD



HP82166A IL-convertor

De meeste mensen gebruiken de HP62166A IL-convertor om een parallelle printer op de IL-loop aan te sluiten. Maar u kunt de krachtige IL-convertor ook gebruiken om elektronische hardware er op aan te sluiten gecontroleerd/bestuurd door de HP-41. Ik heb een I/O-board voor de HP82166A IL-convertor ontwikkeld met 16-bits uitbreidingssloten. Het I/O-board gebruikt een basis applicatie voor handshake-timing van Gary Friedmann. Deze handshake-timing staat beschreven in het boek "Control the world with HP-IL".

IO-BOARD HARDWARE FEATURE LIJST

Er zijn enige handige circuits aan het I/O-board toegevoegd om de I/O-performance te verbeteren. U kunt hardwarematige oplossingen vinden voor:
- poort adressering;
- power on reset;
- MRSQ (manual service request);
- power up/down functie;
- MSRQ-lock wanneer power down;
- een referentie spanning.

De voedingsspanning is extern. Een standaard 220 Volt AC voeding is beschikbaar. Alternatief is er een 6 Volt DC voeding beschikbaar met zonne energie oplaadbare cellen voor modulaire toepassingen. De Stand-by stroom is lager da 10 μA.

HP-41 INTERFACE LOOP CONTROLER

Het beste model om de IL-controler met de HP-41 aan te sturen is de CX-versie met ingebouwde X-functions, X-memory en Time-module. Bovendien heeft u een HP82160 IL-module en de EXT-module nodig om de IL-loop te besturen. In plaats van de EXT-module kunt u de Development module gebruiken. Voor maximum performance kunt u de zaak completeren met de duitse CCD-module. De hard- en software zijn zodanig ontwikkeld dat zij optimaal werken in combinatie met andere loop-apparaten zoals de cassette drive, de thermische printer of de video interface. Om deze reden kunt u omvangrijke IL-systemen configureren.

SOFTWARE VOOR DE I/O EN DE DEVELOPMENT MODULE

Voor het besturen van het I/O-board moet u enige interne status register aanpassen van de HP82166A convertor module. Om dit aan te passen heeft u de EXT-module of alternatief de Development module nodig. Voor de EXT-module wordt er 695 bytes (=100 registers) aan software gebruikt door de HP-41 om het I/O-board te besturen en indien de development module wordt gebruikt is dit 811 bytes (=116 registers).

SOFTWARE VOOR DE EXT MODULE

Het besturen van het I/O-board met de HP-41CX en de EXT I/O-module sneller dan met de Development module. De EXT I/O-module gebruikt het alfa register om data naar de IL-convertor te sturen. Om problemen te vermijden met verlies van leading nullen in het alfa register, werkt de EXT I/O-module in het algemeen met een dummy byte D.

Voor het besturen van het I/O-board met de HP-41 zijn 24 er commando's voorzien voor:
- power up/down;
- initialisatie;
- adressering;
- manual service request;
- interrupt;
- clear;
- 16-bit I/O transfer door het ALFA-register;
- 16-bit I/O transfer door het X-register;
- 8-bit I/O transfer door het X-register.

Voor 8-bit transfer moet met de beschikbare software gebruik gemaakt worden van de X-memory module voor data opslag.

SOFTWARE DEVELOPMENT MODULE

Het besturen van het I/O-board met de HP-41CX en de Development module is meer complex en langzamer dan met de EXT I/O-module. De development module genereert een buffer om data naar de I/O-convertor te zenden. Een voordeel feature van de development module is de INTR-routine, welke de HP-41 automatisch start met een MSRQ-signaal.

Voor het besturen van het I/O-board met de HP-41 zijn 22 commando's voorzien voor:
- power up/down;
- adressering;
- initialisatie;
- manual service request;
- interrupt;
- clear;
- 16-bit I/O transfer door het ALFA-register;
- 16-bit I/O transfer door het X-register;
- 8-bit I/O transfer door het X-register.

I/O-BOARD EN TIME MODULE

U kunt de commando's van de time module gebruiken om automatisch het I/O-board te besturen. U kunt bijvoorbeeld het systeem opstarten (power up) door middel van een alarmfunctie en het starten van bepaalde activiteiten zoals meten, het bewaren van data in het hoofdgeheugen of cassette drive; het daarna instellen van een nieuw tijdalarm en het I/O-board laten slapen tot aan de volgende cyclus.

HP-41 EN DE PC

Normale gesproken wordt de I/O-board data processing geheel door de HP-41 verzorgd. Maar het is mogelijk om HP-41 data naar de PC te zenden. Gebruik hiervoor de PC-IL interface kaart met Link Plus software. De kaart en de software werken goed op 286/16MHz PC-systemen en langzaam op 386SX/25MHz systemen. De Link Plus software emuleert sommige HP-IL apparaten voor de HP-41 zoals:
- twee cassette drives;
- een video display;
- een printer;
- DOS files voor data transfer.

Verzamel de data door middel van de HP-41 en het I/O-board in het veld. Stuur HP-41 databestanden naar de PC in een DOS-bestand en laad het databestand in een spreadsheet of tekstverwerker voor het evalueren dan de data.

I/O-BOARD POORT CONFIGURATIE

Het I/O-board ondersteund 4 stuks 16-bits sloten. Elk slot is verdeeld in 2 stuks 8-bits sloten A en B. Alle sloten zijn verbonden met een algemene verbindingsbus met voeding, handshake lijnen en data lijnen. De hardware logica van het I/O-board kan maximaal twee (geplaatste) 16-bits input modules en twee (geplaatste) 16-bits output modules adresseren. Adresinstellingen worden gedaan met/via jumpers op de modules en niet met behulp van de slot-positie. Geplaatste 8-bit modules hebben additionele software adressering nodig. De slot architectuur van het I/O-board en de hardware en software adressering staat sommige poort configuraties toe voor digitale en analoge input/output.

I/O-BOARD PLUG IN MODULES

- 8-bits digitale input module;
- 8-bits digitale input module met opto coupler;
- 8-bits digitale output module;
- 8-bits digitale output module opto coupler;
- 8-bits digitale output module met open collector;
- 8-bits analoog/digitaal convertor module;
- 8-bits digitaal/analoog convertor module;
- 12-bits analoog/digitaal convertor module;
- 12-bits digitaal/analoog convertor module;
- multiplexer module met relais;
- 16-bits teller module.
- frequentie/spannings convertor module;
- spannings/frequentie convertor module;
- analoge filter module;

signaal.

Voor het besturen van het I/O-board met de HP-41 zijn 22 commando's voorzien voor:
- power up/down;
- adressering;
- initialisatie;
- manual service request;
- interrupt;
- clear;
- 16-bit I/O transfer door het ALFA-register;
- 16-bit I/O transfer door het X-register;
- 8-bit I/O transfer door het X-register.

I/O-BOARD EN TIME MODULE

U kunt de commando's van de time module gebruiken om automatisch het I/O-board te besturen. U kunt bijvoorbeeld het systeem opstarten (power up) door middel van een alarmfunctie en het starten van bepaalde activiteiten zoals meten, het bewaren van data in het hoofdgeheugen of cassette drive; het daarna instellen van een nieuw tijdalarm en het I/O-board laten slapen tot aan de volgende cyclus.

HP-41 EN DE PC

Normale gesproken wordt de I/O-board data processing geheel door de HP-41 verzorgd. Maar het is mogelijk om HP-41 data naar de PC te zenden. Gebruik hiervoor de PC-IL interface kaart met Link Plus software. De kaart en de software werken goed op 286/16MHz PC-systemen en langzaam op 386SX/25MHz systemen. De Link Plus software emuleert sommige HP-IL apparaten voor de HP-41 zoals:
- twee cassette drives;
- een video display;
- een printer;
- DOS files voor data transfer.

Verzamel de data door middel van de HP-41 en het I/O-board in het veld. Stuur HP-41 databestanden naar de PC in een DOS-bestand en laad het databestand in een spreadsheet of tekstverwerker voor het evalueren dan de data.

I/O-BOARD POORT CONFIGURATIE

Het I/O-board ondersteund 4 stuks 16-bits sloten. Elk slot is verdeeld in 2 stuks 8-bits sloten A en B. Alle sloten zijn verbonden met een algemene verbindingsbus met voeding, handshake lijnen en data lijnen. De hardware logica van het I/O-board kan maximaal twee (geplaatste) 16-bits input modules en twee (geplaatste) 16-bits output modules adresseren. Adresinstellingen worden gedaan met/via jumpers op de modules en niet met behulp van de slot-positie. Geplaatste 8-bit modules hebben additionele software adressering nodig. De slot architectuur van het I/O-board en de hardware en software adressering staat sommige poort configuraties toe voor digitale en analoge input/output.

I/O-BOARD PLUG IN MODULES

- 8-bits digitale input module;
- 8-bits digitale input module met opto coupler;
- 8-bits digitale output module;
- 8-bits digitale output module opto coupler;
- 8-bits digitale output module met open collector;
- 8-bits analoog/digitaal convertor module;
- 8-bits digitaal/analoog convertor module;
- 12-bits analoog/digitaal convertor module;
- 12-bits digitaal/analoog convertor module;
- multiplexer module met relais;
- 16-bits teller module.
- frequentie/spannings convertor module;
- spannings/frequentie convertor module;
- analoge filter module;

- rms meet module (log amplifier);
- computer bestuurde vca module;
- computer bestuurde oscilator module.

Het modulaire hardware concept van het I/O-board maakt het mogelijk om het interface systeem te configureren met I/O-modules voor elke taak die u wilt. U kunt ook speciale modules ontwikkelen voor uw eigen applicaties en hardwarematige projecten. Het I/O-board is een goede basis om uw HP-IL apparaten te implementeren.

KWALITEITSTESTEN

Het correct en foutvrij functioneren van de software en interface hardware is getest met een aantal HP-41 controlers, IL-convertors en 8 verschillende, door mij gebouwde, HP-IL I/O-boards.

I/O-BOARD HANDBOEK

Het engelse handboek voor het I/O-board is inclusief een beschrijving van de circuits en documentatie van de software met barcodes voor de HP-41CX. Het handboek is een grote bron voor gebruikers die IL-convertors in hun eigen elektronische uitrusting willen toepassen en voor die mensen die stap voor stap willen iets willen leren over de interface technologie (lees en schrijf bytes naar externe hardware apparaten, spanningsconversie naar het analoge gebied).

IL-MEETLAB

Met dezelfde systeemarchitectuur als het I/O-board heb ik een klein euroboard ontwikkeld voor gebruik in 19" rekken. Als voorbeeld heb ik een IL-meetlab systeem gebouwd met o.a. een HP-41 bestuurde meetunit, programmeerbare voedingsspanning, functie generator en een interface uitbreidingspoort.

Het meetsysteem wordt bestuurd door 60 software functies beschikbaar op 5 stuks gebruikers toetsenborden. Het 4 kB grootte programma is geschreven in USER code en opgeslagen in een Eramco RSU (128 kB rambox in kaartlezer behuizing). Het zelfde programma is gebrand in een 16 kB Zeprom module te samen met kopieën van de I/O module en CCD module.

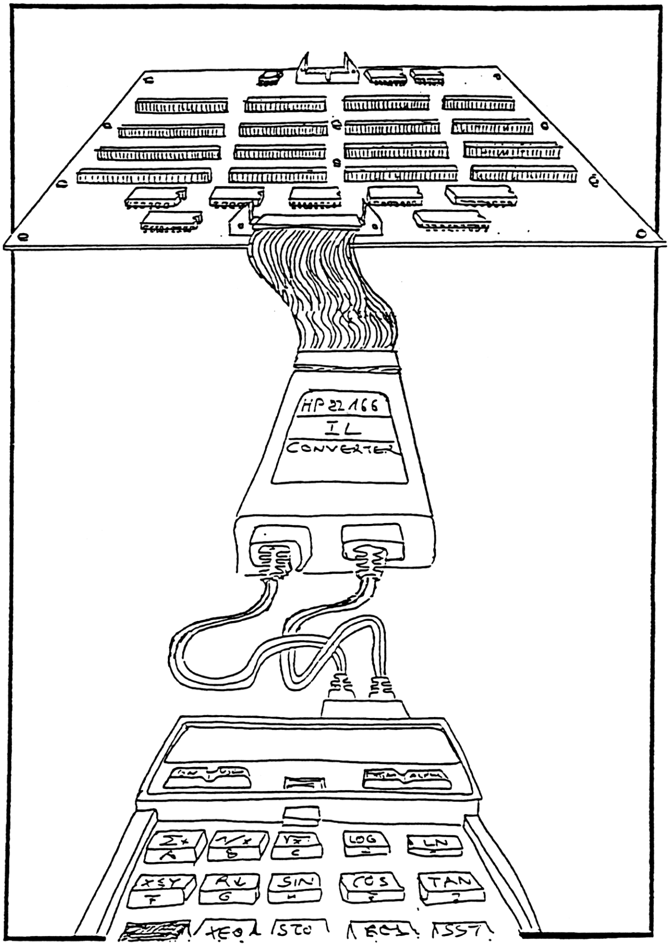
Het IL-meetlab is een indrukwekkend voorbeeld om metingen en besturingen met een klein HP-41 computer systeem en HP82116A HP-IL convertor te besturen.

UITRUSTINGSBRONNEN

De HP82116A IL-convertor is het sleutel onderdeel voor het I/O-board. Voor deze unit bestaan sommige bouwpakketten. Printed circuit boards voor het I/O-board bestaan maar tot op heden alleen in eenzijdige uitvoering. U moet veel additionele aansluitingen met wire wrapping of soldeertechnieken uitvoeren. Dit is gemakkelijk voor elektronische beroepsmensen. Voor mensen die geen complexe meetinstrumenten hebben kan ik enige kritische componenten uitlijnen. Elektronische beginners kunnen een compleet en getest I/O-board inclusief DC-voeding verkrijgen. Het maken van plug-in modules niet moeilijk en door een elektronische beginner worden gedaan.

CONCLUSIE

Tegenwoordig is de HP-41 een nostalgische calculator. Met de extra accessoires zoals de in te steken uitbreidingsmodules kunnen de hardware beperkingen worden omzeild. Met het gebruik van de IL-convertor en het I/O-board opent u een interessant gebied voor besturing en ontwikkeling van externe hardware. Nu kunt u metingen en besturingen realiseren via uw HP-41 die anders met veel grotere systemen worden gedaan. Met het koppelen van uw handheld aan de PC kunt u met moderne software gereedschap uw data analyseren.



Boekbespreking

Christoph Klug ondersteund nog steeds heel enthousiast het HP-IL systeem. Hij heeft een I/O-board ontworpen voor gebruik met de HP82116A HP-IL convertor voor algemene doeleinden. Hij heeft ook een handboek geschreven voor de bouw hiervan. Maar het handboek kan ook op zich worden gelezen met de bijbehorende programma's.

Het handboek is ingedeeld volgens de volgende hoofdstukken:
1 introductie
2 HP-41 controler
3 I/O-board hardware
4 voedingsspanning
5 I/O-board modules
6 praktische tips
7 geavanceerd programmeren
8 referenties
9 centronix printer
10 HP-41 bar codes

Christoph begint met een beschrijving van de HP82166A convertor en zijn I/O-board en daarna de HP-41 met de modules die hij gebruikt. Hij stelt een HP-41CX voor omdat in deze de extra tijdfuncties en extended geheugen zijn ingebouwd. Hij gebruikt de CCD module en de HP-IL I/O module of de HP-IL development module voor betere controle op de HP-IL loop en apparaten. Natuurlijk is een HP-41 HP-IL module tevens noodzakelijk.

Het I/O-board zelf kan worden gebruikt met 8-bits of 16-bits modules. Het volgende gedeelte van het handboek beschrijft de functies van het I/O-board en voorziet daarna de HP-41CX van programma's voor de besturing. Sommige van deze programma's bevatten syntetic HP-41 commando's; de CCD module kan worden gebruikt om deze commando's in te voeren; de Zenrom kan ook worden gebruikt. Testprogramma's worden tevens gegeven.

De volgende hoofdstukken beschrijven de hardware van het I/O-board (dus u kunt een I/O-board zelf bouwen) en de details van de voeding. Er is zelfs een beschrijving van een regelaar voor een zonnepaneel om de (een daarvoor geschikte) batterij op te laden als deze een lange tijd in bedrijf is geweest. Vervolgens worden alle insteekmodules beschreven met alle technische data gevolgd door een aantal praktische tips voor het hardwarematig bouwen en testen van het I/O-board met bijbehoren. Hierna worden een aantal tips gegeven voor geavanceerd programmeren van de HP-41 met o.a. het gebruik van de IL-module, CCD-modulen X-functies. Er is tevens een beschrijving van Centronics aansluiting en een programma voor het aansturen van een HP-Deskjet 500 via de HP 82166A IL-convertor. Het boek wordt gecompleteerd door alle barcode programma's met voorbeelden en er is een referentielijst van boeken welke zijn geraadpleegd.

Alhoewel de HP-41 en HP-IL enigszins verleden tijd is kan met het gebruik van de HP 82166A met de HP-41 een goedkoop meetsysteem worden opgezet met een grote variatie aan insteekmodules.

Cristoph Klug kan voor een ieder die daarvoor interesse heeft service verlenen met het bouwen hiervan van lege PCB's tot compleet geteste systemen. Er is ook ook datacassette of een ZepRom-module met HP-41 software beschikbaar voor de aansturing. De ZepRom-module bevat tevens gedeeltes van de software uit de uitbreidingsmodules. Er zijn ook bouwpakketen te verkrijgen.
U kunt schrijven naar (engels/duits):

Cristoph Klug
Körnerstrasse 47 B
31141 Hildesheim
Duitsland

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

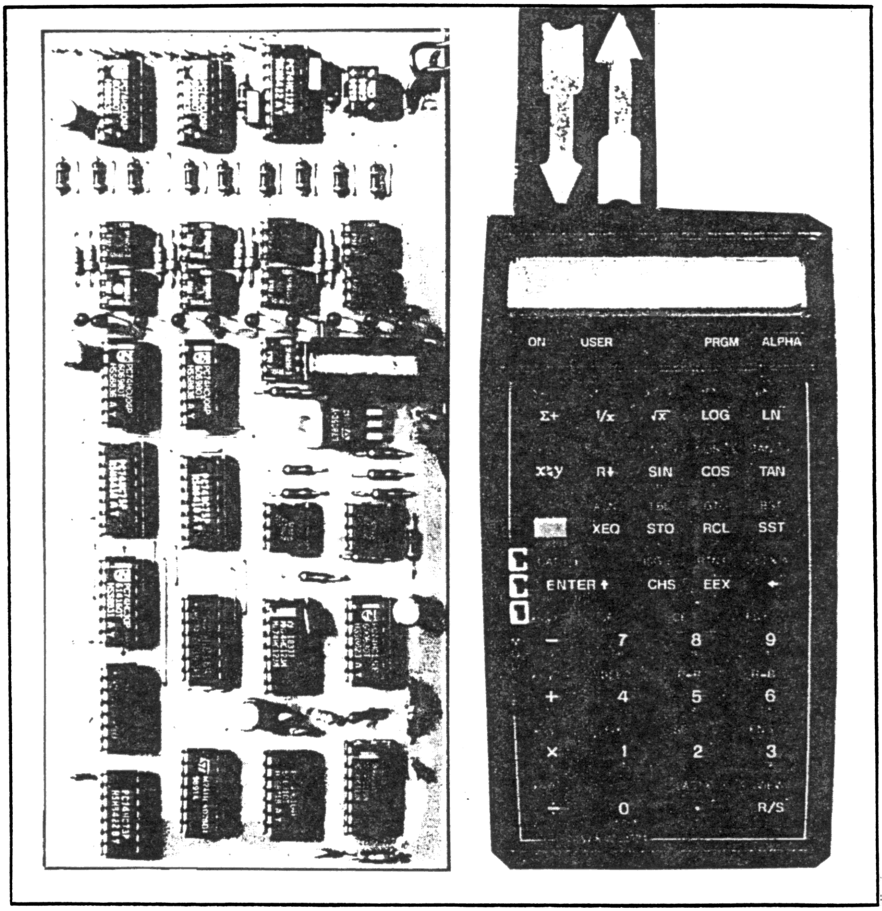
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

History of I/O-Board :

Controlinterface	**IIX.20**
IL-Rack	**IIX.21**
8 Bit I/O-Board	**IIX.22**
8 Bit Euro I/O-Board	**IIX.23**
16 Bit I/O-Board	**IIX.24**
IL-Messlab	**IIX.25**

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

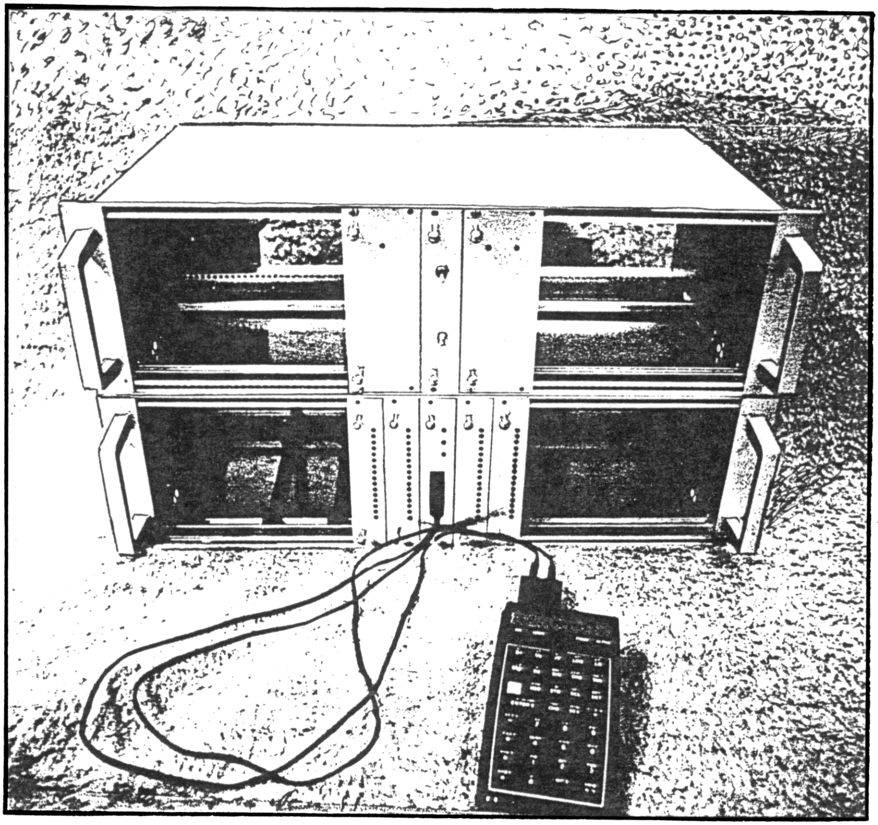
The Controlinterface :



The evolution process of I/O-Board start with the relais interface from W. Ressel, presented in PRISMA, the journal of the German Computer Club CCD. This plain unit switched four power relais, controlled by HP-IL. First I expanded wordsize from 4 bit to 8 bit, later I changed the used 74LS circuits to 74HC circuits for lower power consumption. This low coast Controlinterface was presented in PRISMA (No.2 März/April 1990), but it have two disadvantages : Only data output and not addressable within Interface Loop. Therefore exist no compability to other loop devices !

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

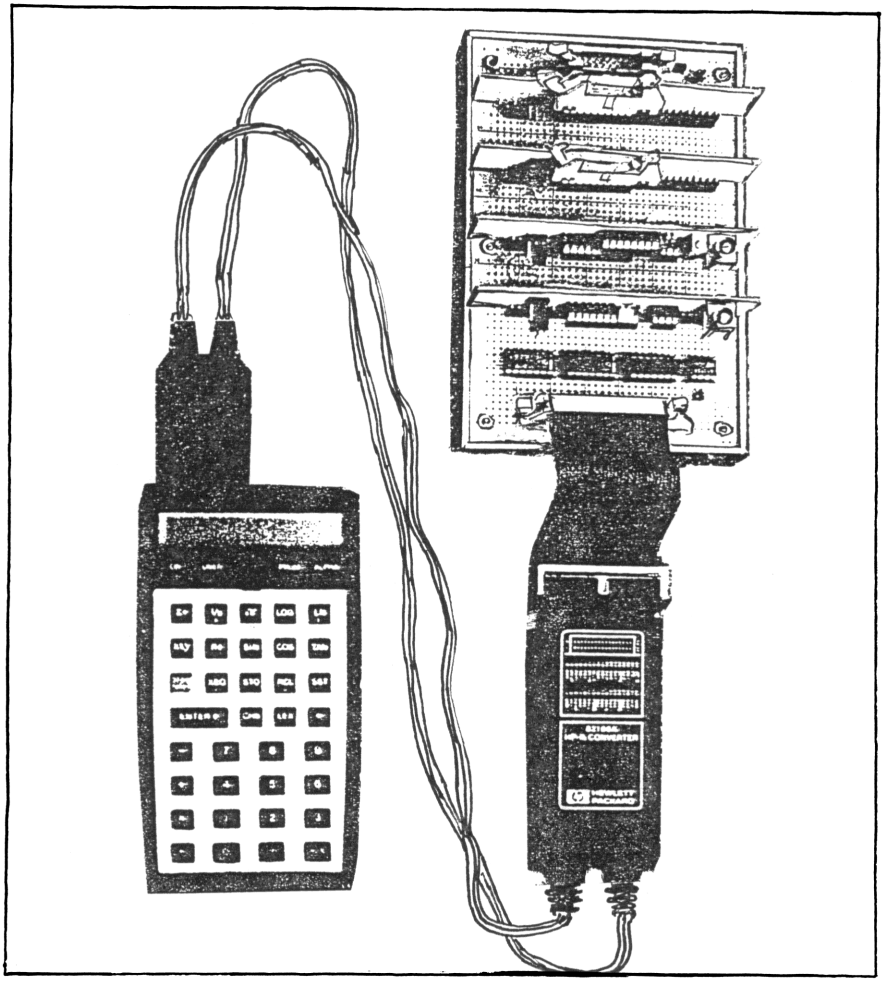
The IL-Rack :



To overcome disadvantages of Controlinterface, I continue development using the HP 82166 A IL-Converter. Two stacked 19 inch Rack systems containing the interface hardware (lower) and power supply (upper) for the IL-Converter. System make possible twelve 12 bit output slots on right side (= 144 output lines) and twelve 16 bit input slots on left side (= 192 input lines). This large scale enterprise was the basic development platform for evolving and testing some hardware solutions for input/output handshake and port adressing. Later followed the development of some complex slot devices like temperature measurement module, voltmeter module, frequency counter module and generator module. But this exurberantely grown machine was to voluminous for practical use with small HP-41 handheld computer in modular applications !

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

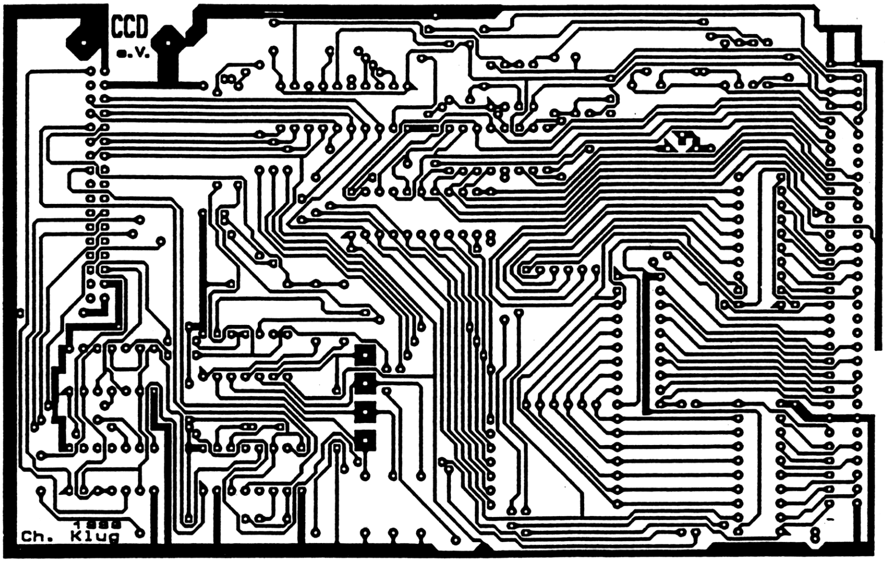
The 8 Bit I/O-Board :



Next step was realizing a cheap I/O system with more profit to small and medium applications, typically for practical use with the HP-41 handheld computer. Some basic ideas from G. Friedman's book "Control the world with HP-IL" influenced the development. The advantage of a modular hardware system was taken from the IL-Rack. Board addressed two input- and two output ports. 8 Bit plug in modules arised for digital and analog I/O. For power supply I used a stationary 220V AC supply.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

The 8 Bit Euro I/O-Board :



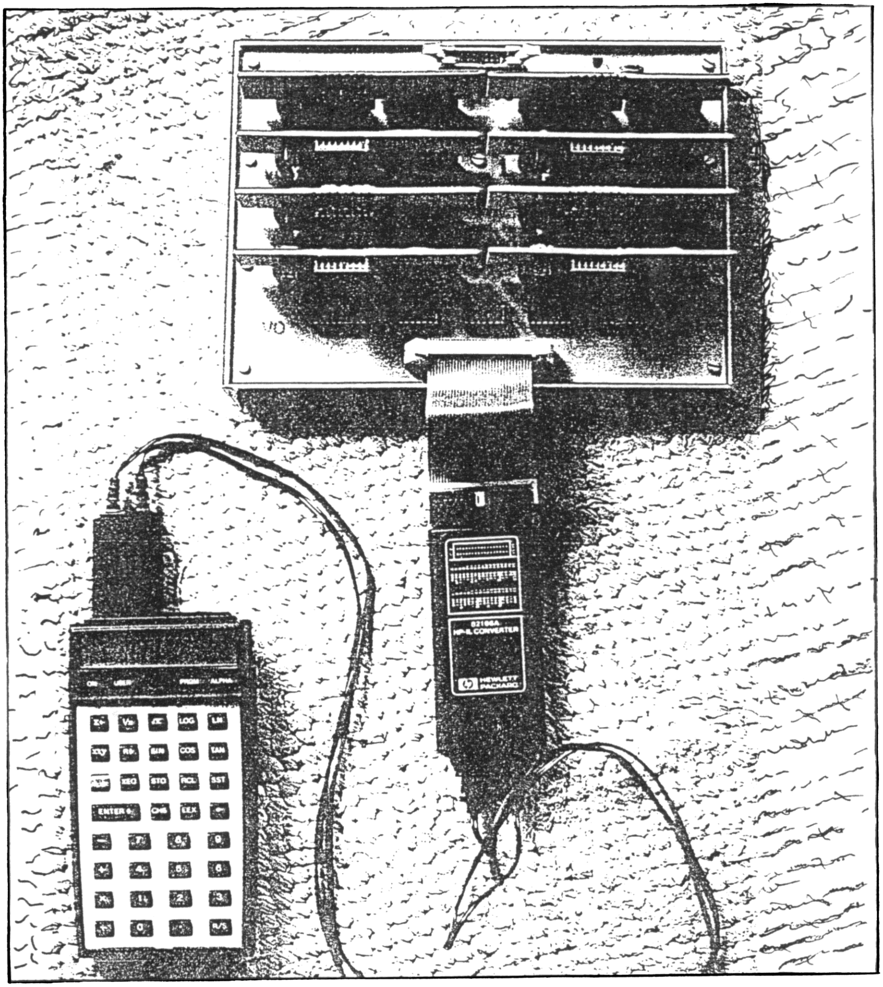
For CCD the basic hardware circuits of modular 8 bit I/O-Board was transfered to an Euro-Board with 64 pin connector. This board has a digital 8 bit inputport, a digital 8 bit output port, an analog input (8 bit ADC) and an analog output (8 bit DAC). System was presented in PRISMA journal issue No.3 Mai+Juni 1990 and issue No.4 Juli+August 1990.

The 16 Bit I/O-Board :

Disadvantage of the 8 bit I/O-Board was the small amount of ports. Therefore I expanded wordsize up to 16 bit, doubling the slot number. Pin configuration was compatible to existing 8 bit I/O-Board modules. But now insertion of powerful 16 bit modules was possible. This was the moment of creating 12 bit analog converters and the 16 bit counter module. An other limitation was the port adressing by using trigger- and clear line of IL-Converter. Incompatibility with other IL devices result. For example IL-Cassette Drive rewind medium to header. Advanced port addressing was developed using pulsed trigger line. Making possible mobile applications with the I/O-Board system, a special 6V DC power supply was realized. Continued on next page !

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

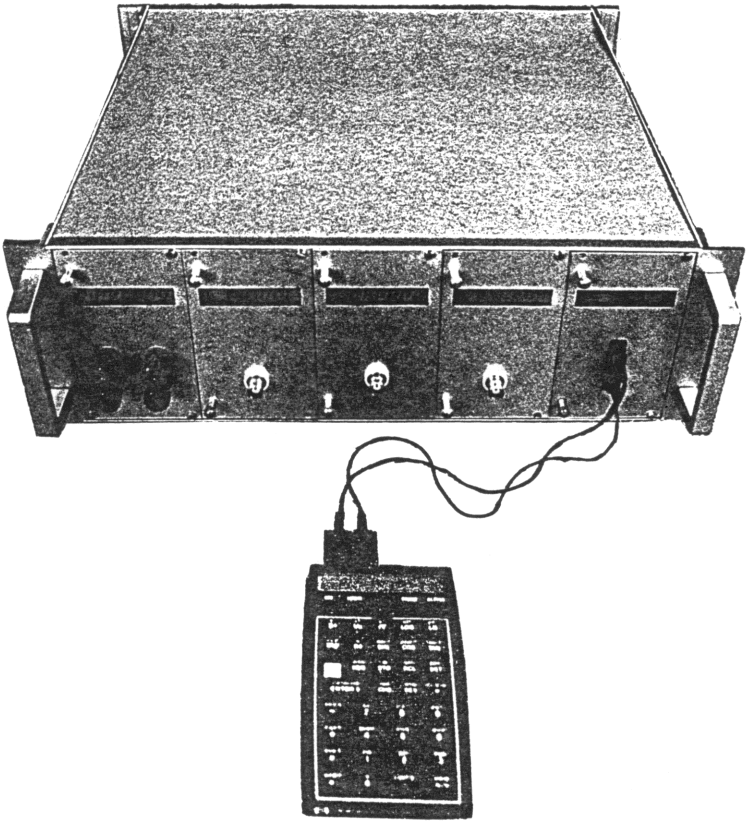
The 16 Bit I/O-Board :



First generation of DC power supply used bistable relais, optimiced second generation driving an on/off line, for electronic switching power supply hardware. Picture above showes the first 16 bit I/O-Board prototype. The excellent hardware concept of actual I/O-Board is presented to you with this book.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

The IL-Messlab :



This efficient labour measurement unit was created to give an example about an advanced application using the HP Interface Loop. IL-Messlab realizes the fusion of IL-Rack and 16 bit I/O-Board technologie : Existing digital voltmeter, frequency counter and function generator were taken from IL-Rack, completed by some power supplys and the basic circuit architecture of 16 bit I/O-Board, used for controlling and mounted on a small Euro-Board. The whole hardware is packed into a handy rack case, containing a complete electronic measurement labour ! A Zeprom-Module exist for controlling by HP-41, containing two utility roms and 4 kByte software with 60 functions available on 5 user keyboards.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX References :

HP-41 CX User's Manual
Part 1
00041-90476

HP-41 CX User's Manual
Part 2
00041-90494

HP 82160 A
HP-IL Module
Owner's Manual
82160-90003

HP 82183 A
Extended I/O-Module
Owner's Manual
82183-90001

HP 00041-15043
HP-IL Development Module
Owner's Manual
00041-90449

HP-41C Service Manual
Alphanumeric Programmable
Scientific Calculator
Hewlett Packard Company
00041-90008

Extend Your HP-41
W. Mier-Jedrzejowicz
Synthetix
ISBN 0-9510733-0-3

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP 82166 A IL-Converter References :

HP-IL Converter
82166-90002
Technical Manual

HP 82166A
HP IL Converter
82165-90012
Manual Supplement

HP 82166C
The HP-IL Interface Kit
82166-90020
Technical Guide

Firmware Design
for HP-IL Devices
82166-90024

The HP-IL
Integrated Circuit User's Manual
82166-90016

The HP-IL
Interface Specification
82166-90017

The HP-IL System
An Introductory Guide
to the Hewlett-Packard
Interface Loop
Gerry Kane / Steve Harper / David Ushijima
ISBN 0-931988-77-2

Control The World With HP-IL
Gary Friedman
Synthetix
ISBN 0-9612174-9-9

Advanced Programming :

ZENROM MODULE
The HP-41Programmer Module
Synthetic Programming
Machine Language Programming
Zengrange Ltd, England 1984

CCD MODULE
Benutzerhandbuch
Computer Club Deutschland
W&W Software Products GmbH, 1985

EXTENDED IL ROM
The HP-IL Enhancement Module
for use with the HP-41
Handheld Computer
Skwid Ink, USA 1986

RAM STORAGE UNIT
ES-41 DATABASE
A Database Oriented Operating System
for the Eramco Systems RAM Storage Unit
Eramco Systems, The Netherlands 1986

HP-41 Advanced Programming Tips
by Alan Mc Cornack and Keith Jarett
Synthetix, USA 1987

ZEPROM MODULE
An Erasable Programmable Read Only
Memory Module for the HP-41
Handheld Computer
Zengrange Ltd, England 1988

LINK PLUS
Handheld Computer ↔ PC Communications
via the Hewlett Packard Interface Loop
Southern Software, USA 1990

TRANS41
UP/Down Load Programs/Data To/From PC↔HP-41
Tacit Logic Systems Inc, USA 1989

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Hewlett Packard Journal :

Detailed informations about development and technologies of HP-41 handheld computer and some HP-IL Devices, and about the people who create this fantastic system :

Hewlett Packard Journal March 1980 Vol. 31 No. 3	HP-41 Handheld Computer
Hewlett Packard Journal January 1981 Vol. 32 No. 1	HP-41 Bar Code
Hewlett Packard Journal December 1982 Vol. 33 No.12	HP 7470A IL-Plotter
Hewlett Packard Journal January 1983 Vol. 34 No.1	HP-IL Interface Loop
Hewlett Packard Journal February 1983 Vol. 34 No.2	HP-IL Voltmeter & HP-IL Datalogger
Hewlett Packard Journal May 1983 Vol. 34 No. 5	HP 82161 Digital Cassette Drive
Hewlett Packard Journal June 1983 Vol. 34 No. 6	HP 82168A Telephone Interface
Hewlett Packard Journal May 1985 Vol. 36 No. 5	HP-IL Think Jet Printer

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

PPC Calculator Journal :

HP 82166A IL-Converter related articles published in PPC Journal. Most of Gary Friedman´s papers sumed up in his book "Control The World With HP-IL" :

PPC Calculator Journal V9 N4 May June Juli 1982	The Data Frame HP-IL Converter Jim De Arras
PPC Calculator Journal V10 N7 August 1983	82165A HP-IL/GPIO Overview and Control Application Gary Friedman
PPC Calculator Journal V10 N7 August 1983	82166A Converter Applications Part I Printers Jeremy Smith
PPC Calculator Journal V10 N7 August 1983	82166A Converter Applications Part II Other Richard Nelson
PPC Calculator Journal V10 N8 September October 1983	HP 82166 A Interface to Osborne Computer Noel B. Brinkley
PPC Calculator Journal V11 N4 May 1984	Notes on GPIL, IL Conv, XI/O & DEV Gary Friedman
PPC Calculator Journal V11 N6 July 1984	HP-41-Based Telephone Answering Machine Utilizing Speech Synthesis and Touch Tone Control Gary Friedman
PPC Calculator Journal V11 N7 August 1984	HP-41-Based Telephone Answering Machine Utilizing Speech Synthesis and Touch Tone Control Part II Gary Friedman

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

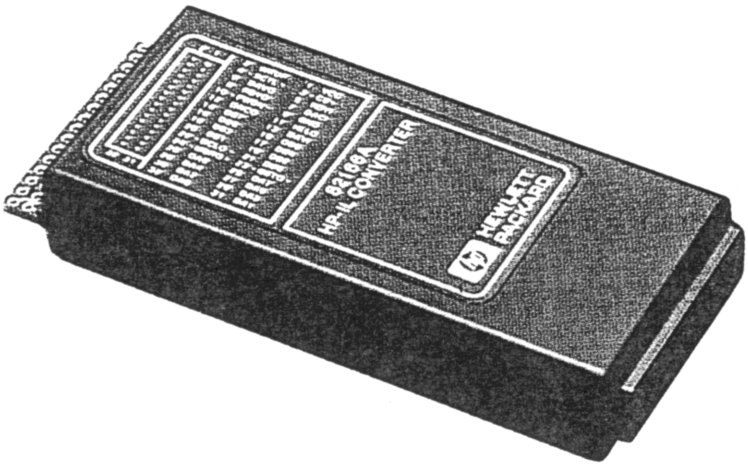
PPC Calculator Journal V11 N7 August 1984	Positive Handshake on the IL Converter Gary Friedman
PPC Calculator Journal V12 N1 January 1985	HP-41 listens to HP-75 Stefano Piccardi
PPC Calculator Journal V12 N11 November 1985	HP-71 Controlled Slide Projector Dissolve Unit (Or The World's Most Expensive Dimmer) Gary Friedman
PPC Calculator Journal V13 N1 January 1986	HP-71 Controlled Slide Projector Dissolve Unit (Or The World's Most Expensive Dimmer) Part II Gary Friedman
PPC Calculator Journal V14 N2 February 1987	Connecting an Analog to Digital Converter to HP-41 Gill Dunne
PPC Calculator Journal V14 N3 March 1987	Room Temperature Measurement with the HP-41 Gill Dunne

Interface - Devices :

HP 82166A IL-Converter	IIX.35
Walcher IL-Converter	IIX.36
HP 82163A Video Interface	IIX.37
HP 82164A RS232 Interface	IIX.38
HP 82165A GPIO Interface	IIX.39
HP 82169A HP-IB Interface	IIX.40
W&W EPSON-IL Interface	IIX.41
W&W Masterface	IIX.42
Grabau GR7 Video Interface	IIX.43
HP-IL / PC Interface Card	IIX.44
Interloop-IL / PC Interface Card	IIX.45

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

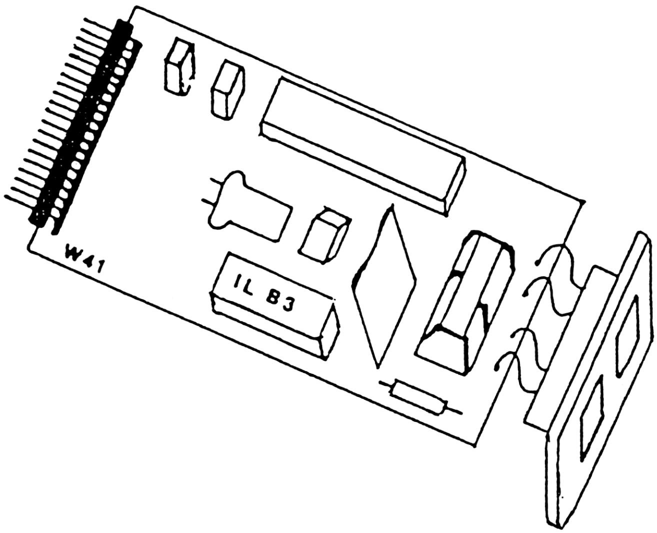
HP 82166A IL-Converter :



IL-Converter engineering kit used for interfacing external hardware like I/O-Board to HP-IL. Most people take it only for connecting a centronix printer to Interface Loop. Small size of 110 x 45 x 18 mm is possible by the four layer printed board. Other internal keyparts are IL-Terminal, IL-Transformer, IL-Chip and CPU. Alternatively you can work with the Walcher IL-Converter or, with limits with the HP 82165A GPIB Interface.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Walcher IL-Converter :



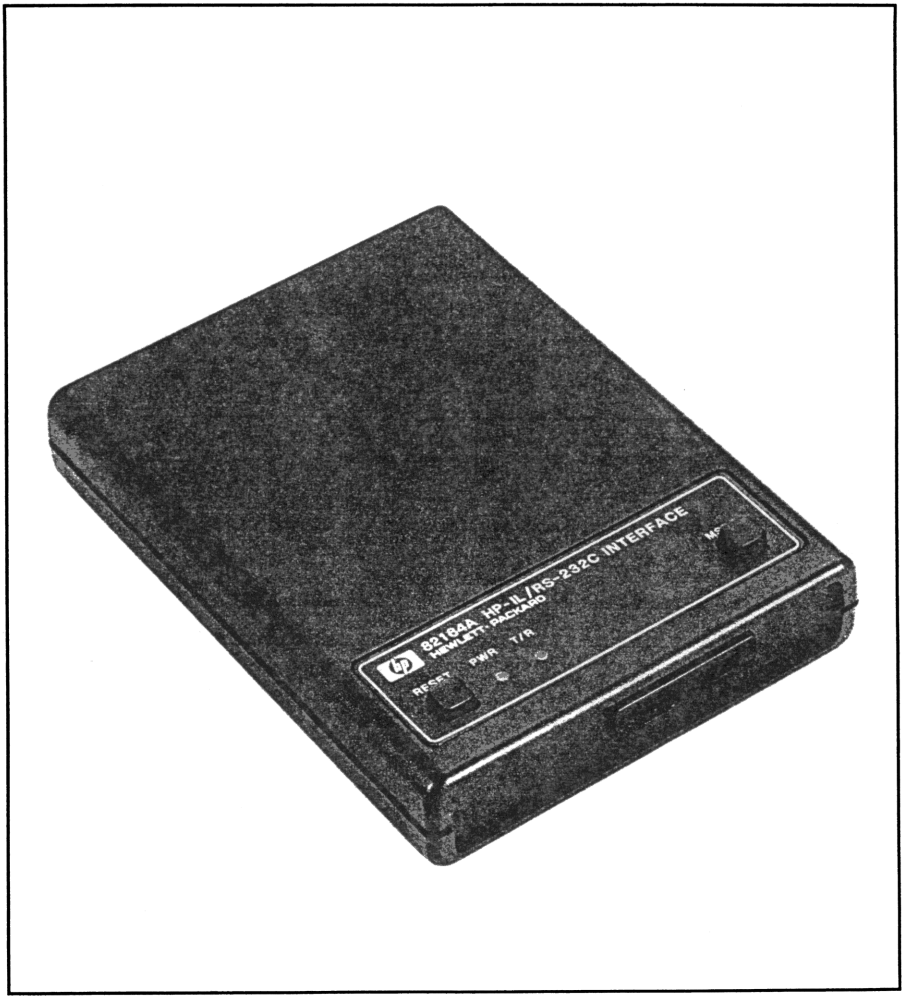
Roland Walcher Elektronik, Germany produced a own version of the HP 82166A IL-Converter for use with there IL-Devices "Mikro-Logger W41" and "Logger W51B". Same IL-Converter is used in the Proemtec pressure measurement system. The Walcher IL-Converter is 100 % pincompatible to the HP 82166A IL-Converter. Because of the doubleside print layout board size is 90 x 56 mm.

HP 82163A Video Interface :

Interface unit for connecting a TV-Monitor or Video-Monitor like the HP 82913A to HP-IL. Monitor acts like a printer device (only text - no graphic). Interface box is powered by AC adapter.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

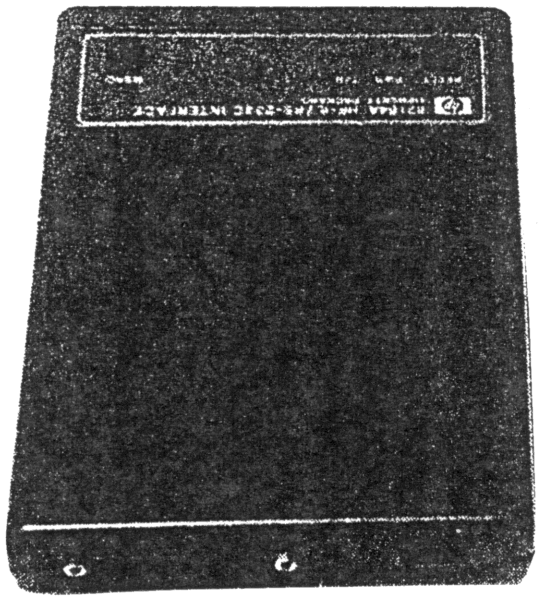
HP 82164A HP-IL/RS232 Interface :



Interface unit for connecting RS232 Devices to HP-IL. For setting internal control registers HP-41 handheld computer needs the I/O-Module for changing RS 232 interface parameters. Interface box is powered by AC adapter.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP 82165 GPIB-Interface :



Produced by HP as replacement part for the HP 82166A IL-Converter because it's high price for multilayer printed board. The HP 82165A called GPIO Interface have intern 5V voltage regulator circuit, powered by same AC adapter like HP-41 or Cass-Drive. Because of stationary use of GPIO Interface it have no PowerUP/Down signal lines (used by I/O-Board) and is therefore not 100% compatible to the HP 82166A IL-Converter.

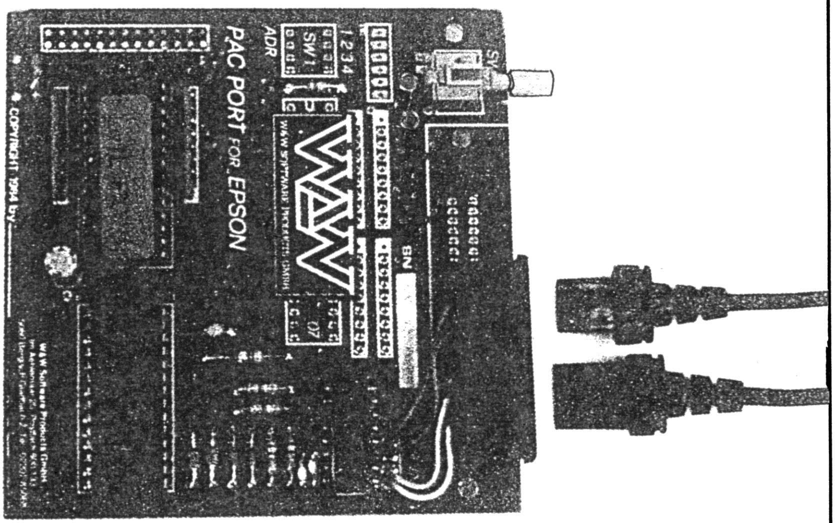
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP 82169A HP-IL/HP-IB Interface :

Interface unit for connecting powerful HP-IB Devices or IEEE Devices to HP-IL. The HP-IB interface standard is used by most measurement equipment worldwide. For setting internal control registers HP-41 handheld computer needs the I/O-Module. Interface box is powered by AC adapter.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

W&W IL-EPSON Printer Interface :



Produced by W&W, Germany. Interface unit for connecting an EPSON Printer to HP-IL. ID is "W&W FX80" and AID is 46 = Printer ADI.

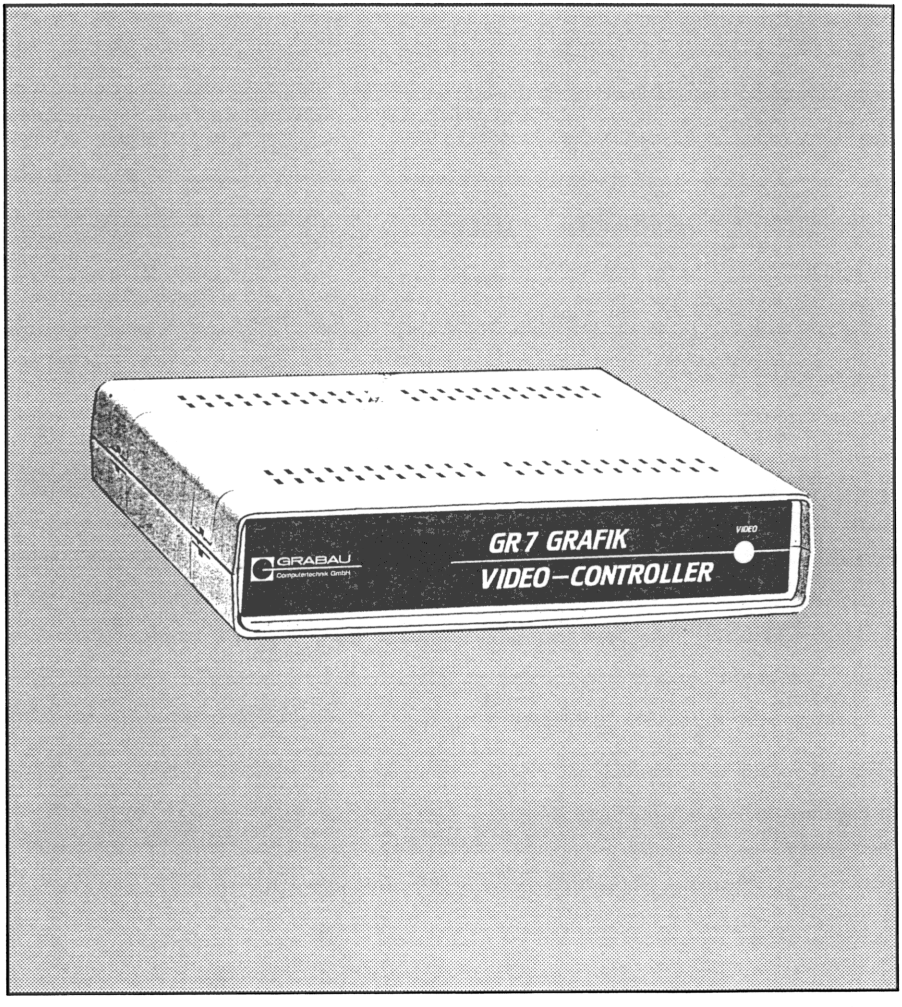
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

W&W Masterface :

Produced by W&W, Germany. Interface unit for connecting a Monitor to HP-IL. Monitor displays text and graphic, last generated by HP-41 Plotter-Module (HPGL). Centronix interface connector for optional printer. Printer emulates HP 7475 Plotter. Additional Mouse connector for controlling system.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

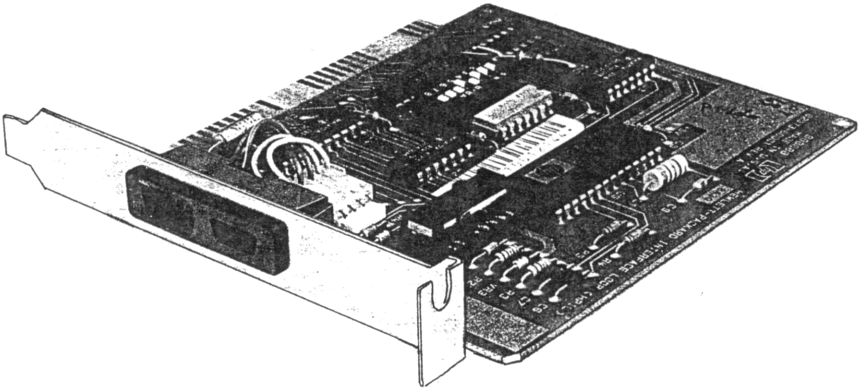
Grabau GR7 Video Interface :



Produced by Grabau Computertechnik, Germany. Interface unit for connecting a Monitor to HP-IL. Monitor displays text and graphic, last generated by HP-41 Plotter-Module (HPGL). Centronix interface connector for optional printer. Printer emulates HP 7475 Plotter.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

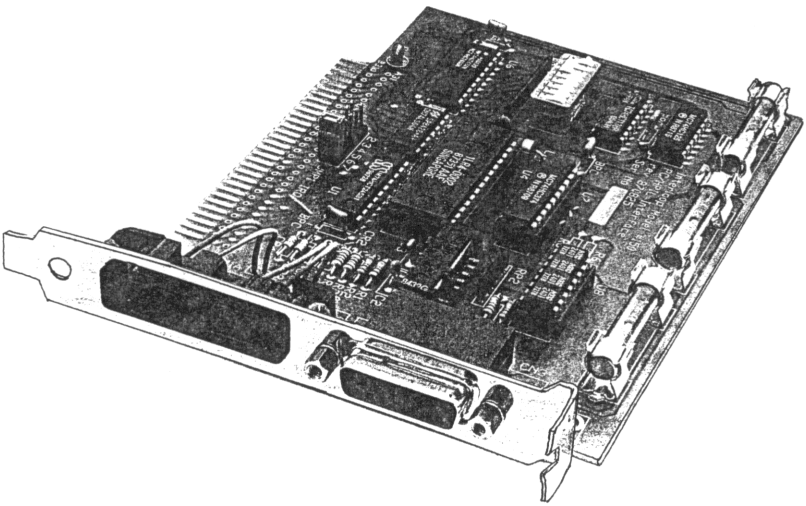
HP 82973A HP-IL/PC-Interface Card :



Produced by Hewlett Packard, USA. PC Interface Card for adapting HP-IL to PC. For informations about PC configuration and application with the HP-41 handheld computer read Chapter XV of I/O-Board manual.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Interloop HP-IL/PC-Interface Card :



Produced by Interloop, USA. Model #150. PC Interface Card for adapting HP-IL to PC. For informations about PC configuration and application with the HP-41 handheld computer read Chapter XV of I/O-Board manual.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

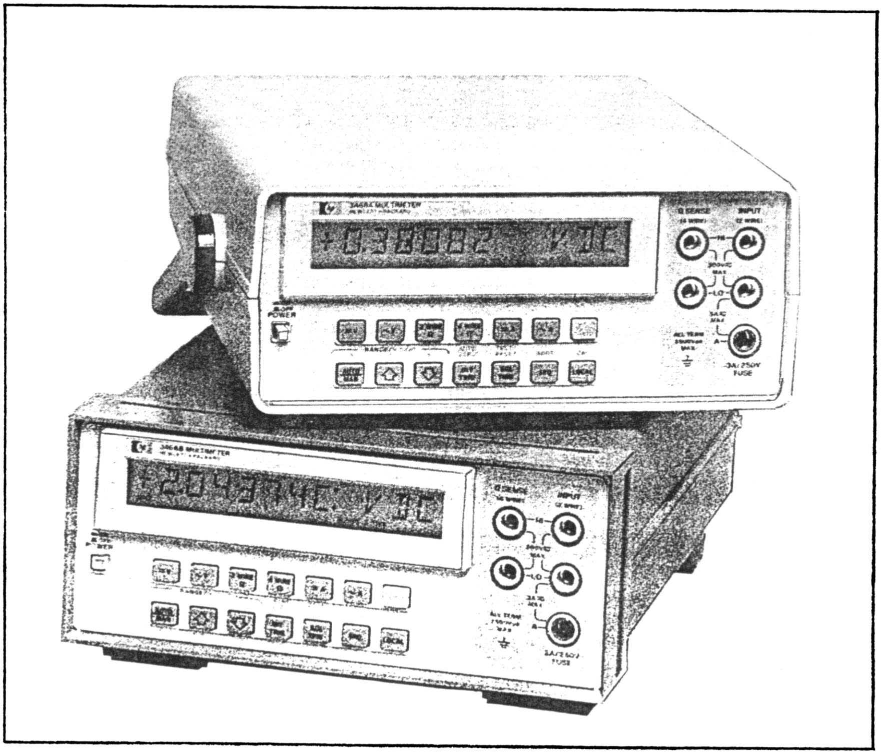
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Measurement - Devices :

HP Digital Multimeter	IIX.49
HP Data Logger	IIX.50
CMT-200	IIX.51
CMT-300	IIX.52
Interloop Step Motor Driver	IIX.53
Interloop I/O-Board	IIX.54
Walcher Mikro-Logger W41	IIX.55
Walcher Mikro Logger W51B	IIX.56
Ultrasonic Material Stress Analysis	IIX.57
Pressure Sensor Calibration	IIX.58
Kristal Interface Products	IIX.59

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

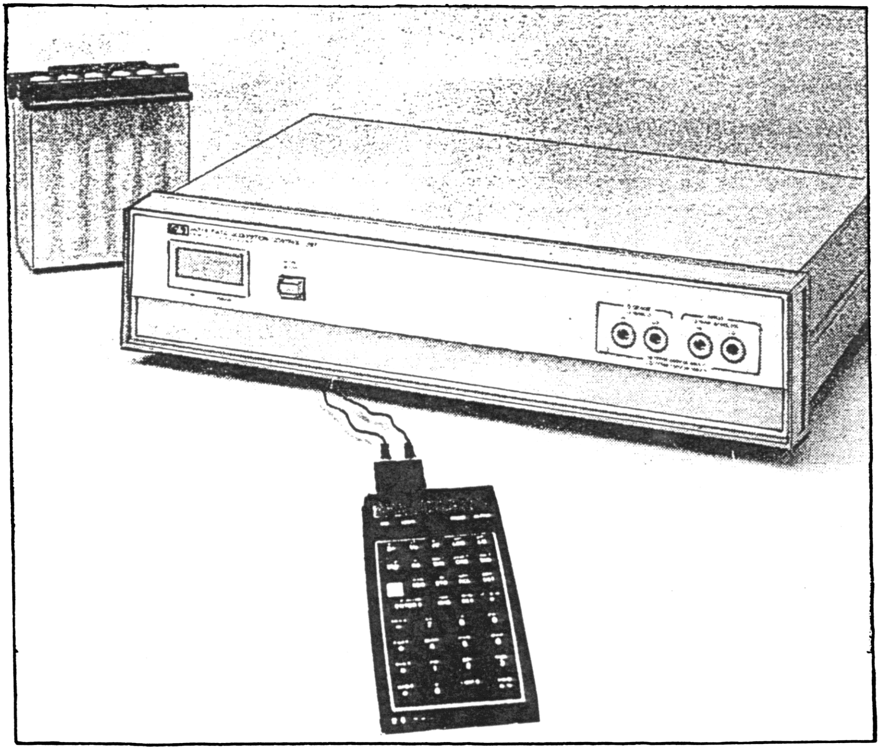
HP 3468 A + HP 3468 B Digital Multimeter :



Hewlett Packard 5½, 4½, 3½ digit Digital Multimeter in transportable case (A) or case for rack mounting (B). DC- and AC- voltage measurement range from 0...300V. DC- and AC- current measurement range from 0...3A. Resistance measurement using two lines or four lines, range from 0...30MΩ. Auto ranging function. Intern electronic calibration modus. Optional intern battery availlable for mobile measurement. Complete remote control possible with HP-41. Maximal two display readings per second with HP-41. Some utility programs for controlling Digital Voltmeter exist inside HP 44468A Data Acquisition Module for HP-41 (see next page).

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

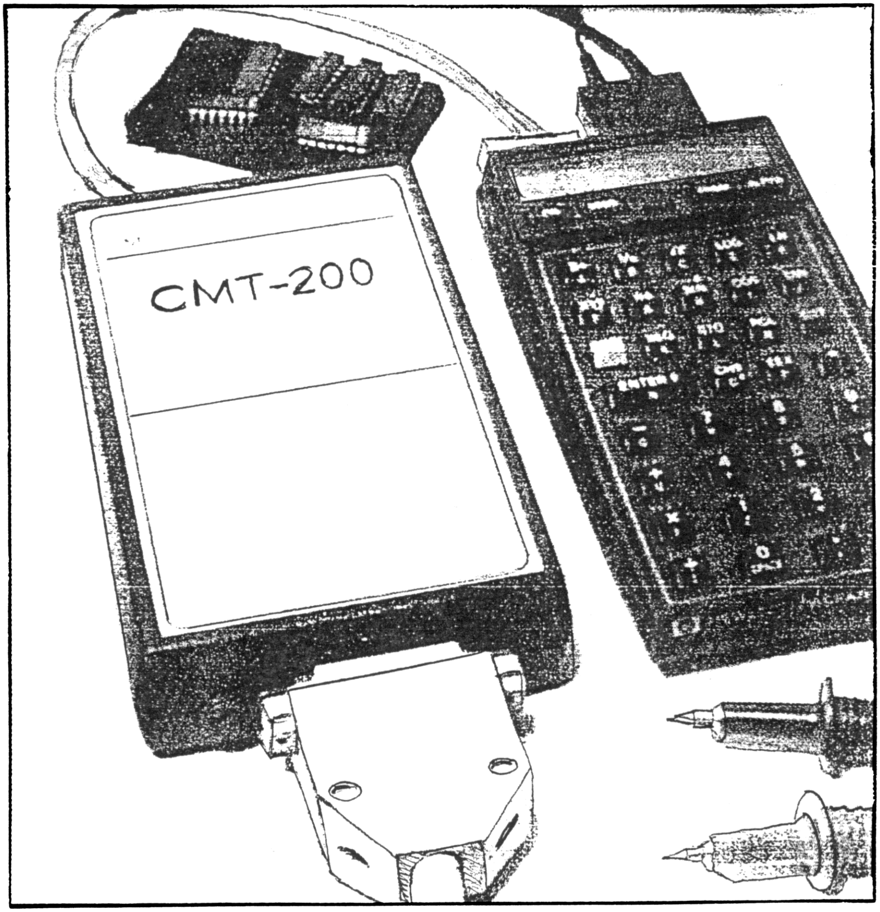
HP 3421 A Data Logger :



Hewlett Packard Data Logger for mobile applications with 12V battery cell. Front connectors for measuring AC- and DC- voltages, frequency, temperature and resistance (two line and four line coupling). 5½, 4½, 3½ digit analog digital converter. 1µV resolution for interfacing thermo coupler elements. Compensation and liniarisation for thermo coupler elements. Maximal input voltage 300V. Intern data buffer for 30 measurments. 2...35 readings per second. Auto ranging function. Intern electronic calibration modus. Rear connectors for maximal 30 differential inputs or 56 singel ended inputs. Frontdisplay shows channel number and status messages. Optional 8 channel multiplexer/2 channel power relais, or 9 channel multiplexer/1 channel power relais or 10 channel multiplexer. Optional digital 8 bit I/O-Module. Optional evolution board. Optional 7 channel 10:1 divider for 300V AC measurement. For use with HP-41 exist the HP 44468A Data Acquisition Module.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

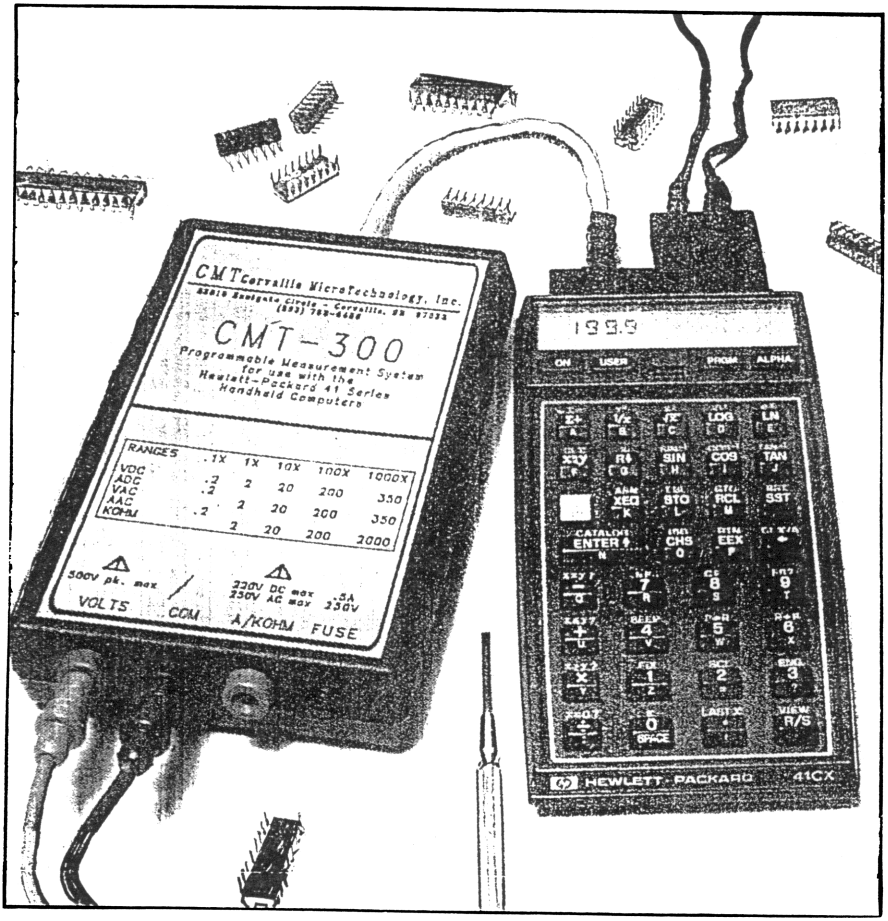
CMT-200 Data Logger System :



Produced by Corvallis Micro Technology, USA. Inserted to one HP-41 plug in expansion port, needs no HP-IL. Expands the HP-41 handheld computer with one 8 bit input port and one 8 bit output port. Two handshake lines exist and two wake up lines for extern hardware and for HP-41. Realizes data logging applications, interfacing a parallel printer and hardware controlling. 38 commands available for operating with the CMT-200 system. A bufferfile is created in main memory.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

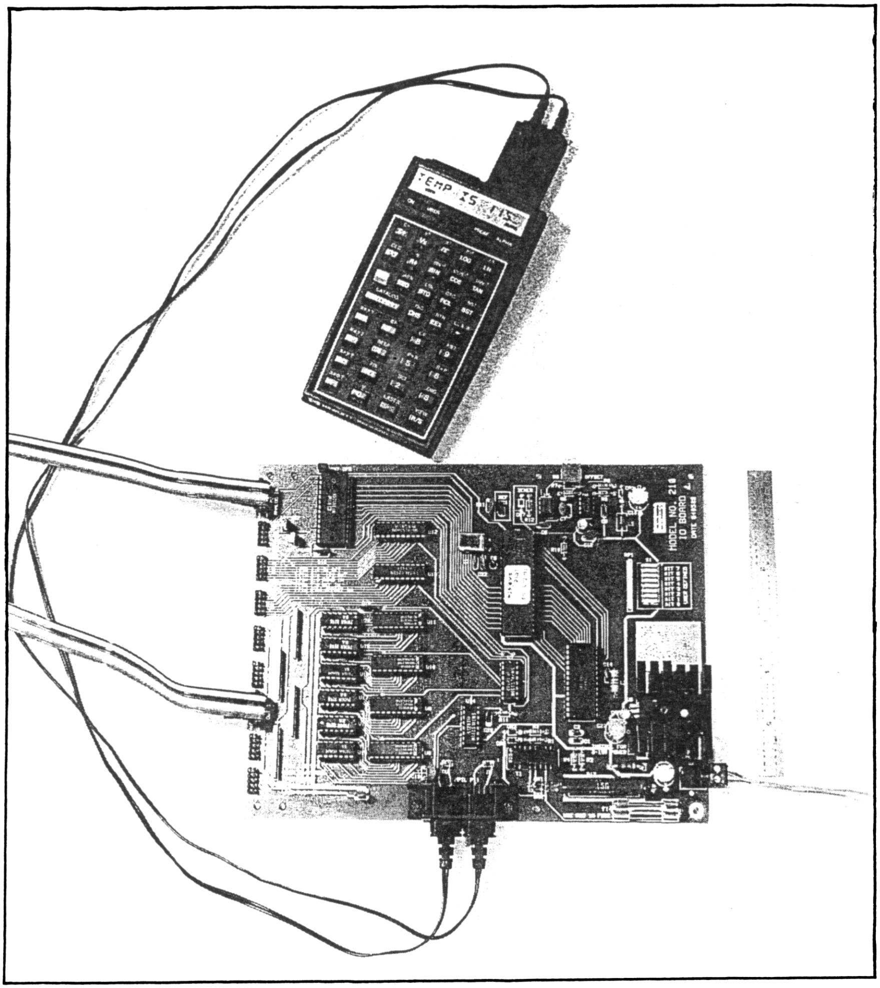
CMT-300 Digital Multimeter System :



Produced by Corvallis Micro Technology, USA. Inserted to one HP-41 plug in expansion port, needs no HP-IL. Expands the HP-41 handheld computer by a programmable digital multimeter. 15 ranges available for measurement of AC- and DC voltages (max 350V), AC- and DC currents (0.2A) and resistances (max 2MΩ). In combination with CMT-200 results a complete measurement system for HP-41.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

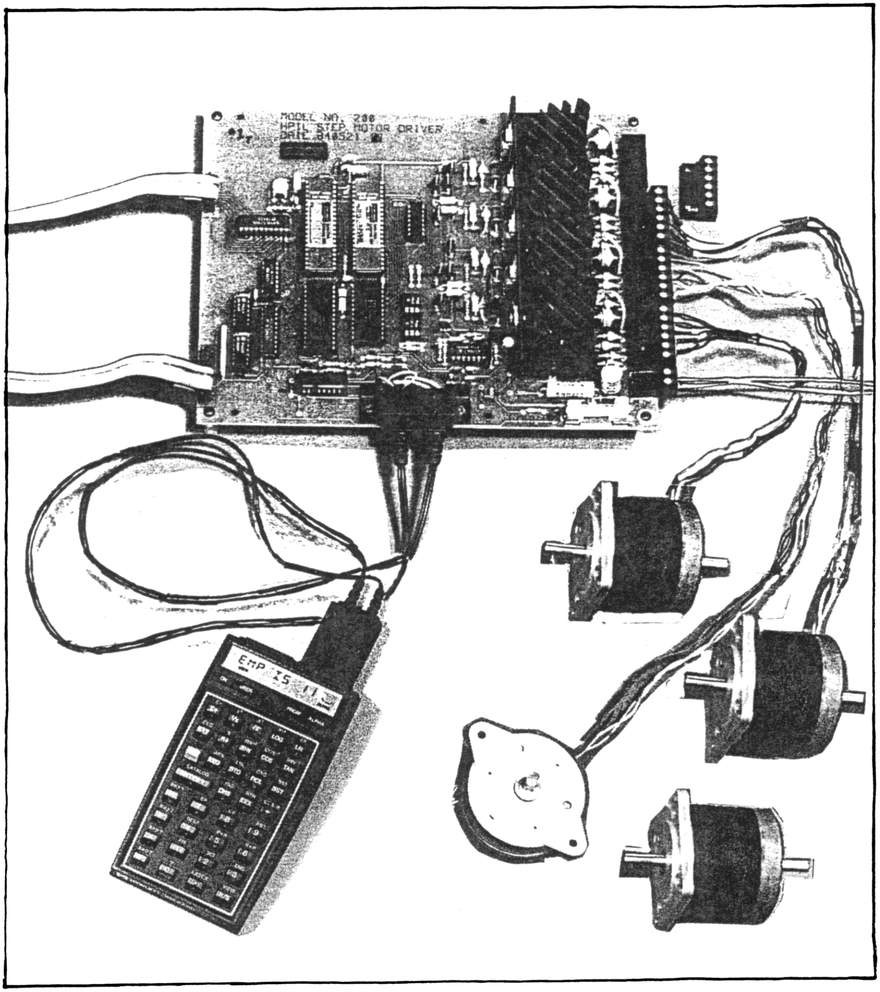
Interloop I/O-Board :



Produced by Interloop, USA. Model #210. For industrial controlling. Four digital 8 bit output ports = 32 digital output lines. Two digital 8 bit input ports = 16 digital input lines. Readable 8 bit Dip switch. 8 channel analog input multiplexer for 8 bit ADC. Board generates negative reference voltage. No analog DAC. 7 step up counter and 7 inpuls counter (16 bit). Option : Model #230 driver board for robotics and motor or lamp control.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

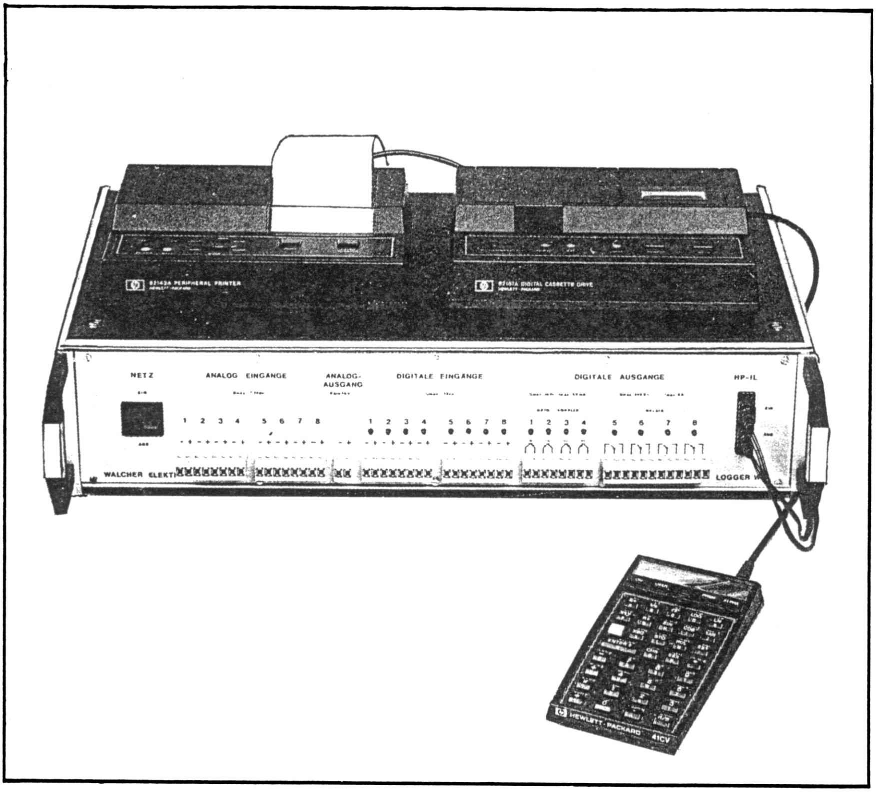
Interloop Step Motor Driver :



Produced by Interloop, USA. Model # 200. Step Motor Driver for robotics. Drives four motors (4 phases, max 24V/5A, max 2000 steps per second, min 0,15 step per second). Motor voltage, current, velocity and acceleration software programmable. 8 bit digital input port and digital 8 bit output port.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

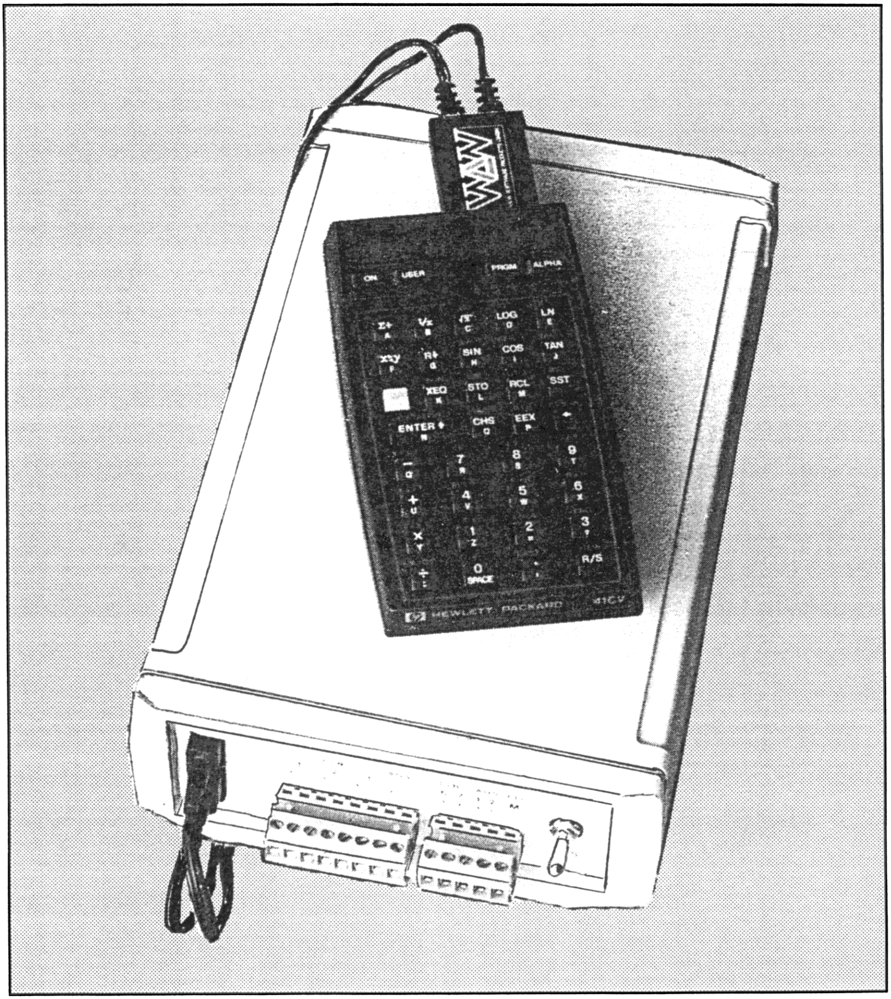
Mikro-Logger W41 :



Produced by Roland Walcher Elektronik, Germany. Stationary rack mounted data logger system for measurement and controlling. Intern HP 82166 A IL-Converter and µC with 9 commands for controlling with HP-41 handheld computer : ASCII text is stored in Alpha register and transfered to IL-Converter. No utility roms necessary. Front pannel connections : Differential 8 channel analog input multiplexer. 13 bit ADC with 500 µV solution. 2V range or 20V range. Singel analog voltage output port from 0...10V. 12 bit DAC. 8 bit opto isolated digital input port. 4 bit opto isolated digital output port and 4 power relais. Status LED´s for digital I/O ports. On rear pannel existing four slots for inserting optional hardware : Temperature measurement modules for PT100 or silizium temperature sensors. Extension and lengthening measurement module. Frequency to voltage converter module. Pressure measurement module. Analog 8 channel multiplexer module. Evolution board for own applications.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

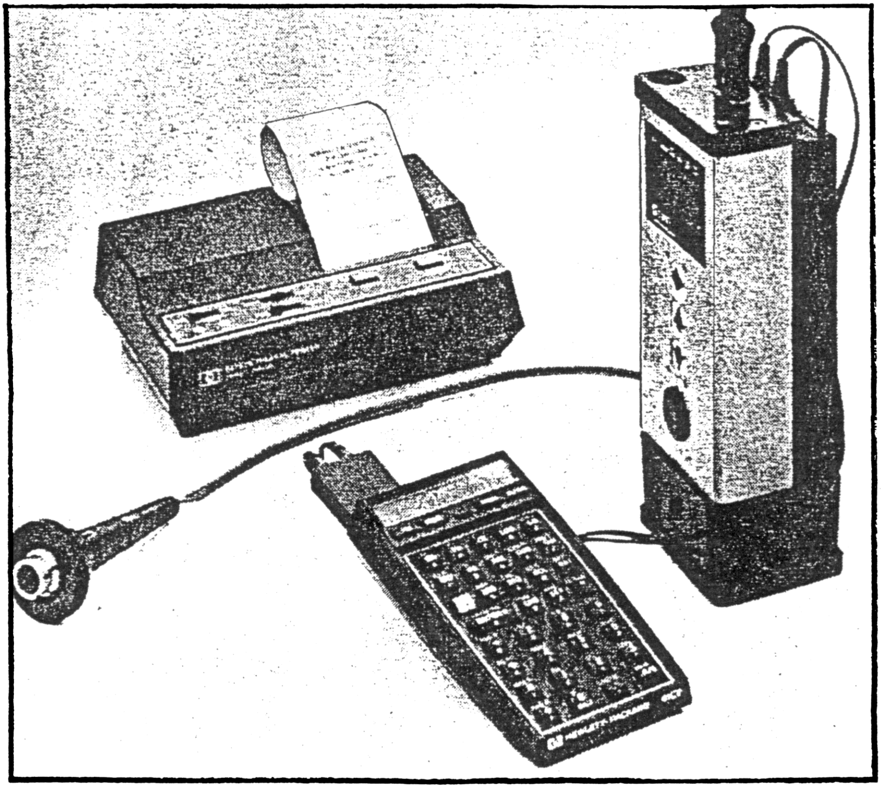
Logger W51B :



Produced by Roland Walcher Elektronik, Germany. A small case contains a mobile data logger system for measurement and controlling. Intern battery power supply, HP 82166 A IL-Converter and µC with 9 commands for controlling with HP-41 handheld computer. 3 bit opto isolated digital input port. 4 bit opto isolated digital output port. Other features and optional hardware expansions identic to Mikro-Logger W 41.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

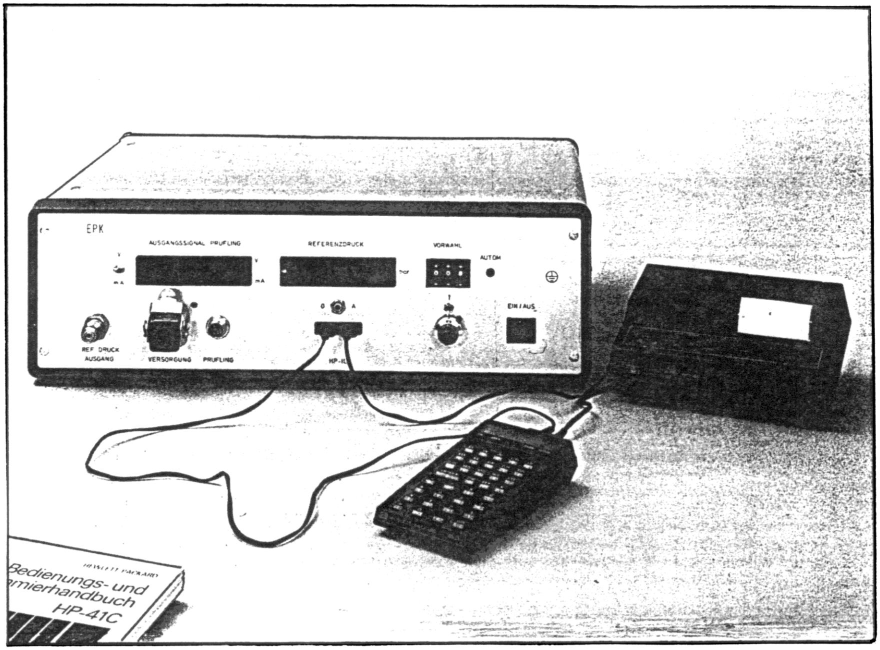
DMX-1 Ultrasonic Material Stress Analyse :



Produced by Krautkrämer, Germany. Special mobile unit for wall material thickness measurement with ultrasonic sensor. Applications for marine engineering and electric power plants. HP-41 software for statistical calculations and data logging. Measurement data transfer to other computer systems.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

EPK Pressure Sensors Calibration :



Produced by Proemtec, Germany. Precision calibration unit for pressure sensor alignment and general pressure measurement. Intern HP 82166 A IL-Converter and battery power supply. Measurement range 0...10 mbar and 0...300 bar. Extern pressure supply. Input for temperatur sensor. HP-41 software for quality tests documentation and liniarisation of pressure characteristic.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

KRISTAL* HP-IL Interface Products :

-K010 BCD Interface, 8 digits plus sign, to communicate with BCD devices

-K011 Centronic interface, with 2k or 8k buffer. Able to emulate an HP-GL plotter using a mini-plotter like the Tandy CGP-115, or a Canon.

-K016 Minitel interface. Minitel was and still is the french videotext terminal. The interface enable a HP-IL controller (HP-41, HP-71) to use the minitel as display and keyboard. The internal modem can also be used, with suitable software.

These interfaces were about the same box size than the HP interface devices like HP 82164, HP 82165 or HP82169.

KRISTAL* HP-IL "Regale" Products :

-K012 V21 modem.

-K013 V23 modem.

-K018 general PIO board (20 I/O TTL lines). Can be connected to opto input boards or relay output board.

-K019 LCD / 16 Keys interface board.

-K026 12 bit A/D converter board.

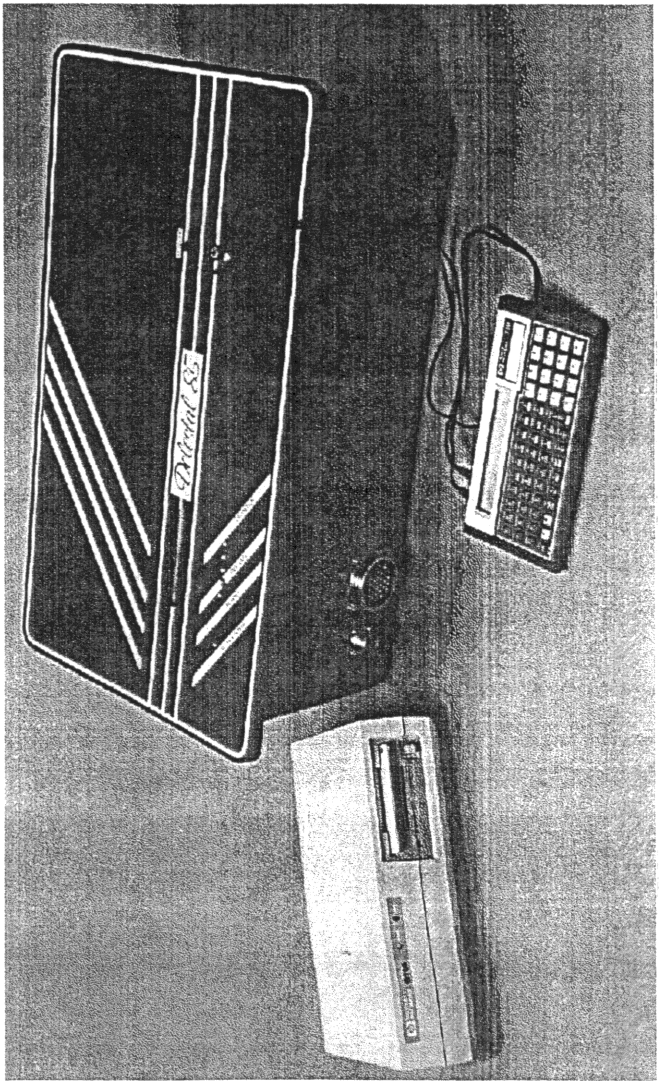
-K044 double PIO board (40 TTL lines)

The "Regale" boards have been used for industrial applications. For example DESTRAL is a trafic counting box, with modem link to a central trafic control system (HP1000). Furthermore exist solutions for a stress control systems and other applications.

Kristal work with the HP-71 handheld computer as HP-IL Controller. Additionally they build a HP-71 replacement hardware for harsh industrial environment applications named K032 and programmed in Forth language.

*→ KRISTAL Informatique S.A. Company / MEYLAN / France

HP 82166 A 16 BIT INPUT / OUTPUT BOARD



DESTRAL is a HP-71 controlled trafic counting box, with modem link to a central trafic control system (HP1000). Made by KRISTRAL / France.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Printer, Plotter, Storage - Devices :

Printer Plotter Data Storage Devices

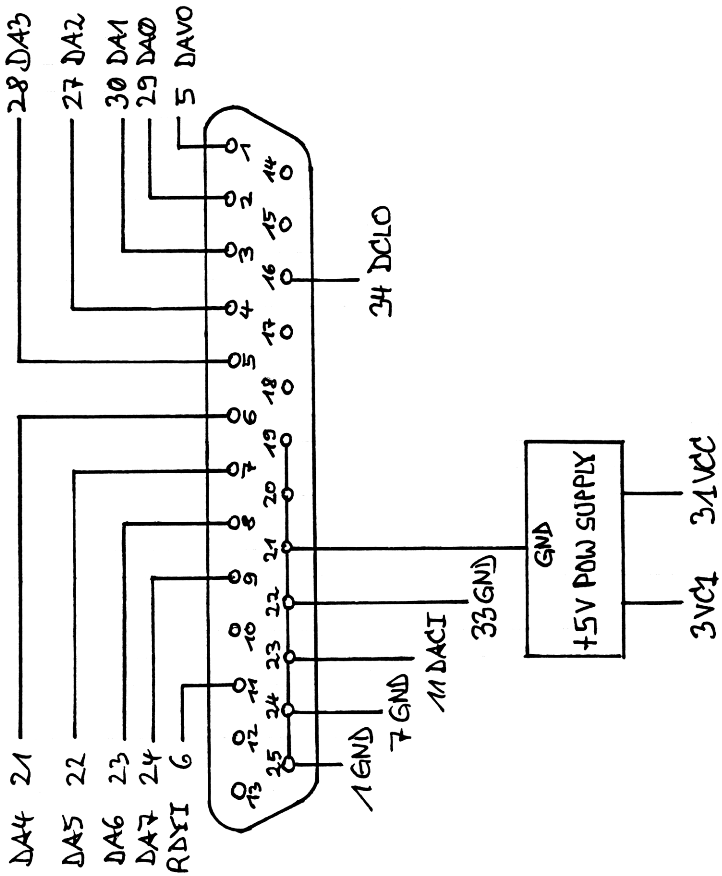
For print 1999 this new chapter is under development. The idea is to complete the list of IL Devices by the well known Thermal Printer, Think Jet Printer, 7470 Plotter, Cass-Drive and Disc-Drive. Furthermore exotic IL Devices are included like a double disc drive or CMT Ram Box.

CHAPTER IX
CENTRONIX PRINTER

Sub Min D Printer Cable	**IX.00**
Centronix Printer Cable	**IX.01**
Plotting Barcodes with HP-41 HP 82166 A IL-Converter and HP Desk Jet 500	**IX.02**

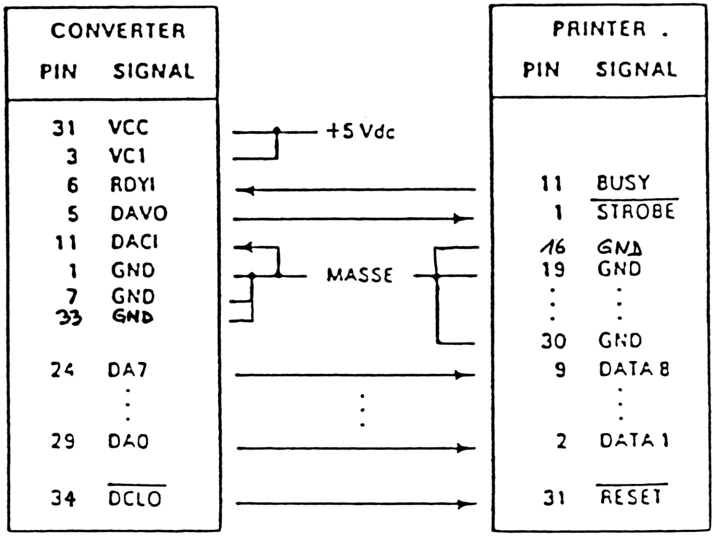
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

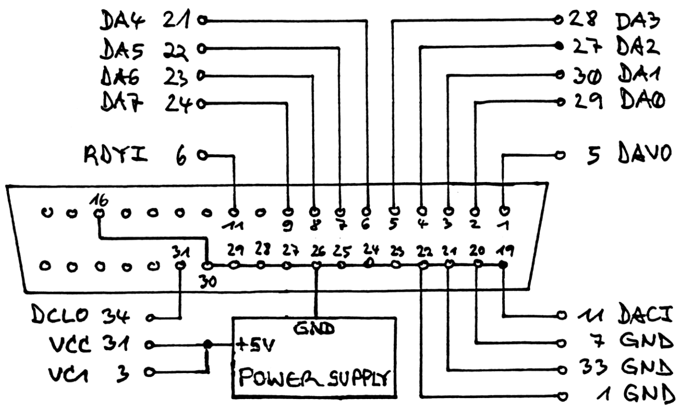
Sub Min D Printer Cable :



HP 82166 A Input / Output Board :

Centronix Printer Interface Connection :





Plotting HP-41 Barcodes with HP Desk Jet 500 by Thomas Mareis and Christoph Klug

The manual of the German CCD-Module gives a powerful program application for plotting HP-41 barcodes with the HP Think Jet Printer as device of the HP Interface Loop. We alter this routine to use the much better graphic solution for plotting barcodes with the modern HP Desk Jet 500.

About buffer limitations of Think Jet the CCD manual plot program print only 10 programmbytes plus 3 controlbytes per barcodeline. But the updated Desk Jet plot programm now print full 13 programmbytes plus 3 controlbytes per barcodeline, that´s the maximum HP-41 Wand can read in. Futhermore we add barcodeline inscriptions with the actual program name (program lines 110 to 126).

The HP 82166A Converter is the easiest way to interface the Desk Jet to HP Interface Loop. Connection is done with a centronic adapter cable, described in the Converter manual. For this application you will found program listing and barcode plot in this article.

Alternatively you can use the PC / HP-IL Interface Board with an old 286 PC, or a slow 386SX PC with HP Desk Jet 500. Then you must alter program line 005 to AUTOIO, line 006 to 36, line 007 to FINDAID and line 008 to SELECT.

Or you connect the HP Desk Jet 500 with HP-IL / RS 232 Converter to the Interface Loop.

The program plots 26 barcodelines on one DIN A 4 paper, then continue automatic on next side (program line 200). The height of one barcodeline were set to 50 pixel (program line 151). Distance between two barcodelines were set to 10 pixel (program line 175). Program line 009 set distance of barcode inscription to left paper edge (18 sign). The grafic width is set in program line 038. It depends on the distance of barcodeline to left paper edge. One barcodeline need around 1380 pixel grafic width plus value from program line 156. This line set distance of barcodeline to left paper edge (545 pixel).

Because whole grafic calculation of a barcodeline is done with the small HP-41 machine, X-Function Module and CCD-Module, it needs more than 6 minutes to plot one barcodeline. A solution to handel this time consumption plot routine is to start it to night and get the results next morning !

Enter program name into Alpha-Register and start barcode plot by executing PBC. It needs SIZE 024, and creates X-Memory ASCII-File μ.

Plotting HP-41 Barcodes with HP Desk Jet 500
by Thomas Mareis and Christoph Klug

The barcode plot program need some synthetic text lines. Here is a list of them in decimal format with short explanations :

line 009:	027, 038, 097, 049, 056, 076	left margin 18 sign
line 036:	027, 042, 116, 051, 048, 048, 082	300 dpi
line 038:	027, 042, 114, 049, 057, 050, 053, 083	1925 pixel
line 040:	012	µ = ASCII file name
line 101:	131	short form exponent
line 113:	„append minus space“	barcode inscription
line 117:	„append space“	barcode inscription
line 122:	027, 042, 098, 049, 087, 000	grafic countenance
line 127:	112, 112	grafic start byte
line 154:	131	short form exponent
line 156:	027, 042, 098, 053, 052, 053, 120	545 pixel X-Offset plus number of grafic bytes
line 176:	027, 042, 098, 049, 087, 000	grafic countenance
line 180:	127, 112	grafic byte 0-bit
line 182:	127, 007	grafic byte 0-bit
line 187:	127, 127	grafic byte 1-bit
line 190:	127, 007, 240	grafic byte 1-bit
line 197:	012	µ = ASCII file name
line 210:	208, 000, 000	long form GTO
line 212:	027, 042, 114, 098, 067	end of grafic
line 214:	027, 038, 108, 048, 072	end of paper

Sometimes occur problems when reading in barcode lines with wand. There are transfer problems commented with message CKSUM ERR. Use SST key (single step) to jump from actual to next barcode line and complete reading in by wand. Or press SST some times to address the barcodeline where you want to continue reading. Subsequently you must insert missing program code manually per listing.

Some directions about correct use of the wand you will find in „Extend your HP 41“ capitel 12.3 , side 341 and in „Tricks, Tips and Routins“ capitel 21-17. More informations about HP-41 barcodes you will find in the german book „Barcodes mit dem HP IL System“ and in the HP publication „Create Your Own HP-41 Bar Code“.

To speed up barcode plotting you can use the american SKWIND INK Module for HP-41, which is programmed in machine language (who have one ?). Or you must transfer the HP-41 program to PC and calculate the grafic barcodes by the efficient CPU (who have a software solution ?).

```
01 LBL "PBC"
02 ASTO 22
03 ASHF
04 ASTO 23
05 "HP82166"
06 FINDID
07 SELECT
08 MANIO
09 "□&a18L"
10 ACA
11 CLA
12 ARCL 22
13 ARCL 23
14 PHD
15 CLRG
16 ASTO 22
17 ASHF
18 ASTO 23
19 STO 00
20 1
21 CLA
22 ARCL 22
23 ARCL 23
24 PPLNG
25 STO 02
26 -
27 A+B
28 PEEKB
29 SF 23
30 6
31 bS?
32 CF 23
33 9,021
34 STO 03
35 SF 21
36 "□*t300R"
37 ACA
38 "□*r1925S"
39 ACA
40 ""
41 30
42 CRFLAS
43 LBL 00
44 RCL 00
45 A-
46 X<> 00
47 PEEKB
48 STO IND 03
49 ST+ 06
50 DSE 01
51 GTO 01
52 143
53 -
54 X<=0?
55 97
56 64
57 -
58 X<=0?
59 34
60 32
61 -
62 X<=0?
63 3
64 STO 01
65 STO 04
66 LBL 01
67 ISG 03
68 X<0?
69 GTO 02
70 DSE 02
71 GTO 00
72 LBL 02
73 RCL 05
74 16
75 MOD
76 LASTX
77 FC? 23
78 ST+ X
79 +
80 ST+ 06
81 STO 07
82 ISG 05
83 CLX
84 RCL 04
85 RCL 01
86 DSE X
87 -
88 RCL 08
89 +
90 STO 08
91 RCL 06
92 +
93 255
94 MOD
95 X=0?
96 LASTX
97 STO 06
98 RCL 03
99 INT
100 DSE X
101 E3
102 /
103 9
104 +
105 STO 03
106 3
107 -
108 CLA
109 ADV
110 RCL 05
111 CHS
112 ARCLI
113 "□- "
114 CHS
115 10
116 X>Y?
117 "□ "
118 ARCL 22
119 ARCL 23
120 RDN
121 ACA
122 "□*b1W□"
123 ACA
124 ACA
125 ACA
126 ACA
127 "pp"
128 SF 22
129 LBL 03
130 X<>Y
131 RCL IND X
132 7
133 CHS
134 LBL 04
135 bC?
136 XEQ 07
137 LASTX
138 bS?
139 XEQ 08
140 LASTX
141 ISG X
142 GTO 04
143 APPCHR
144 CLA
145 RDN
146 ISG Y
147 GTO 03
148 XEQ 08
149 XEQ 07
150 APPCHR
151 50
152 LBL 05
153 RCLPT
154 E3
155 *
156 "□*b545x"
157 ARCLI
158 "□W"
159 ACA
160 CLX
161 SEEKPT
162 LBL 06
163 GETREC
164 FS? 17
165 SF 01
166 FC? 17
167 CF 01
168 SF 17
169 OUTA
170 FS? 01
171 GTO 06
172 X<>Y
173 DSE X
174 GTO 05
175 10
176 "□*b1W□"
177 GTO 10
178 LBL 07
179 FS? 22
180 "□p"
181 FC? 22
182 "□□"
183 RTN
184 LBL 08
185 FC?C 22
186 GTO 09
187 "□□"
188 RTN
189 LBL 09
190 "□□ "
191 SF 22
192 RTN
193 LBL 10
194 ACA
195 DSE X
196 GTO 10
197 ""
198 CLFL
199 RCL 05
200 26
201 MOD
202 X=0?
203 OUTA
204 16
205 RCL 01
206 DSE X
207 *
208 STO 08
209 DSE 02
210 GTO 00
211 PURFL
212 "□*rbC"
213 OUTA
214 "□&l0H"
215 OUTA
216 BEEP
217 END
```

PLNG = 424 Bytes
CHK August 1997

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

-1- PBC

-2- PBC

-3- PBC

-4- PBC

-5- PBC

-6- PBC

-7- PBC

-8- PBC

-9- PBC

-10- PBC

-11- PBC

-12- PBC

-13- PBC

-14- PBC

-15- PBC

-16- PBC

-17- PBC

-18- PBC

-19- PBC

-20- PBC

-21- PBC

-22- PBC

-23- PBC

-24- PBC

-25- PBC

-26- PBC

-27- PBC

-28- PBC

-29- PBC

-30- PBC

-31- PBC

-32- PBC

-33- PBC

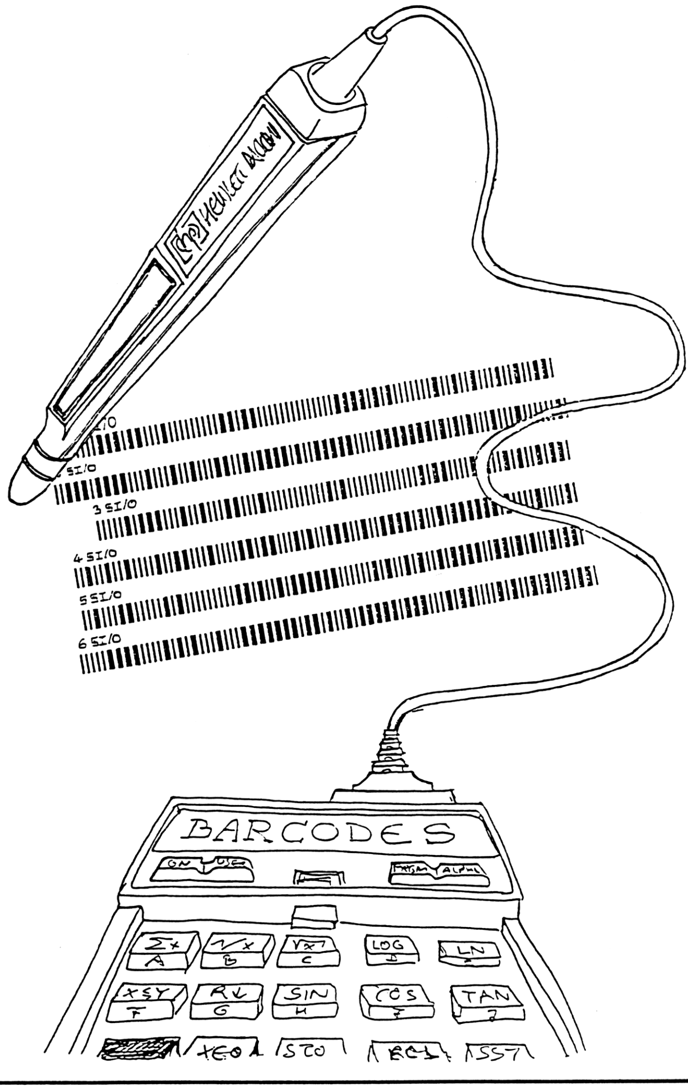
CHAPTER X
HP-41 BARCODES

Software I/O-Module	X.02
Examples	X.06
Software Development Module	X.09
Example	X.14
Software CCD-Module	X.15
Advanced Programming	X.16

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Barcodes for HP-41 CX :

Presented barcodes for HP-41 CX are generated by the German CCD-Module and HP Desk Jet 500. Used plotprogramm PBCDJ (see appendix) is an update of the barcode plotprogram PBC published in CCD-Modul Manual. Adaption of HP Desk Jet 500 to HP Interface Loop is done by HP 82166 A IL-Converter and parallel printer cable.



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Barcodes $I/O :

-1- $I/O

-2- $I/O

-3- $I/O

-4- $I/O

-5- $I/O

-6- $I/O

-7- $I/O

-8- $I/O

-9- $I/O

-10- $I/O

-11- $I/O

-12- $I/O

-13- $I/O

-14- $I/O

-15- $I/O

-16- $I/O

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Barcodes $IN1X :

-1- $IN1X

-2- $IN1X

-3- $IN1X

-4- $IN1X

-5- $IN1X

-6- $IN1X

-7- $IN1X

-8- $IN1X

-9- $IN1X

-10- $IN1X

-11- $IN1X

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Barcodes $IN1A :

-1- $IN1A

-2- $IN1A

-3- $IN1A

-4- $IN1A

-5- $IN1A

-6- $IN1A

-7- $IN1A

-8- $IN1A

-9- $IN1A

-10- $IN1A

-11- $IN1A

-12- $IN1A

-13- $IN1A

-14- $IN1A

-15- $IN1A

-16- $IN1A

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Barcodes $IN1A :

-17- $IN1A

-18- $IN1A

-19- $IN1A

-20- $IN1A

-21- $IN1A

-22- $IN1A

-23- $IN1A

-24- $IN1A

-25- $IN1A

-26- $IN1A

-27- $IN1A

-28- $IN1A

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Barcodes $LIGHT and $COUNT :

-1- $LIGHT

-2- $LIGHT

-3- $LIGHT

-4- $LIGHT

-1- $COUNT

-2- $COUNT

-3- $COUNT

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Barcodes $ADC and $DAC :

-1- $ADC

-2- $ADC

-3- $ADC

-4- $ADC

-5- $ADC

-6- $ADC

-1- $DAC

-2- $DAC

-3- $DAC

-4- $DAC

-5- $DAC

HP-41 CX Barcodes $SAMP and $DATA :

-1- $SAMP

-2- $SAMP

-3- $SAMP

-4- $SAMP

-5- $SAMP

-6- $SAMP

-7- $SAMP

-8- $SAMP

-9- $SAMP

-10- $SAMP

-1- $DATA

-2- $DATA

-3- $DATA

-4- $DATA

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Barcodes DI/O :

-1- DI/O

-2- DI/O

-3- DI/O

-4- DI/O

-5- DI/O

-6- DI/O

-7- DI/O

-8- DI/O

-9- DI/O

-10- DI/O

-11- DI/O

-12- DI/O

-13- DI/O

-14- DI/O

-15- DI/O

-16- DI/O

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Barcodes DI/O :

-17- DI/O

-18- DI/O

-19- DI/O

-20- DI/O

-21- DI/O

-22- DI/O

-23- DI/O

-24- DI/O

-25- DI/O

-26- DI/O

-27- DI/O

-28- DI/O

-29- DI/O

-30- DI/O

-31- DI/O

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Barcodes DOUT1 :

-1- DOUT1

-2- DOUT1

-3- DOUT1

-4- DOUT1

-5- DOUT1

-6- DOUT1

-7- DOUT1

-8- DOUT1

-9- DOUT1

-10- DOUT1

-11- DOUT1

-12- DOUT1

-13- DOUT1

-14- DOUT1

-15- DOUT1

-16- DOUT1

HP-41 CX Barcodes DOUT1 :

-17- DOUT1

-18- DOUT1

-19- DOUT1

-20- DOUT1

-21- DOUT1

-22- DOUT1

-23- DOUT1

-24- DOUT1

-25- DOUT1

-26- DOUT1

-27- DOUT1

-28- DOUT1

-29- DOUT1

-30- DOUT1

-31- DOUT1

HP-41 CX Barcodes DOUT1 :

-32- DOUT1

-33- DOUT1

HP-41 CX Barcodes DLIGHT :

-1- DLIGHT

-2- DLIGHT

-3- DLIGHT

-4- DLIGHT

-5- DLIGHT

-6- DLIGHT

-7- DLIGHT

-8- DLIGHT

-9- DLIGHT

-10- DLIGHT

-11- DLIGHT

-12- DLIGHT

-13- DLIGHT

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Barcodes LB :

-1- LB

-2- LB

-3- LB

HP-41 CX Barcodes $CHK :

-1- $CHK

-2- $CHK

-3- $CHK

-4- $CHK

HP-41 CX Barcodes $OUT1H :

-1- $OUT1H

-2- $OUT1H

-3- $OUT1H

-4- $OUT1H

-5- $OUT1H

-6- $OUT1H

-7- $OUT1H

-8- $OUT1H

-9- $OUT1H

-10- $OUT1H

-11- $OUT1H

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 CX Barcodes $BCD :

-1- $BCD

-2- $BCD

-3- $BCD

HP-41 CX Barcodes B↑D :

-1- B^D

-2- B^D

-3- B^D

-4- B^D

HP-41 CX Barcodes D↑B :

-1- D^B

-2- D^B

-3- D^B

-4- D^B

HP-41 CX Barcodes D↑H :

-1- D^H

-2- D^H

HP-41 CX Barcodes H↑D :

-1- H^D

-2- H^D

-3- H^D

HP-41 CX Barcodes $ALOAD :

-1- $ALOAD

-2- $ALOAD

-3- $ALOAD

-4- $ALOAD

-5- $ALOAD

-6- $ALOAD

-7- $ALOAD

-8- $ALOAD

-9- $ALOAD

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

-10- $ALOAD

-11- $ALOAD

-12- $ALOAD

-13- $ALOAD

-14- $ALOAD

-15- $ALOAD

-16- $ALOAD

-17- $ALOAD

-18- $ALOAD

-19- $ALOAD

-20- $ALOAD

-21- $ALOAD

-22- $ALOAD

-23- $ALOAD

-24- $ALOAD

-25- $ALOAD

-26- $ALOAD

-27- $ALOAD

-28- $ALOAD

-29- $ALOAD

-30- $ALOAD

-31- $ALOAD

-32- $ALOAD

-33- $ALOAD

-34- $ALOAD

-35- $ALOAD

-36- $ALOAD

-37- $ALOAD

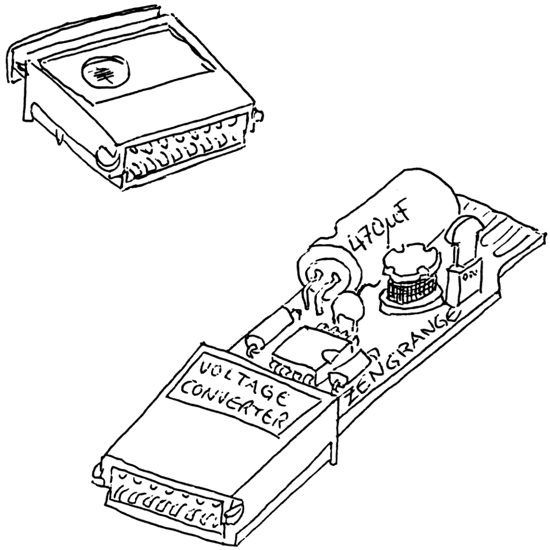
-38- $ALOAD

CHAPTER XI
ZEPROM-MODULE

HP-41 and Zeprom-Module	XI.01
I/O-Board Module in Zeprom	XI.02
$16 User Keyboard	XI.03
$8 User Keyboard	XI.04
$1 User Keyboard	XI.05
XROM Numbers	XI.06
Program Listings	XI.07
Burning Zeprom-Modules	XI.13

HP 82166 A Input / Output Board :

HP-41 Zeprom-Module :



HP 82166 A Input / Output Board :

HP-41 and Zeprom-Module :

The Zeprom-Module is a special EPROM, housed in a HP-41 plug in module case. It is produced by Zengrange (London), who also developed the well known HP-41 Zenrom-Module. Storing own user programs inside Zeprom is done by adapting the Zeprom-Module to a small plug in burning tool and using the Zengrange Programmer-Rom software, which is stored inside new Zeprom-Module. Erasing is done by UV light. For more tips about burning Zeprom-Modules read the Zeprom manual and additional paper at the end of this chapter.

Size of intern Zeprom memory is 4 x 4 kByte = 16 kByte, corresponding to two ports of HP-41. Using a straight 16 kByte Zeprom-Module you can realize an optimal HP-41 port configuration for work with HP Interface Loop and I/O-Board.

Inside Zeprom on core 1 and core 2 is stored a version B copy of German CCD-Module (8 kByte). On core 3 is stored a copy of I/O-Module (4 kByte). And on core 4 is stored complete control software for I/O-Board and some utility functions.

CCD Module 1B
CCD Module 2B
I/O-Module
Control Software

Straight 16 kByte Zeprom-Module

This means complete HP-41 hardware extensions and control software needed for I/O-Board are realized in only one HP-41 plug in port. Software is protected against Memory Lost, and HP-41 main memory is complete free for your own program applications ! I/O-Board controlling commands now part of CAT 2.

Zeprom	X-Memory
free for use	IL-Module

HP-41 port configuration

Attention : In adjacnent port of straight Zeprom-module do not plug in any rom-module, only a system rom module (IL-Module) or a ram module (Inserting a X-Memory Module or a Double X-Memory Module you get maximal performance).

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

I/O-Board Module stored in ZEPROM :

I/O-Board Module stored in Zeprom core 4 contains 48 commands for controlling I/O-Board and 15 utility functions. The basic I/O-Board control programms summed up to one main program making burning process easier. Therefore some numeric labels changed, and new numeric labels inserted behind existing global Alpha labels, to make jumping faster by using three byte GTO´s. I/O-Board Module command set dividet to following blocks (see XROM listing on page XI.06) :

First block make possible initialisation and status check of I/O-Board (CHAPTER II and VII). Following three blocks containing 16 Bit I/O commands (Alpha-, X-Register CHAPTER II and Hex CHAPTER VII), 8 Bit I/O commands (CHAPTER II) and 1 Bit commands (CHAPTER VII). Next two blocks hold alarm functions (CHAPTER VII) and transfer functions (CHAPTER XIV).

Next block with 5 new commands expands existing function set, allowing comfortable and fast control of I/O-Board, by creating three software selectable HP-41 User-keyboards :

$16 Activates User keyboard with 16 Bit commands.
$16 is assigned to key 11 = A.

$8 Activates User keyboard with 8 Bit commands.
$8 is assigned to key 12 = B.

$1 Activates User keyboard with 1 Bit commands.
$16is assigned to key 13 = C.

$CRFL Creates X-Memory data-, alarm-, and key-files for use with I/O-board. Duration of $CRFL needs some minutes.

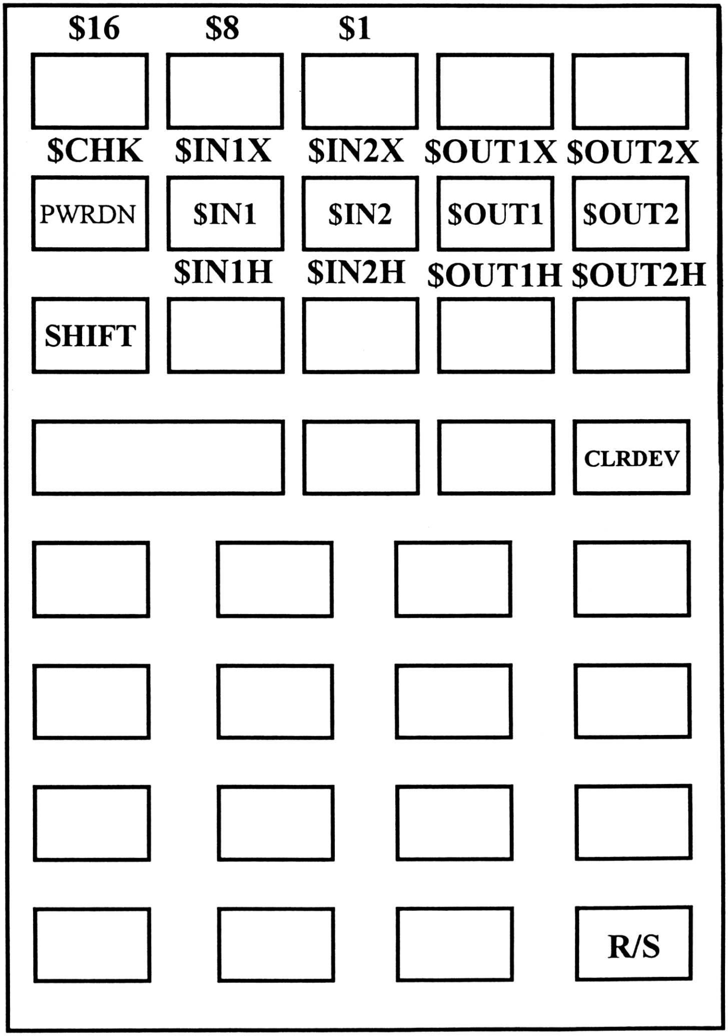
$PURFL Purge X-Memory data-, alarm-, and key-files, used by I/O-Board.

Next block contains bin + hex base conversation functions (CHAPTER VII), followed by the Link-Plus command set for data transfer between HP-41 and PC (CHAPTER XV).

Last two blocks containing utility functions. For information read CHAPTER IX about printing barcodes, or the manuals of CCD-Module and I/O-Module.

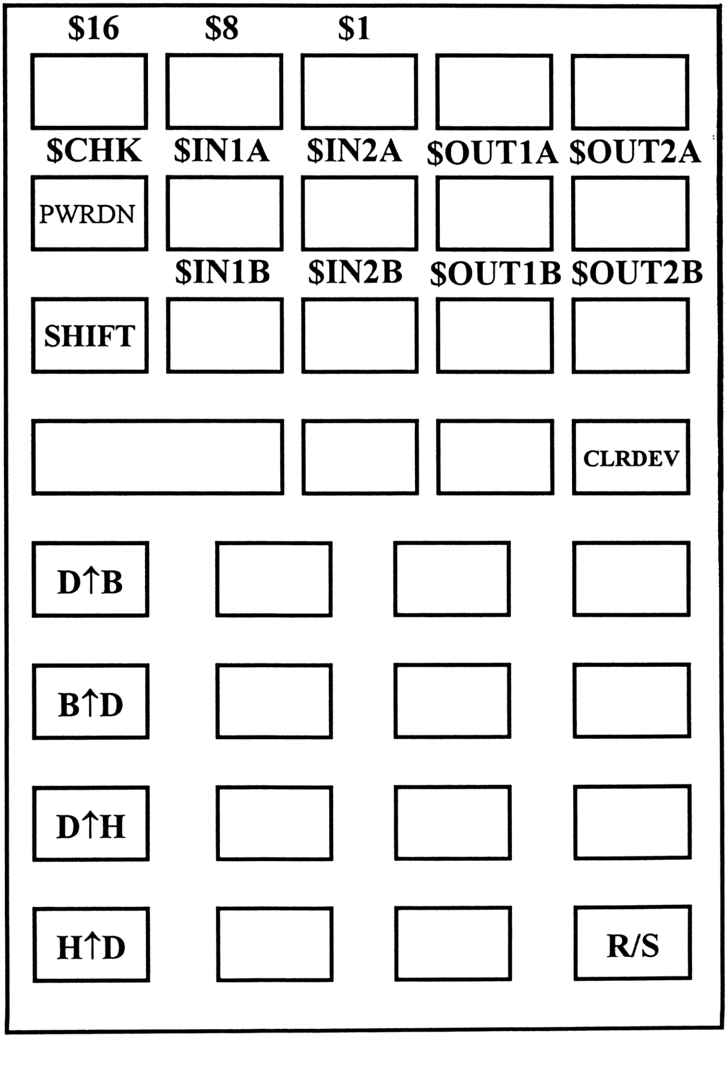
HP 82166 A Input / Output Board :

I/O-Module
$16 USER KEYBOARD
16 Bit Commands



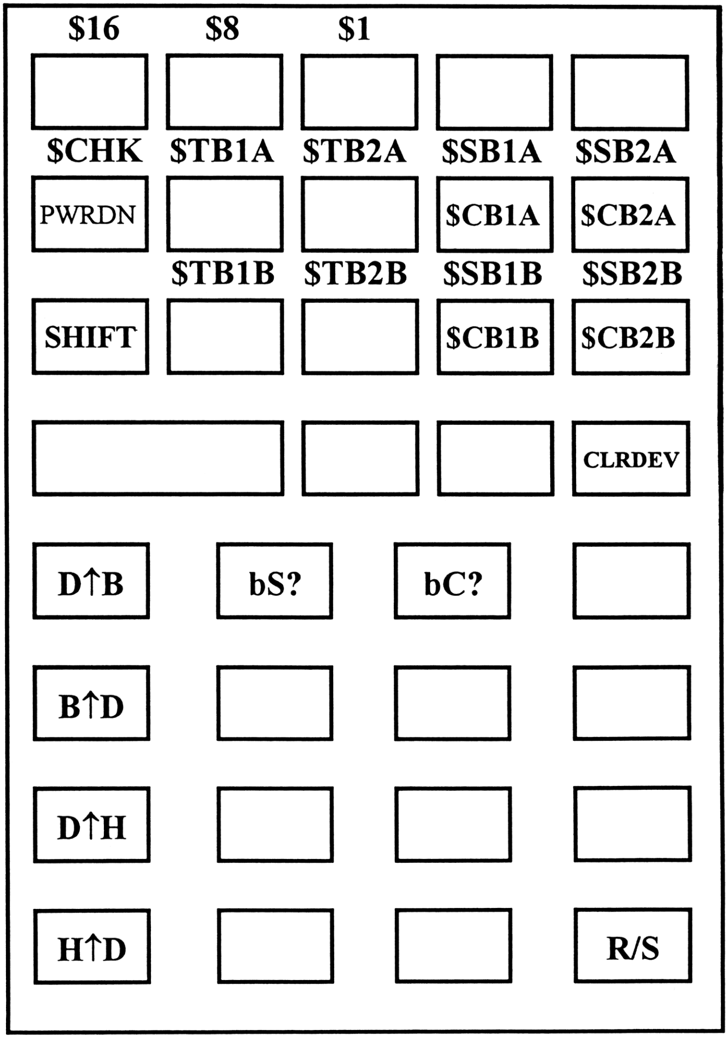
HP 82166 A Input / Output Board :

I/O-Module
$8 USER KEYBOARD
8 Bit Commands



HP 82166 A Input / Output Board :

I/O-Module
$1 USER KEYBOARD
1 Bit Commands



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

I/O-Board Module XROM Numbers :

XROM 31.01	$CHK	initialisation
		check status
XROM 31.02	$I/O	select
		IL Converter
XROM 31.03	$MSRQ	man serv requ
XROM 31.04	$IN1	
XROM 31.05	$IN2	16 Bit I/O
XROM 31.06	$OUT1	Alpha Regist
XROM 31.07	$OUT2	
XROM 31.08	$IN1X	
XROM 31.09	$IN2X	16 Bit I/O
XROM 31.10	$OUT1X	X-Register
XROM 31.11	$OUT2X	
XROM 31.12	$IN1H	
XROM 31.13	$IN2H	16 Bit I/O
XROM 31.14	$OUT1H	Hexadecimal
XROM 31.15	$OUT2H	
XROM 31.16	$IN1A	
XROM 31.17	$IN1B	
XROM 31.18	$IN2A	
XROM 31.19	$IN2B	8 Bit I/O
XROM 31.20	$OUT1A	X-Register
XROM 31.21	$OUT1B	
XROM 31.22	$OUT2A	
XROM 31.23	$OUT2B	
XROM 31.24	$Tb1A	
XROM 31.25	$Tb1B	test bit
XROM 31.26	$Tb2A	
XROM 31.27	$Tb2B	
XROM 31.28	$Sb1A	
XROM 31.29	$Sb1B	set bit
XROM 31.30	$Sb2A	
XROM 31.31	$Sb2B	

XROM 31.32	$Cb1A	
XROM 31.33	$Cb1B	clear bit
XROM 31.34	$Cb2A	
XROM 31.35	$Cb2B	
XROM 31.36	$ALOAD	
XROM 31.37	$ADATA	alarm
XROM 31.38	$ASET	functions
XROM 31.49	$AVIEW	
XROM 31.40	$SENDX	
XROM 31.41	$RECVX	transfer
XROM 31.42	$SENDR	functions
XROM 31.43	$RECVR	
XROM 31.44	$16	16 bit keyb
XROM 31.45	$8	8 bit keyb
XROM 31.46	$1	1 bit keyb
XROM 31.47	$CRFL	create XM
XROM 31.48	$PURFL	purge XM
XROM 31.49	D/B	bin
XROM 31.50	B/D	hex
XROM 31.51	D/H	base
XROM 31.52	H/D	conversion
XROM 31.53	L+SENDR	
XROM 31.54	L+RECVR	
XROM 31.55	L+SENDF	Link Plus
XROM 31.56	L+RECVF	transfer
XROM 31.57	L+SENDT	functions
XROM 31.58	L+NAME	
XROM 31.59	L+NAME?	
XROM 31.60	PBC	prt barcode
XROM 31.61	ST	synth text
XROM 31.62	CDE	code
XROM 31.63	MSCOPY	mass storage

```
01*LBL "$CHK"
02 SF 25
03 PWRUP
04 FC? 25
05 GTO 10
06 XEQ 11
07 XEQ "$MSRQ"
08 RTN
09*LBL 10
10 "$ERR"
11 ASTO X
12 CLA
13 RTN
14*LBL 11
15 "HP82166A"
16 FINDID
17 SELECT
18 "D@⊕⊕⊕"
19 LAD
20 0
21 DDL
22 4
23 OUTAN
24 UNL
25 ADRON
26 "$I/O-FL"
27 CLFL
28*LBL "$I/O"
29 "HP82166A"
30 FINDID
31 SELECT
32 MANIO
33 SF 17
34 CLA
35 CLX
36 RTN
37*LBL "$MSRQ"
38 CLX
39 X<>F
40 INSTAT
41 FS? 06
42 GTO 12
43 X<>Y
44 X<>F
45 "$OK"
46 ASTO X
47 CLA
48 RTN
49*LBL 12
50 X<>Y
51 X<>F
52 "$SRQ"
53 ASTO X
54 CLA
55 RTN
56*LBL "$IN1"
57*LBL 20
58 TRIGGER
59 X<> X
60 X<> X
61 TRIGGER
62 2
63 INAN
64 CLX
65 RTN
66*LBL "$IN2"
67*LBL 21
68 TRIGGER
69 TRIGGER
70 TRIGGER
71 2
72 INAN
73 CLX
74 RTN
75*LBL "$OUT1"
76*LBL 22
77 TRIGGER
78 2
79 OUTAN
80 CLX
81 RTN
82*LBL "$OUT2"
83*LBL 23
84 TRIGGER
85 TRIGGER
86 2
87 OUTAN
88 CLX
89 RTN
90*LBL "$IN1X"
91*LBL 24
92 XEQ 20
93 ATOXR
94 ATOXR
95 256
96 *
97 +
98 CLA
99 RTN
100*LBL "$IN2X"
101*LBL 25
102 XEQ 21
103 ATOXR
104 ATOXR
105 256
106 *
107 +
108 CLA
109 RTN
110*LBL "$OUT1X"
111 16
112 WSIZE
113 "D"
114 X<>Y
115 XTOAH
116 XEQ 22
117 RTN
118*LBL "$OUT2X"
119 16
120 WSIZE
121 "D"
122 X<>Y
123 XTOAH
124 XEQ 23
125 RTN
126*LBL "$IN1H"
127 16
128 WSIZE
129 XEQ 24
130 "IN1H="
131 ARCLH
132 CLX
133 PROMPT
134 RTN
135*LBL "$IN2H"
136 16
137 WSIZE
138 XEQ 25
139 "IN2H="
140 ARCLH
141 CLX
142 PROMPT
143 RTN
144*LBL "$OUT1H"
145 16
146 WSIZE
147 "OUT1H="
148 PMTH
149 "D"
150 XTOAH
151 XEQ 22
152 RTN
153*LBL "$OUT2H"
154 16
155 WSIZE
156 "OUT2H="
157 PMTH
158 "D"
159 XTOAH
160 XEQ 23
161 RTN
162*LBL "$IN1A"
163*LBL 30
164 "$I/O-FL"
165 4
166 SEEKPTA
167 TRIGGER
168 X<> X
169 X<> X
170 TRIGGER
171 2
172 INAN
173 ATOXR
174 ATOXR
175 SAVEX
176 CLA
177 RTN
178*LBL "$IN1B"
179*LBL 31
180 "$I/O-FL"
```

```
5
SEEKPTA
TRIGGER
X<> X
X<> X
TRIGGER
2
INAN
ATOXR
SAVEX
CLA
RTN
*LBL "$IN2A"
*LBL 32
"$I/O-FL"
6
SEEKPTA
TRIGGER
TRIGGER
TRIGGER
2
INAN
ATOXR
ATOXR
SAVEX
CLA
RTN
*LBL "$IN2B"
*LBL 33
"$I/O-FL"
7
SEEKPTA
TRIGGER
TRIGGER
TRIGGER
2
INAN
ATOXR
SAVEX
CLA
RTN
*LBL "$OUT1A"
*LBL 34
"$I/O-FL"
0
SEEKPTA
X<>Y
SAVEX
0
SEEKPT
"D"
GETX
XTOA
GETX
XTOA
TRIGGER
2
OUTAN
CLA
CLX
RTN
*LBL "$OUT1B"
*LBL 35
"$I/O-FL"
1
SEEKPTA
X<>Y
SAVEX
0
SEEKPT
"D"
GETX
XTOA
GETX
XTOA
TRIGGER
2
OUTAN
CLA
CLX
RTN
*LBL "$OUT2A"
*LBL 36
"$I/O-FL"
2
SEEKPTA
X<>Y
SAVEX
2
SEEKPT
"D"
GETX
XTOA
GETX
XTOA
TRIGGER
TRIGGER
2
OUTAN
CLA
CLX
RTN
*LBL "$OUT2B"
*LBL 37
"$I/O-FL"
3
SEEKPTA
X<>Y
SAVEX
2
SEEKPT
"D"
GETX
XTOA
GETX
XTOA
TRIGGER
TRIGGER
2
OUTAN
CLA
CLX
RTN
*LBL "$Tb1A"
STO L
8
WSIZE
XEQ 30
LASTX
RTN
*LBL "$Tb1B"
STO L
8
WSIZE
XEQ 31
LASTX
RTN
*LBL "$Tb2A"
STO L
8
WSIZE
XEQ 32
LASTX
RTN
*LBL "$Tb2B"
STO L
8
WSIZE
XEQ 33
LASTX
RTN
*LBL "$Sb1A"
0
XEQ 40
Sb
XEQ 34
LASTX
RTN
*LBL "$Sb1B"
1
XEQ 40
Sb
XEQ 35
LASTX
RTN
*LBL "$Sb2A"
2
XEQ 40
Sb
XEQ 36
LASTX
RTN
*LBL "$Sb2B"
3
XEQ 40
Sb
XEQ 37
LASTX
RTN
*LBL "$Cb1A"
```

```
361 0
362 XEQ 40
363 Cb
364 XEQ 34
365 LASTX
366 RTN
367*LBL "$Cb1B"
368 1
369 XEQ 40
370 Cb
371 XEQ 35
372 LASTX
373 RTN
374*LBL "$Cb2A"
375 2
376 XEQ 40
377 Cb
378 XEQ 36
379 LASTX
380 RTN
381*LBL "$Cb2B"
382 3
383 XEQ 40
384 Cb
385 XEQ 37
386 LASTX
387 RTN
388*LBL 40
389 X<>Y
390 STO L
391 RDN
392 "$I/O-FL"
393 SEEKPTA
394 8
395 WSIZE
396 GETX
397 LASTX
398 END
```

```
01*LBL "$16"
02 "^16"
03 GETK
04 RTN
05*LBL "$8"
06 "^8"
07 GETK
08 RTN
09*LBL "$1"
10 "^1"
11 GETK
12 RTN
13*LBL "$CRFL"
14 "$I/O-FL"
15 8
16 CRFLD
17 "ALM-FL"
18 CRFLD
19 "$16"
20 11
21 PASN
22 "$8"
23 12
24 PASN
25 "$1"
26 13
27 PASN
28 "$CHK"
29 21
30 PASN
31 "PWRDN"
32 -21
33 PASN
34 "$IN1X"
35 22
36 PASN
37 "$IN1"
38 -22
39 PASN
40 "$IN2X"
41 23
42 PASN
43 "$IN2"
44 -23
45 PASN
46 "$OUT1X"
47 24
48 PASN
49 "$OUT1"
50 -24
51 PASN
52 "$OUT2X"
53 25
54 PASN
55 "$OUT2"
56 -25
57 PASN
58 "$IN1H"
59 32
60 PASN
61 "$IN2H"
62 33
63 PASN
64 "$OUT1H"
65 34
66 PASN
67 "$OUT2H"
68 35
69 PASN
70 "CLRDEV"
71 -44
72 PASN
73 CLA
74 -51
75 PASN
76 -52
77 PASN
78 -53
79 PASN
80 -61
81 PASN
82 -71
83 PASN
84 -81
85 PASN
86 "^16"
87 SAVEK
88 "$IN1A"
89 22
90 PASN
91 "$IN2A"
92 23
93 PASN
94 "$OUT1A"
95 24
96 PASN
97 "$OUT2A"
98 25
99 PASN
100 "$IN1B"
101 32
102 PASN
103 "$IN2B"
104 33
105 PASN
106 "$OUT1B"
107 34
108 PASN
109 "$OUT2B"
110 35
111 PASN
112 CLA
113 -22
114 PASN
115 -23
116 PASN
117 -24
118 PASN
119 -25
120 PASN
121 42
122 PASN
123 43
124 PASN
125 "D^B"
126 -51
127 PASN
128 CLA
129 -52
130 PASN
131 -53
132 PASN
133 "B^D"
134 -61
135 PASN
136 "D^H"
137 -71
138 PASN
139 "H^D"
140 -81
141 PASN
142 "^8"
143 SAVEK
144 "$Tb1A"
145 22
146 PASN
147 "$Tb2A"
148 23
149 PASN
150 "$Sb1A"
151 24
152 PASN
153 "$Cb1A"
154 -24
155 PASN
156 "$Sb2A"
157 25
158 PASN
159 "$Cb2A"
160 -25
161 PASN
162 "$Tb1B"
163 32
164 PASN
165 "$Tb2B"
166 33
167 PASN
168 "$Sb1B"
169 34
170 PASN
171 "$Cb1B"
172 -34
173 PASN
174 "$Sb2B"
175 35
176 PASN
177 "$Cb2B"
178 -35
179 PASN
180 CLA
```

```
181 42
182 PASN
183 43
184 PASN
185 "bS?"
186 -52
187 PASN
188 "bC?"
189 -53
190 PASN
191 "^1"
192 SAVEK
193 CLA
194 CLX
195 RTN
196*LBL "$PURFL"
197 "$I/O-FL"
198 PURFL
199 "ALM-FL"
200 PURFL
201 "^16"
202 PURFL
203 "^8"
204 PURFL
205 "^1"
206 PURFL
207 CLA
208 END
```

```
01*LBL "D^B"
02 X<>F
03 STO L
04 CLA
05 7
06*LBL 01
07 FS? IND X
08 "⊦1"
09 FC? IND X
10 "⊦0"
11 DSE X
12 GTO 01
13 FS? IND X
14 "⊦1"
15 FC? IND X
16 "⊦0"
17 LASTX
18 X<>F
19 ANUM
20 RTN
21*LBL "B^D"
22 1 E7
23 /
24 ENTER^
25 CLX
26 X<>F
27 7
28 RCL Z
29*LBL 02
30 INT
31 X≠0?
32 SF IND Y
33 RDN
34 LASTX
35 FRC
36 10
37 *
38 DSE Y
39 GTO 02
40 X≠0?
41 SF 00
42 RCL Z
43 X<>F
44 RTN
45*LBL "D^H"
46 CLA
47 ARCLH
48 CLX
49 RTN
50*LBL "H^D"
51 ALENG
52 0
53*LBL 03
54 16
55 *
56 ATOX
57 57
58 -
59 X>0?
60 2
61 X<=0?
62 9
63 +
64 +
65 DSE Y
66 GTO 03
67 X<0?
68 CLX
69 .END.
```

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

```
01*LBL "$SENDR"
02 STO 00
03 512
04 SIZE?
05 -
06 STO Y
07 1000
08 /
09 +
10 ST+ 00
11 TRIGGER
12 "$I/O-FL"
13 0
14 SEEKPTA
15 GETX
16 "D"
17 XTOA
18*LBL 01
19 RCL 00
20 PEEKR
21 STO L
22 XEQ 20
23 ISG 00
24 GTO 01
25 RTN
26*LBL "$RECVR"
27 STO 00
28 512
29 SIZE?
30 -
31 STO Y
32 1000
33 /
34 +
35 ST+ 00
36 CLX
37 X<>F
38 STO L
39 TRIGGER
40*LBL 02
41 INSTAT
42 FC? 01
43 GTO 02
44 LASTX
45 X<>F
46*LBL 03
47 XEQ 30
48 RCL 00
49 X<>Y
50 POKER
51 ISG 00
52 GTO 03
53 RTN
54*LBL "$SENDF"
55 ASTO Y
56 ASHF
57 ASTO X
58 "$I/O-FL"
59 0
60 SEEKPTA
61 GETX
62 X<>Y
63 TRIGGER
64 CLA
65 ARCL T
66 ARCL Z
67 SEEKPTA
68 RDN
69 "D"
70 XTOA
71*LBL 04
72 SF 25
73 GETX
74 FC? 25
75 GTO 05
76 STO L
77 XEQ 20
78 GTO 04
79*LBL 05
80 CLX
81 STO L
82 XEQ 20
83 CLA
84 CLX
85 RTN
86*LBL "$RECVF"
87 0
88 SEEKPTA
89 X<>F
90 STO L
91 TRIGGER
92*LBL 06
93 INSTAT
94 FC? 01
95 GTO 06
96 LASTX
97 X<>F
98*LBL 07
99 XEQ 30
100 SF 25
101 SAVEX
102 FS? 25
103 GTO 07
104 STO L
105 CLA
106 RTN
107*LBL 20
108 4,6
109 PEEKB
110 XTOA
111 2
112 OUTAN
113 ABSP
114 4,5
115 PEEKB
116 XTOA
117 2
118 OUTAN
119 ABSP
120 4,4
121 PEEKB
122 XTOA
123 2
124 OUTAN
125 ABSP
126 4,3
127 PEEKB
128 XTOA
129 2
130 OUTAN
131 ABSP
132 4,2
133 PEEKB
134 XTOA
135 2
136 OUTAN
137 ABSP
138 4,1
139 PEEKB
140 XTOA
141 2
142 OUTAN
143 ABSP
144 4,0
145 PEEKB
146 XTOA
147 2
148 OUTAN
149 ABSP
150 LASTX
151 RTN
152*LBL 30
153 2
154 INAN
155 4,6
156 ATOXR
157 POKEB
158 2
159 INAN
160 4,5
161 ATOXR
162 POKEB
163 2
164 INAN
165 4,4
166 ATOXR
167 POKEB
168 2
169 INAN
170 4,3
171 ATOXR
172 POKEB
173 2
174 INAN
175 4,2
176 ATOXR
177 POKEB
178 2
179 INAN
180 4,1
181 ATOXR
182 POKEB
183 2
184 INAN
185 4,0
186 ATOXR
187 POKEB
188 CLA
189 LASTX
190 END
```

Burning HP-41 Zeprom Modules
by Christoph Klug

The Zeprom module is a powerful device for permanent storage of your own programm applications used with the HP 41 handheld computer. It's great capacity of 16 kByte allows you to store extensive user code programms or some copys of commercial modules for your private use, or both in combination.

Doing this, your HP-41 system is prevented against memory lost, furthermore you save module ports which you can use now to insert additional X-Memory modules or system rom-modules like the IL-Module.

The easiest way is to burn a straight 16 kByte Zeprom. Then you don't need the complex port switching routines of the Zeprom. The only limitation is, that it's not allowed to insert a rom-module beside a straight 16 kByte Zeprom. But you can insert a X-Memory module or a system rom in the adjacent port.

A Ram Box unit like the Eramco RSU is a fantastic tool for software development and test, followed by later storage of 4 kByte blocks in a Zeprom module. You can optimize the programms inside the RSU without the erasing procedures needed by the Zeprom.

After finishing a 4 kByte block with your programms, you transfer it to the cassette drive with the MLDL operating system function SAVEROM. In same manner you can copy commercial rom-modules to the cassette drive.

Now follows the burning process. You need two Zeprom modules and the Zeprom Voltage Converter = ZVC (One at a time programmer) from Zengrange.

Zeprom Modul 1 Programmer Rom	IL-Module Cassette-Drive
ZVC with Zeprom Modul 2	Port 4 do not use

The first Zeprom you insert in Port 1 of the HP-41. It contains the programmer rom software from Zengrage, you need to burn a straight 16 kByte Zeprom. Beside the first Zeprom insert the IL-module with the cassette drive in Port 2. This is the source of the 4 kByte blocks you want to burn inside the second Zeprom.

Insert the One at a time programmer on Port 3. Erase the second Zeprom with UV lamp, than adapt it to the One at a time programmer on Port 3. Port 4 do not use (free). Take care to use a new set of batteries for the HP-41, the AC power supply and rechargery cells are not qualified to supply the One at a time programmer for burning Zeproms.

Because the Zeprom adapted to the One at a time programmer is completely wiped to burn a straight 16 kByte Zeprom (4 x 4 kByte blocks), the needed programmer rom software for burning were found in the first Zeprom on Port 1 (Master). With this HP-41 port configuration you also can burn and copy modules with the same XROM number like the programmer rom software, for example the german CCD-module.

The 4 kByte block transfer from the cassette drive to Zeprom is done by the programmer rom software function ILBURN. This function allows a comfortable and quick burning process.

Although the HP-41 machine is a nostalgic handheld computer today, Zengrange offers good technical service and sale for their Zeprom modules 1995 too ! Zeprom modules are opportune compact hardware soltuions to pass over storage limitations of the HP-41 system.

To give you an example for using a Zeprom, I burn one zeprom to operate an interface loop controlled labor measurement system hardware by the HP-41 handheld. The hardware consists of a computer controlled dual power supply, a function generator, a frequency counter, a digital multimeter and some extern interface ports. 4 kByte user code software with over 60 functions assigned to 5 softkey selected keyboards control the unit. This software is completed by the required I/O-module (4 kByte) and the CCD-module (8 kByte). Using the zeprom the whole software is packed in only one HP-41 port !

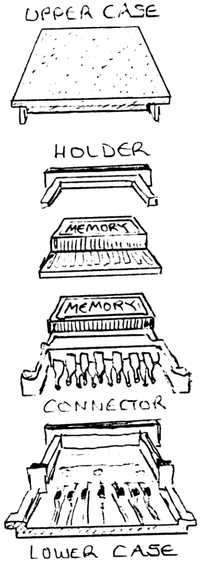
Juli 1995 Christoph Klug HPCC # 879

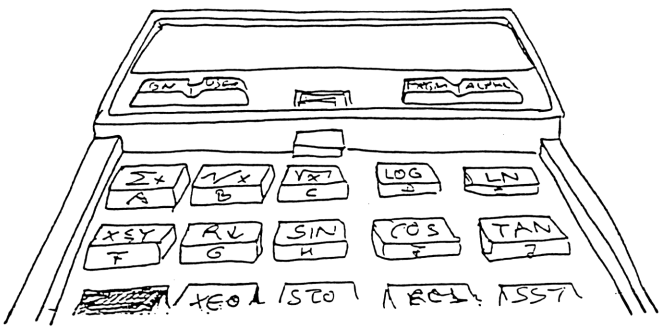
CHAPTER XII
DOUBLE X-MEMORY MODULE

Introduction	**XII.01**
Open Module Case	**XII.01**
Connect Intern Wiring	**XII.02**
Test Module	**XII.02**

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Double X-Memory Module





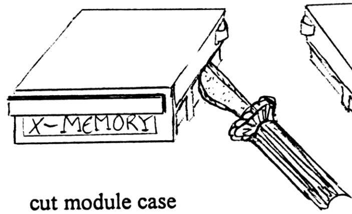
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Introduction :

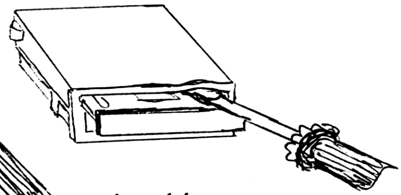
Double X-Memory Modules optimizing plug in port consumption of HP-41 : With a Double X-Memory Module beside a straight 16 kByte Zeprom-Module you reach full X-Memory space (600 Register) and maximal overall performance for your handheld. Informations about HP-41 port addressing you find inside HP-41 Service Manual ! Because Double X-Memory Modules are ram modules, we can adress them by intern wiring : Adressing is done only by B3 pin of module (left-right position). Realize your own Double X-Memory Module by mechanical fusion of two standart X-Memory Modules inside one case. Carry out following steps :

Open Module Case :

First open X-Memory Modul case by cutting connection between upper and lower case with sharp scalpel. Than insert a small skrew driver between the module holder and upper case and crack the module.



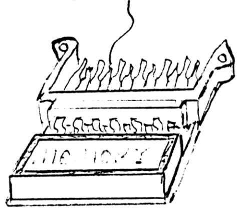
cut module case



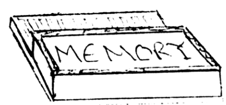
crack module

When both module are open take them to pices. Now remove the complete connector block of one X-memory Module from printed board with hot air soldering tool (upper module). Alternatively cut connector pins with nippers and remove them with soldering-iron one after another. Generally do not overheat sheded memory chips !

remove B3 pin from printed board



lower module

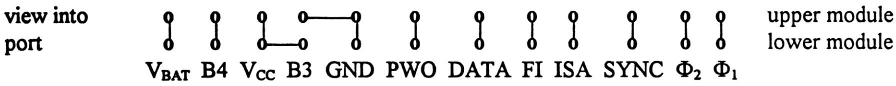


upper module

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Connect Intern Wiring :

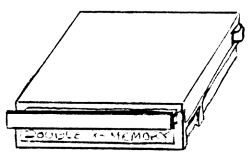
Now remove B3 connector pin from lower module and bridge B3 printed conductor to VCC line. Than solder short thin noninsulated wires to connector pins of lower module. Stack upper module over lower module and connect wires between both modules pin to pin. The B3 printed conductor of upper module connect to GND.



Test Module :

Now insert Double Module with lower case shell inside HP-41 and test available memory space with CAT 4 command. With empty X-Memory you get 600 into X-register, the number of free X-Memory registers.

Modify upper case and modul holder using a small file to reach enough place for the upper module. At last close modul case and glue it, now complete work is finshed.

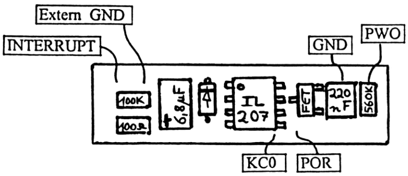


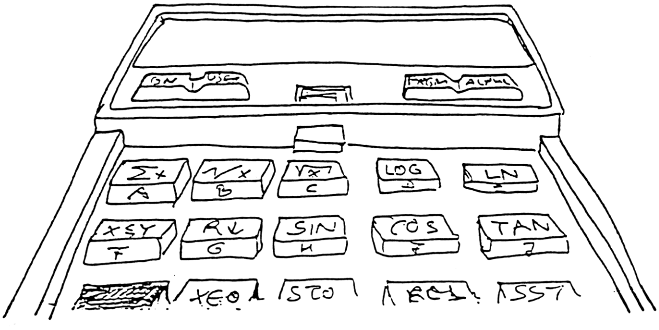
CHAPTER XIII
EXTERN HP-41 INTERRUPT

Introduction	XIII.01
Interrupt with Plug In Modules	XIII.01
Interrupt with intern hardware	XIII.03
Extern Interrupt and Time Alarm	XIII.06
Extern Power Supply for HP-41	XIII.07

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Extern HP-41 Interrrupt





HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Introduction :

Up to now we power up HP-41 handheld computer manually by pressing ON-Key or by Control Alarms with Time Module for executing some activities with I/O-Board. If we are working with Barcode Reader, we can additionally power on HP-41 by activate Wand-Key.

If we find a additional hardware solution for waking up systeme from OFF modus (sleep) to ON modus (executing a program) as a response to extern events, we can expand applications for HP-41 and I/O-Board.

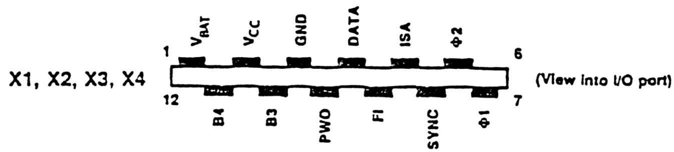
For example an automatic alarm system for protecting a house : Normally security system sleeps. Some time it wakes up periodically, checking state of sensors and printing some status messages (time alarm). If a thief release a security sensor, system wakes up (extern interrupt), detects the place of trouble and start some activities like switching on signal lamp or activating signal horn.

Using the manual service request line we can trigger only the active system to extern events : Existing solution for Development Module hold HP-41 in Stand By modus and runs INTR programm after service request and switch off after 10 minutes. With I/O-Module we run a program loop for scanning service request signal. This solutions only ideal for spanning short time intervals. Because for long time applications battery power consumption is to high !

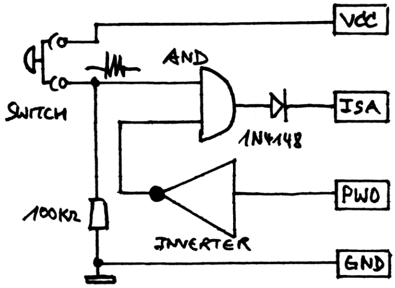
Inside HP-41 Service Manual we find some helpful informations for realizing extern interrupt. I developed two different hardware solutions for realizing extern power on. First solution uses HP-41 plug in ports, second solution needs a small hardware circuit mounted inside the HP-41 case.

Interrupt with Plug In Modules :

Most HP-41 user knows the barcode reader (Wand). Pressing wand switch power up the handheld computer. This is a feature of the ISA line of HP-41 plug in port. CPU wake up when a plug in accessory momentarily set the ISA line high. Following picture shows you the HP-41 plug in port pin configuration :



But you need additionally mcode routine for reaching ON modus. Plug in the AUTO/DUPLICATION Module containing the needed mcode routine and following small hardware circuit. You can adapt circuit to HP-41 port by opening the AUTO/DUP module or by inserting a second port connector from an old module.



Now install following software program. When HP-41 is switched on, AUTO/DUP-Module runs the RECOVER program automatically. Switching on by ISA line needs additional setting of Flag 11 (auto start Flag) when HP-41 goes to OFF mode :

```
01 LBL SLEEP
02 SF 11              auto start flag
03 PWRDN              power down I/O-Board
04 OFF                switch off HP-41
04 LBL RECOVER        AUTO/DUP-Module
05 XEQ $CHK           initialisation I/O-Board
06 PSE
07 GTO IND X
08 LBL $OK
09 ---------
10 ---------          your own program
11 ---------
nn GTO SLEEP
oo END
```

This first solution for realizing extern interrupt needs one or two HP-41 slots. Therefore I prefer the following second solution, because hardware modification inside HP-41 case is small and easy :

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

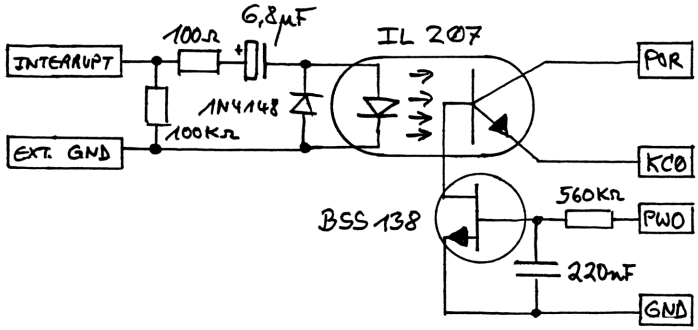
Interrupt with intern HP-41 hardware :

When you are pressing the HP-41 ON key, a switch pull down Power On Reset (POR) line signal level from +6V to keyboard matrix line KC0 with momentary ground level. CPU detects low POR level and wakes up HP-41 to ON modus !

The extern interrupt by intern HP-41 hardwaremodifikation is realized with following circuit : A transistor (switch) is wired parallel to ON-Key. Because the transistor is part of an opto-coupler element (IL 207) there is no risc for damanging HP-41 hardware by extern interrupt signal !

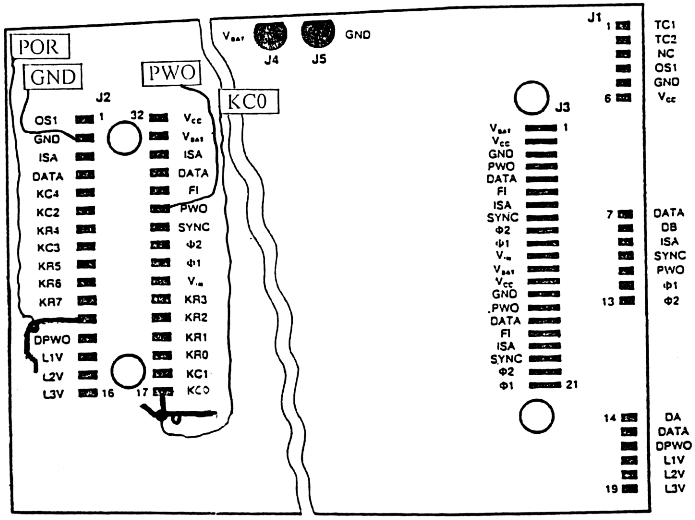
The opto-coupler input signal puls is generated on the rising edge of extern interrupt signal, determined by the 6,8µF elco and not by duration of extern interrupt pulse. Interrupt voltage puls ranges from 2V min to 10V (max elco voltage). Puls current is lower than 1mA, active high current typ 50µA. This attributes allows you much flexibility for generating the extern interrupt puls signal !

When HP-41 is in power on modus and runs a program CPU set PoWer On line PWO to high level. We use this signal to lock the opto coupler by a Fet-Transistor (BSS 138 = N-channel, enhancement). For that reason extern interrupt signal can not switch off HP-41 during a running program !



For mounting SMD circuit above beside the battery holder switch off handheld and remove battery case. Now open HP-41 case by removing rubber feet and the four skrews. Than remove logic PCA, but do not touch sensitive cmos circuits ! Now solder four thin isolated wires to POR, KC0, PWO lines and GND as shown on next page. Because we only solder Keyboard PC Board there is no risc for the logic PCA.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD



Now glue or fix with foam small interrupt circuit beside battery holder (lower case). For placing the corresponding extern interrupt line connector (see XIII.07) I use the battery charger slot. At last rebuild your HP-41, insert batteries and test system about correct function.

01 LBL SLEEP	
02 SF 11	auto start flag
03 PWRDN	power down I/O-Board
04 OFF	switch off HP-41
04 LBL WKUP	
05 XEQ $CHK	initialisation I/O-Board
06 PSE	
07 GTO IND X	
08 LBL $OK	
09 ---------	
10 ---------	your own program
11 ---------	
nn GTO SLEEP	
oo END	

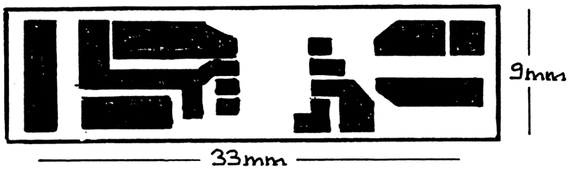
Software above you need for extern interrupt capability. Flag 11 is used for auto starting WKUP routine after pressing On key or detecting extern interrupt pulse.

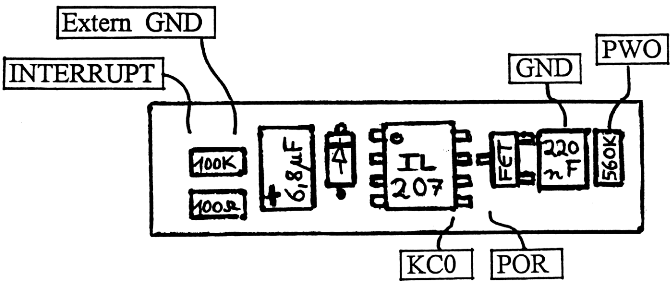
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

List of Surface Mounted Components :

SMD opto coupler	Siemens IL 207
SMD N-Channel enhenc. Fet	Siemens BSS 138
SMD diode	rohm ISS 355
SMD resistor 0805	560 KΩ
SMD resistor 0805	100 KΩ
SMD resistor 0805	100 Ω
SMD ceramic capacitor	220 nF
SMD elco capacitor	6,8 μF/10V

Printed Board Design for Extern Interrupt :





Extern Interrupt and Time Alarm :

For controlling I/O-Board by time alarms I prefer Non-interrupting Control Alarms (↑ALM) !!! Because Interrupting Control Alarms (↑↑ALM) stop any actual running activitys of system and start own job, it is complex to operate with them without any trouble for extern I/O-Board hardware. Savest solution is to do only one job at any time and after job is finished you can start new activities. This is realized by the Non-interrupting Control Alarms : The alarm becomes past due if a program is running. You can start past due alarms under program control by the ALMNOW command. Or HP-41 starts them automatic when running program is finished and switch off handheld.

During a running program (for example a Non-interrupting Control Alarm ↑ALM) extern interrupt signal can not stop or switch off HP-41 (because lock hardware of opto-coupler) = one job at any time ! But than you have no possibility to sense any extern interrupt event !!! Therefore work with additionally manual service request signales.

In most I/O-Board applications ↑ALM (Non-interrupting Control Alarm) and WKUP (extern interrupt) can start same software routine (on last page add LBL ALM behind LBL WKUP in program line 04). But sometime you need different program solutions for time alarm and for extern interrupt. Than close both routines by jumping to SLEEP, which set Flag 11 and switches off handheld :

```
01 LBL SLEEP
02 SF 11          auto start flag
03 PWRDN          power down I/O-Board
04 OFF            switch off HP-41
04 LBL WKUP       extern interrupt
05 XEQ $CHK       initialisation I/O-Board
09 ---------
10 ---------      your own interrupt program
11 GTO SLEEP
12 RTN
13 LBL ALM        time alarm
14 XEQ $CHK       initialisation I/O-Board
15 ----------
16 ----------     your own time program
17 GTO SLEEP
18 END
```

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

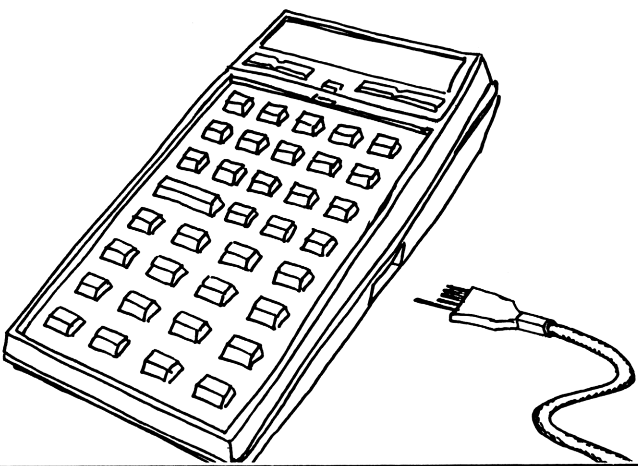
Extern DC Power Supply for HP-41 :

Mounting connector for extern interrupt inside battery charger slot, using an old HP 82120 rechargeable battery unit, we need no mechanical modification of HP-41 case. If we add a second connector for adapting an extern DC power supply unit, we have the best solution for practical work with HP-41.

Extern DC power supply expands available HP-41 battery capacity for long time applications with I/O-Board : A set of rechargeable Ni-Cad Lady cells (size N = LR1) for HP-41 only have 150 mA/h battery capacity. A set of alkaline batteries have 800 mA/h battery capacity. Extern power supply with four alkali-mangan Mignon batteries (size AA = LR6) make possible 3095 mA/h battery capacity, only for half of coast required for expensive Lady batteries !

Open old HP 82129 battery unit with saw and remove charger circuit and damaged battery cells. Now we have enough place for inserting a 6Volt 100 mA/h lithium photo battery (size V28 PXL = Ø13 mm x 25,2 mm) as backup power supply, a small micro-switch and a 5 pin connector for extern interrupt and DC power supply.

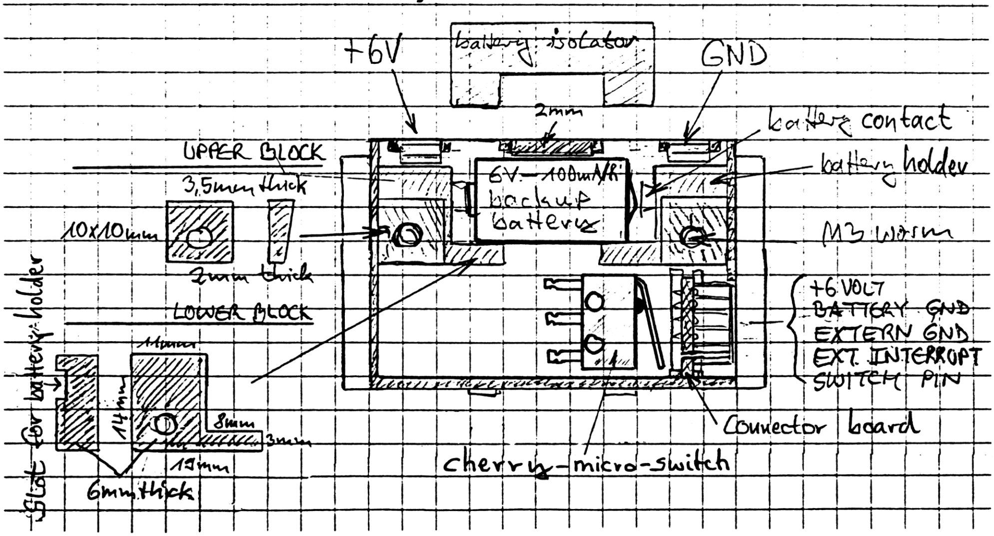
Inserted connector plug activates the micro-swich by a special pin. Than supply changes from intern backup battery to extern power supply unit ! This allows you removing extern DC power supply unit for transport and storage of HP-41, without data lost of intern memory ! If you supply handheld computer only with small backup battery, avoid switching to On-modus or running programms, because price of backup battery is higher than for a complete set Lady batteries.



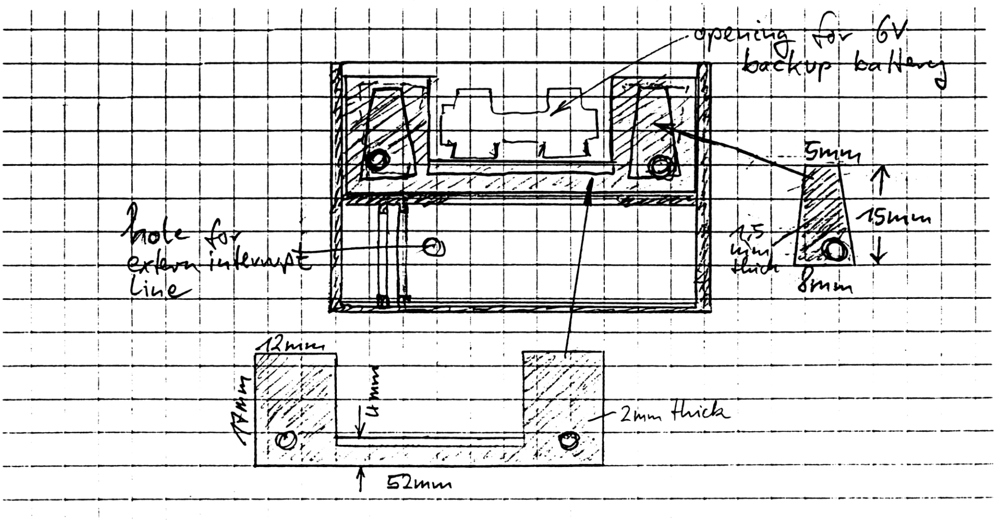
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Extern DC Power Supply for HP-41 :

HP 82129 battery unit - modifikations lower case



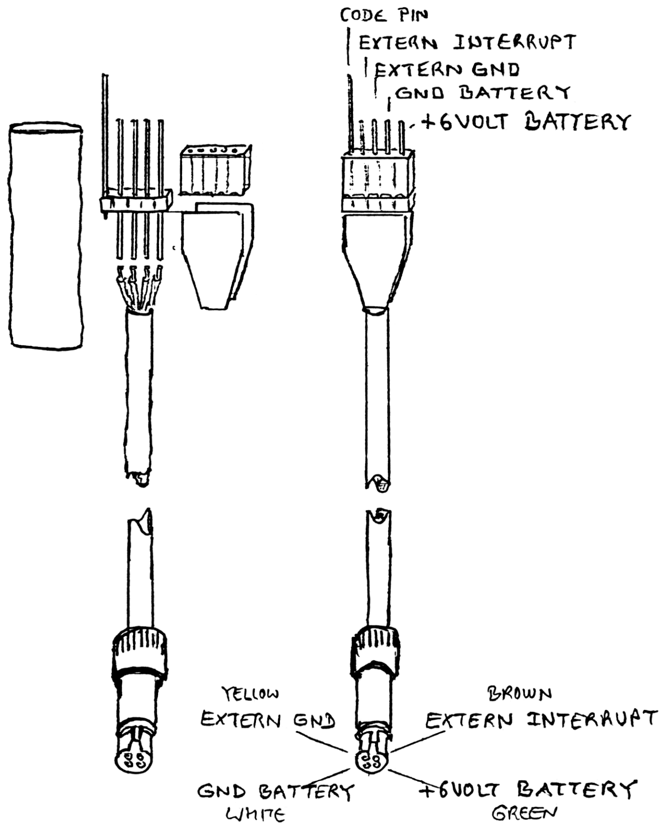
HP 82129 battery unit - modifikations upper case



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Extern DC Power Supply for HP-41 :

5 pin plug in connector and wiring

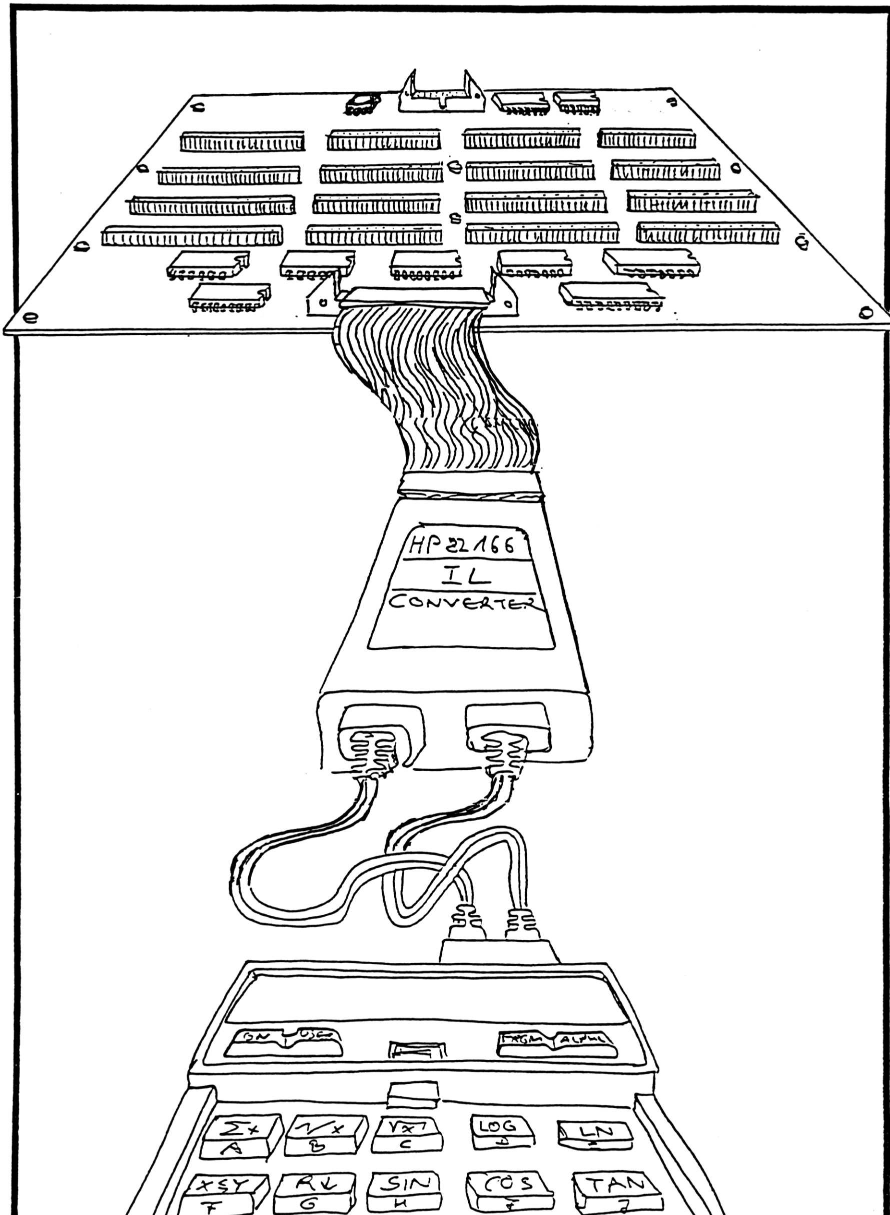


CHAPTER XIV

Data Transfer between two HP-41 using I/O-Boards :

Introduction	**XIV.01**
Transfer Software	**XIV.01**
Software Explanation	**XIV.02**
Transfer Hardware	**XIV.02**
Circuit Diagram	**XIV.03**
Timing Diagram	**XIV.04**
Printed Board	**XIV.05**
Program Listing	**XIV.06**
Barcodes	**XIV.07**

HP 82166 A 16 BIT INPUT / OUTPUT BOARD



HP 82166 A Input / Output Board :

Data-Transfer between two HP-41 using I/O-Boards :

Introduction :

HP 82166A IL-Converter manual and EXT I/O-Module manual contains example routines for executing program and data exchange between two HP-41 systems, using two IL-Converters adapted with belonging evolution board.

For existing I/O-Board controlled by HP-41, a Transfer-Module and belonging software designed to make possible bidirectional data transfer of X-Register, Main Memory Register Block or X-Memory Datafile with a second system consisting of HP-41and I/O-Board. Using 8 bit port OUT1B for sending data and 8 bit port IN1B for receiving data, within one minute twelve Main Memory Registers transfered. The neighbouring 8 bit ports OUT1A and IN1A are unaffected by data transfer.

Transfer-Module Software :

Advanced functions of CCD-Module, make possible transfer of ordinary numeric data and of Non Normalized Numbers = NNN´s. Working with NNN´s expands your possibility for storing data in Main Memory. For example use the programms WF (write file) and RF (read file) inside CCD-Module manual, you copy Buffers or ASCII-Files from X-Memory to Main Memory. Originaly WF and RF planed for file transfer to magnetic cards. After copying files to Main Memory data transfer to the other handheld is easy. Or realize a data logger application with storing data in compressed format inside Main Memory. Later transfer data to other system and start decompressing proccess. Following four commands given for sending and receiving data :

$SENDR	Send Main Memory Data Register Block. Enter control number bbb.eee. bbb and execute $SENDR. bbb = first Data Register of block, eee = last Data Register of block.
$RECVR	Receive Main Memory Data Register Block. Enter control number bbb.eee. bbb and execute $RECVR. bbb = first Data Register of block, eee = last Data Register of block.
$SENDF	Send XM-Datafile. Enter file name in Alpha Register and execute $SENDF.
$RECVF	Receive XM-Datafile. Enter file name in Alpha-Register and execute $RECVF.
$SENDX	Send X-Register. Transfers 7 Byte data received by $RECVX command.
$RECVX	Receive X-Register. Waits for 7 Byte data, sended by $SENDX command.

HP 82166 A Input / Output Board :

Handshake between sending and receiving Transfer-Module is nonbidirectional. Begin data transfer with running $RECVR, $REVCF or $RECVX on receiving HP-41, than executing $SENDR, $SENDF or $SENDX command on sending HP-41. During data transfer both HP-41 run with parallel processing. For working with $SENDF and $RECVF, X-Memory Datafiles must exist with same size. $SENDF, $SENDX and $RECVF, $RECVX only use Alpha-Register and Stackregisters. $SENDR and $RECVR use additionaly Dataregister R00 for the loopcounter. Status of Flag 00...07 not changed by software.

Software Explanation :

This chapter contains informations about used software techniques like stack operations, calculation of absolute register adresses and advanced programming (CCD-Module). Program length of $SENDR is 456 Bytes.

Program lines 11, 39, 63, 91, 110 and 167 addresses Transfer-Module to port OUT1B and IN1B. Lines 12-17, 58-61+69/70 and 111-116 read X-Memory file $I/O-FL to prevent altering of neighbouring OUT1A output port. Lines 21, 76 and 109 store value for transfer process in Last X, make possible stack operations. LBL 20 takes Last X value byte per byte (PEEKB) and appends them to existing Alpha-Register contens for sending to Interface Loop. ABSP clears rightmost Alpha-character and hold dummy byte D plus OUT1A byte in Alpha-Register for next 16 bit output.

Line 36-38, 44/45 and 87+89/90, 96/97 and 164-166, 172/173 save status of Flag 00...07. LBL 02, LBL 06 and LBL 10 check the Interface Loop, waiting for arriving input data. LBL 30 copy input data byte per byte (POKEB) from Alpha to Last X and store value to X-Register.

Lines 02 and 27 store control number for register block operations to R00. Lines 03-10 and 28-35 calculates the corresponding absolute address numbers of register block. Absolute address numbers used for PEEKR in line 20 and POKER in line 50 for recalling and storing NNN´s.

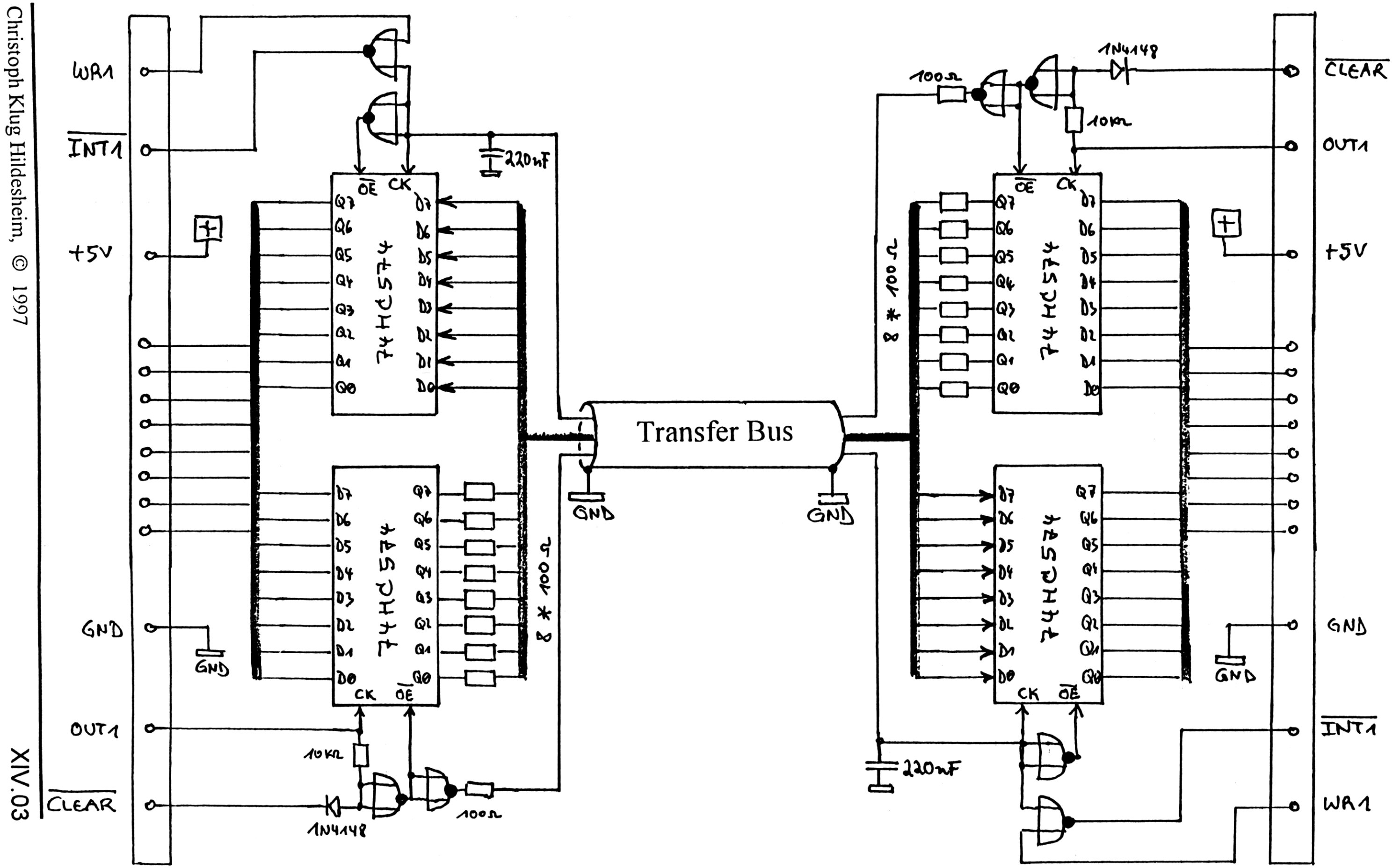
Transfer-Module Hardware :

Hardware circuits for sending and receiving data are mounted to a common 8 bit plug in card. Two identic Transfer-Modules are needed for both I/O-Boards.

Belonging 8 bit data transfer bus lines works bidirectional. Therefore used 74HC574 Octal D-Filp Flops switched to high impedance tri-state mode. Two handshake lines exist, one for every direction. Serial 100 Ω resistors addet to output bus lines for driving longer bus distances. Correct data exchange I tested with 30 meter shilded cable (8 data lines, 2 handshake lines, shield = GND).

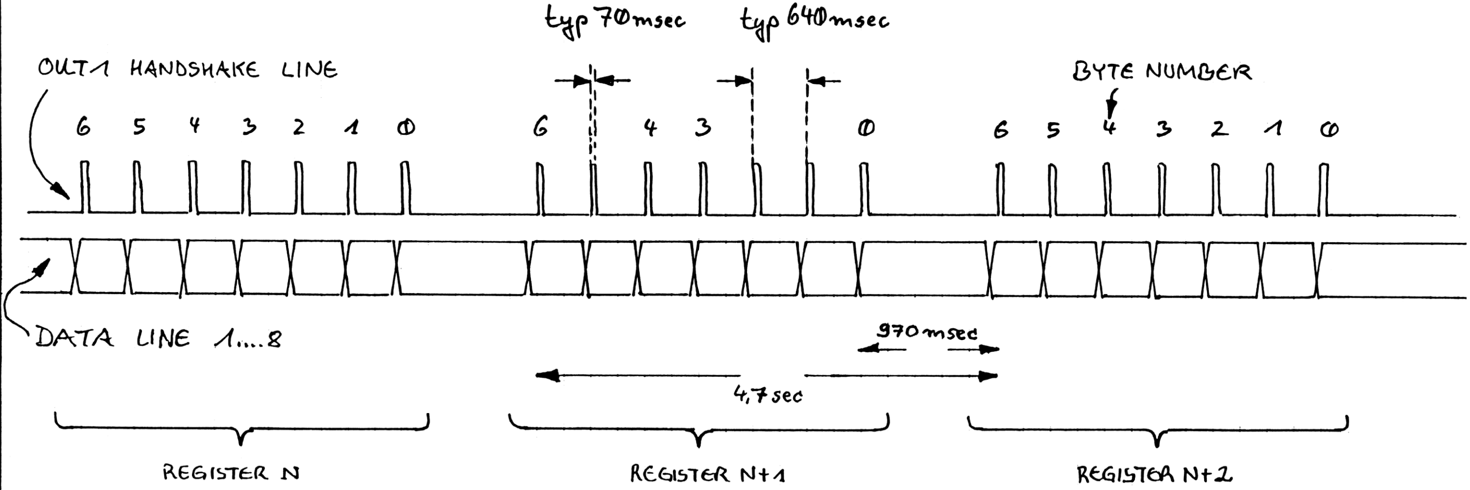
Addressing of Transfer-Module and belonging software is fixed to Port OUT1B and IN1B. **Remove INT1 Jumpers from neighbouring IN1A input modules** (but remove not WR1 and RD1 Jumpers), because common INT1 signals are generated on Transfer-Modules with nor-gates !

Data-Transfer between two HP-41 using I/O-Boards :



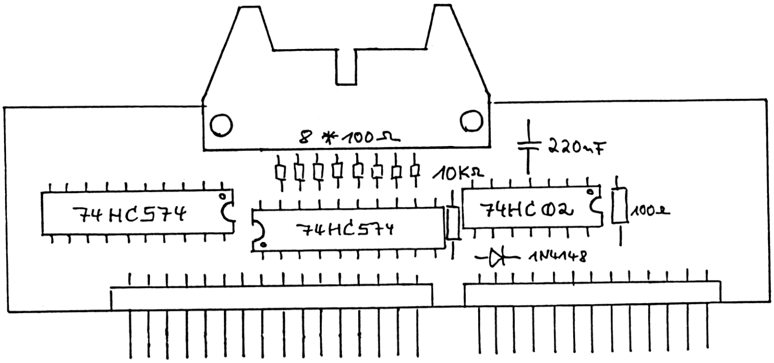
Data-Transfer between two HP-41 using I/O-Boards :

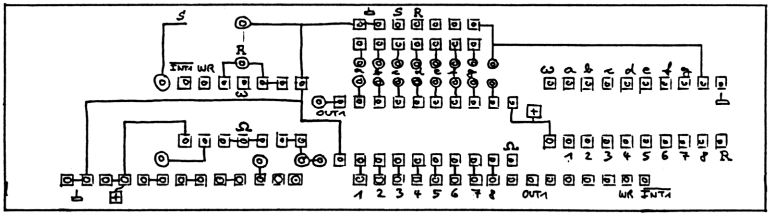
OUT1 handshake timing diagram



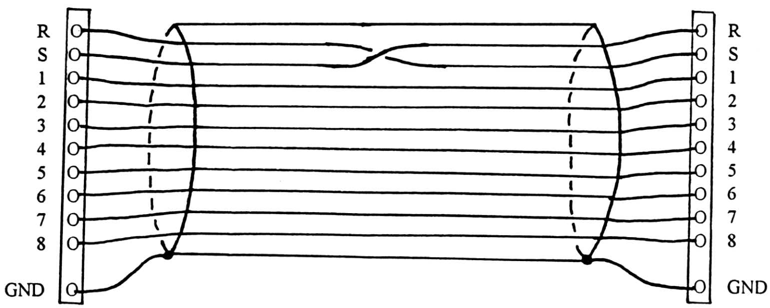
HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Transfer-Module Hardware :





Transfer Bus Connection :



HP 82166 A Input / Output Board :

```
01*LBL "$SENDR"
02 STO 00
03 512
04 SIZE?
05 -
06 STO Y
07 1000
08 /
09 +
10 ST+ 00
11 TRIGGER
12 "$I/O-FL"
13 0
14 SEEKPTA
15 GETX
16 "D"
17 XTOA
18*LBL 01
19 RCL 00
20 PEEKR
21 STO L
22 XEQ 20
23 ISG 00
24 GTO 01
25 RTN
26*LBL "$RECVR"
27 STO 00
28 512
29 SIZE?
30 -
31 STO Y
32 1000
33 /
34 +
35 ST+ 00
36 CLX
37 X<>F
38 STO L
39 TRIGGER
40*LBL 02
41 INSTAT
42 FC? 01
43 GTO 02
44 LASTX
45 X<>F
46*LBL 03
47 XEQ 30
48 RCL 00
49 X<>Y
50 POKER
51 ISG 00
52 GTO 03
53 RTN
54*LBL "$SENDF"
55 ASTO Y
56 ASHF
57 ASTO X
58 "$I/O-FL"
59 0
60 SEEKPTA
61 GETX
62 X<>Y
63 TRIGGER
64 CLA
65 ARCL T
66 ARCL Z
67 SEEKPTA
68 RDN
69 "D"
70 XTOA
71*LBL 04
72 SF 25
73 GETX
74 FC? 25
75 GTO 05
76 STO L
77 XEQ 20
78 GTO 04
79*LBL 05
80 CLX
81 STO L
82 XEQ 20
83 CLA
84 CLX
85 RTN
86*LBL "$RECVF"
87 0
88 SEEKPTA
89 X<>F
90 STO L
91 TRIGGER
92*LBL 06
93 INSTAT
94 FC? 01
95 GTO 06
96 LASTX
97 X<>F
98*LBL 07
99 XEQ 30
100 SF 25
101 SAVEX
102 FS? 25
103 GTO 07
104 STO L
105 CLA
106 RTN
107*LBL "$SENDX"
108*LBL 08
109 STO L
110 TRIGGER
111 "$I/O-FL"
112 0
113 SEEKPTA
114 GETX
115 "D"
116 XTOA
117*LBL 20
118 4,6
119 PEEKB
120 XTOA
121 2
122 OUTAN
123 ABSP
124 4,5
125 PEEKB
126 XTOA
127 2
128 OUTAN
129 ABSP
130 4,4
131 PEEKB
132 XTOA
133 2
134 OUTAN
135 ABSP
136 4,3
137 PEEKB
138 XTOA
139 2
140 OUTAN
141 ABSP
142 4,2
143 PEEKB
144 XTOA
145 2
146 OUTAN
147 ABSP
148 4,1
149 PEEKB
150 XTOA
151 2
152 OUTAN
153 ABSP
154 4,0
155 PEEKB
156 XTOA
157 2
158 OUTAN
159 ABSP
160 LASTX
161 RTN
162*LBL "$RECVX"
163*LBL 09
164 CLX
165 X<>F
166 STO L
167 TRIGGER
168*LBL 10
169 INSTAT
170 FC? 01
171 GTO 10
172 LASTX
173 X<>F
174*LBL 30
175 2
176 INAN
177 4,6
178 ATOXR
179 POKEB
180 2
181 INAN
182 4,5
183 ATOXR
184 POKEB
185 2
186 INAN
187 4,4
188 ATOXR
189 POKEB
190 2
191 INAN
192 4,3
193 ATOXR
194 POKEB
195 2
196 INAN
197 4,2
198 ATOXR
199 POKEB
200 2
201 INAN
202 4,1
203 ATOXR
204 POKEB
205 2
206 INAN
207 4,0
208 ATOXR
209 POKEB
210 CLA
211 LASTX
212 END
```

HP 82166 A Input / Output Board :

-1- $SENDR

-2- $SENDR

-3- $SENDR

-4- $SENDR

-5- $SENDR

-6- $SENDR

-7- $SENDR

-8- $SENDR

-9- $SENDR

-10- $SENDR

-11- $SENDR

-12- $SENDR

-13- $SENDR

HP 82166 A Input / Output Board :

-14- $SENDR

-15- $SENDR

-16- $SENDR

-17- $SENDR

-18- $SENDR

-19- $SENDR

-20- $SENDR

-21- $SENDR

-22- $SENDR

-23- $SENDR

-24- $SENDR

-25- $SENDR

-26- $SENDR

-27- $SENDR

-28- $SENDR

-29- $SENDR

-30- $SENDR

-31- $SENDR

-32- $SENDR

-33- $SENDR

-34- $SENDR

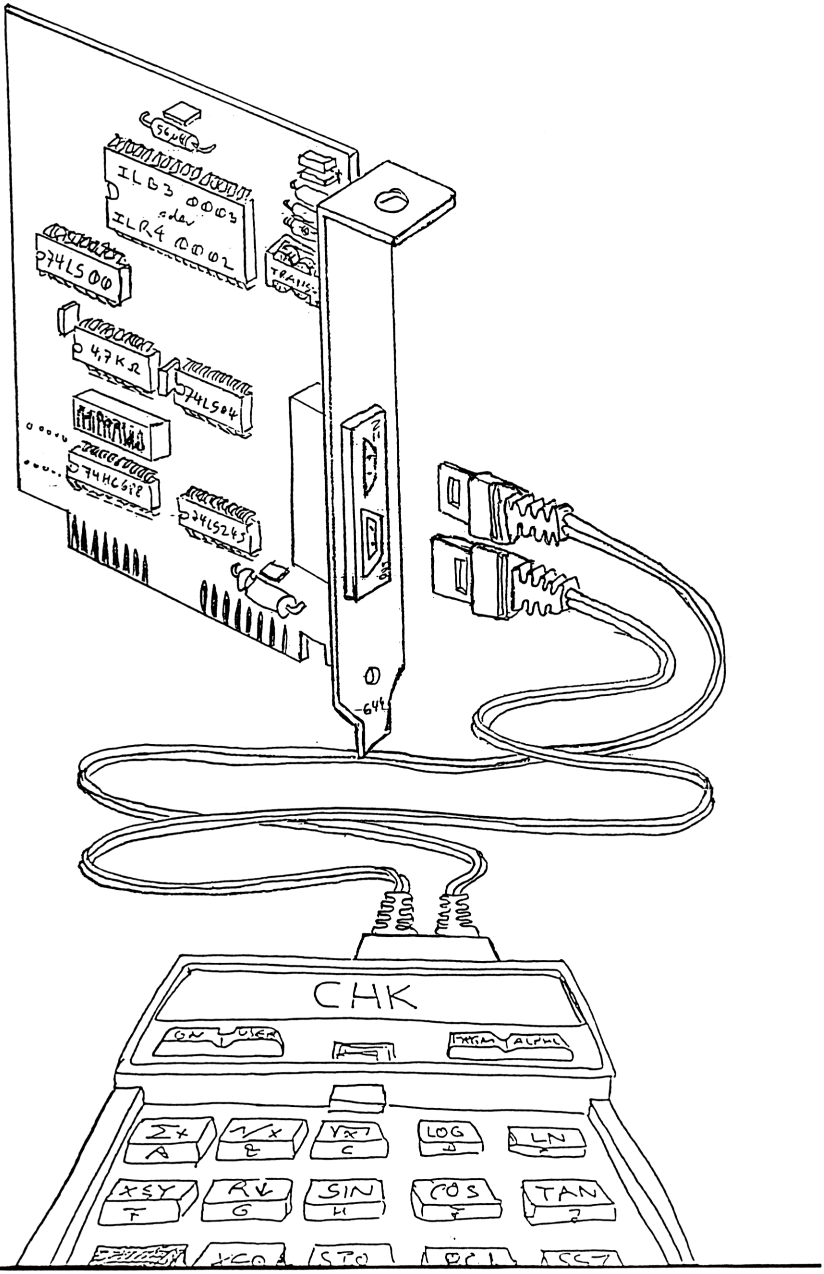
-35- $SENDR

-36- $SENDR

CHAPTER XV
HP-41↔PC DATA TRANSFER

Introduction	XV.01
HP-IL↔PC Interface Card	XV.01
Link Plus PC Installation	XV.04
HP-41 Link Plus Software	XV.05
Program Documentation	XV.10
Link Plus Barcodes	XV.10
HP-41 → PC Data Upload by Trans 41	XV.14
Trans 41 Barcodes	XV.16
HP-41 PC Emulator EMU 41	XV.18

HP 82166 A 16 BIT INPUT / OUTPUT BOARD



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Introduction :

Today the PC is the standart tool for executing calculations and data processing. By using HP-IL Interface Loop we adapt HP-41 handheld computer to PC : This is helpfully for realizing mobile applications like mobile data logging using handheld computer and I/O-Board, followed by stationary post processing with powerful PC. The following equipment make possible connection between HP-41 and PC :

For data transfer between HP-41 and PC we need a HP-IL↔PC Interface Card. Furthermore we need special PC software for driving the HP-IL↔PC Interface Card like Link Plus or Trans 41. Link Plus emulate six IL-Devices for use with handheld computer HP-41 : Two Cassette Drives, a Video Display, a Printer, a DOS-File for data transfer and a DOS-Device like second Printer or RS232-Interface. Trans 41 emulates a Cassette Drive a Printer and a DOS-File.

Link Plus Software only run´s correctly with slow speed PC´s like 286/16MHz. Fortunately Trans 41 Software is not limited to old PC´s, you can use it with modern machines like 486/66MHz and faster ! By using additionaly I/O-Module HP 82183, we reach complete control of Link Plus Software : Bidirectional data transfer between HP-41 and Link Plus DOS-File, and changing parameters by handheld computer, normally setted by Link Plus menü. Inside Trans 41 DOS-File we can only uploading data from HP-41 handheldcomputer to PC.

HP-IL↔PC Interface Card :

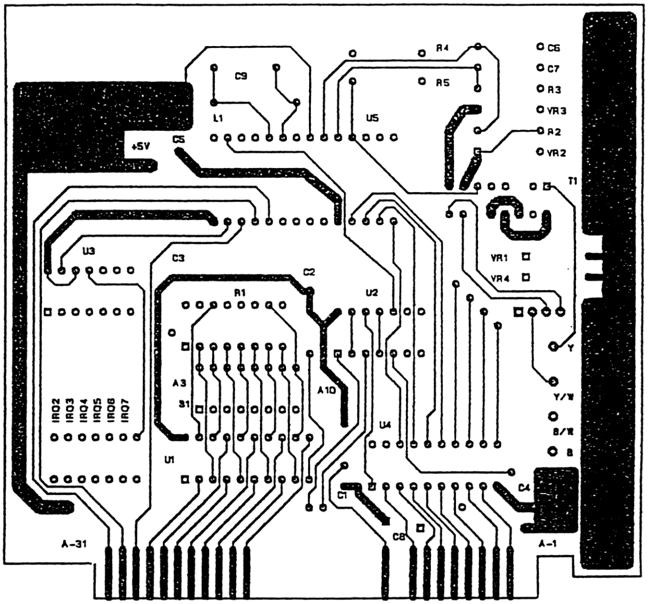
For use with PC two interface cards exist for connecting HP-IL : The HP 82973 and the Interloop 150 IL-Card. Last have some more features like the HP product.

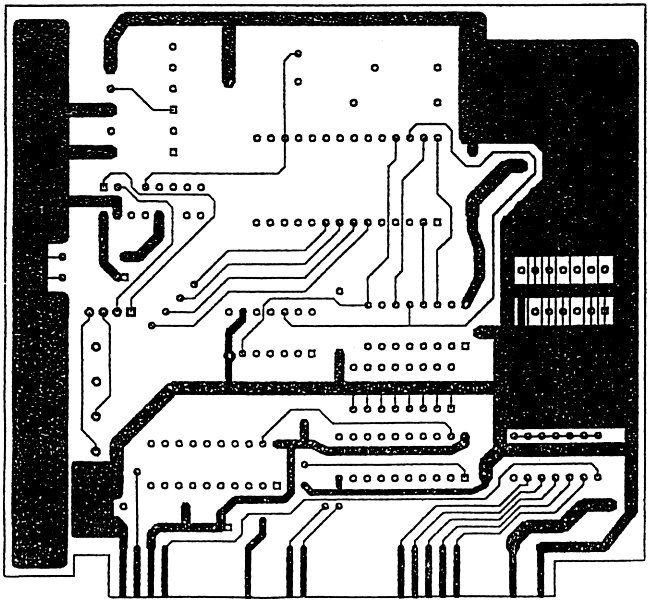
Because I could not find original HP-IL↔PC Interface Card long time on second hand market, I create an own rebuild version of the HP 82973 by help of Thomas Mareis, a member of former CCD Computer Club Deutschland. The electronic kit consist of a double side PCB, IL-Terminal, IL-Transformer, IL-Chip, surpressor diodes and some other electronic standart components.

On following pages you find only a basic documentation about HP-IL↔PC Interface Card, without additional informations about building and testing. Contact the author for a finished sample of HP-IL↔PC Interface Card.

Address dip-switches set to hex 700, the default setting for use with Link Plus.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD





HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-IL↔PC Interface Card Component List :

Anzahl :	Schaltkreise :	Anmerkung :
1	IL-Chip 1LB3 0003 oder 1LR4002	verbaut in fast allen IL-Peripheriegeräten wie 82161 oder 9114 (U5)
1	SN 74HC688	20 Pin (U1) 1820-2311
1	SN 74LS04	14 Pin (U2) 1820-1199
1	SN 74LS00	14 Pin (U3) 1820-2656
1	SN 74LS245	20 Pin (U4) 1820-2075

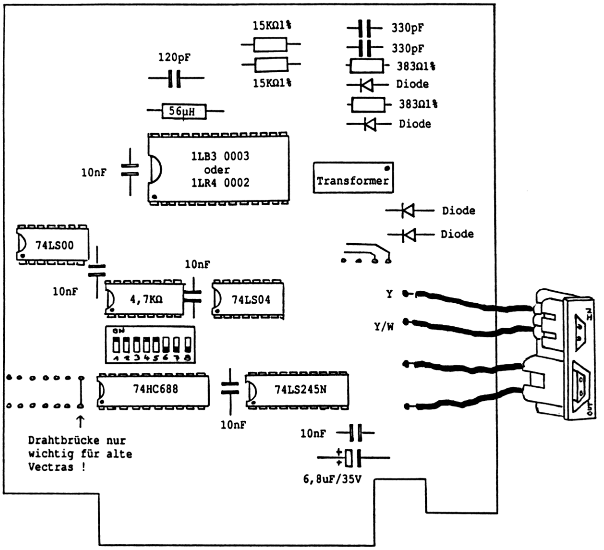
Anzahl :	Widerstände :	Anmerkung :
2	383 Ohm 1 % 1/4 Watt	(R2, R3)
2	15 KOhm 1% 1/4 Watt	(R4, R5)
1	4,7 KOhm 15 fach Netzwerk im Dipgehäuse	Beckmann Netzwerk Typ 898-1

Anzahl :	Kondensatoren :	Anmerkung :
5	10 nF keramisch	103K (C1....C5)
1	6,8 µF / 35 Volt Folienkondensator	auch Elko möglich ! (C8)
2	330 pF keramisch	(C6, C7)
1	120 pF keramisch	(C9)

Anzahl :	Dioden:	Anmerkung :
4	Motorola P6KE18ARL 18 Volt Suppressordiode	(VR1....VR4)

Anzahl :	Sonstige Bauteile :	Anmerkung :
1	IL-Transformer 9100-4226	in allen IL-Peripheriegeräten verbaut (T1)
1	IL-Steckerleiste 5061-4306	in Peripheriegeräten wie 2225B und 9114 verbaut
1	8-fach Dip Schalter	(SW1)
1	6-fach Jumper oder Lötbrücke	
1	HF-Drossel 56 µH / 5%	ähnlich wie im HP 41 die Spule für die Taktfrequenz. Kunstoffgehäuse.
1	PC-Kartenhalter	IBM-KH-G44

HP 82166 A 16 BIT INPUT / OUTPUT BOARD



Link Plus PC Installation :

Link Plus was developed for use with 286 PC's. The last update from Southern Software is version 2.06 from 1989. One feature of last version is a additional slow down command for working with some faster running 386 PC's. Unfortunately any Link Plus activities closed, and no service exist today from Southern Software. Therefore get Link Plus from second hand market, from user clubs or from the author.

CPU speed of actual PC systems like 486 or Pentium is much to fast for working correctly with Link Plus software. For installation of HP-IL↔PC Interface Card and Link Plus only use a slow speed PC system ! Test your individual CPU speed working correctly with Link Plus application : Send data from handheld computer to Printer #4 or DOS-File #5. Because Link Plus emulates this IL-Devices something faster than Video Display #3 ! Your PC speed is right, if no doubling of received characters occures.

For example I use a 286/20 MHz PC and run Link Plus with Turbo mode switched off. Or a COMPAQ 386/20 MHz PC. There I install a boot-manager for changing between actual DOS 6.22 + WINDOWS and original COMPAQ DOS 3.31. Last have a special MODE SPEED command for slowing down CPU speed.

If HP-41 displays TRANSMIT ERR when working with DOS-File #5 or DOS-Device #6, start Link Plus with smaller buffer size (see Link Plus manual appendix) !

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 Link Plus Software :

The following software is developed from informations given in Link Plus manual. Because advanced use of I/O-Module not contained in Link Plus manual, I translate some applications from HP-71 program code for use with HP-41. The HP-IL↔PC Interface Card generally is expected at interface loop address #1 to #6. Than address #5 is the DOS-File, we select for data transfer between PC and HP-41. Additional IL-Devices like Cassette Drive or IL-Converter insert behind PC-Card to interface loop address #7 and following !

Presented HP-41 program transfers numeric numbers and alpha data strings with maximal 6 characters (corresponding to one HP-41 register). First set DOS-File name by Link Plus menü. Then enter register block number bbb,eee in HP-41 X-Register, describing first register bbb and last register eee of data register block inside main memory. Now execute L+SENDR or L+RECVR for data block transfer.

L+SENDR is the optimiced version of UPL (upload) inside LINK PLUS manual described on page 41 :

```
01 LBL "L+SENDR"            LINK PLUS Send Data Register Block from HP-41 Main
02 AUTOIO                                                      Memory to DOS-File
03 5                   loop address #5
04 SELECT              select DOS-File
05 MANIO
06 CF 17               end of line  carry return
07 X<>Y
08 LBL 01
09 CLA
10 ARCL IND X          recall data from HP-41 main memory
11 OUTA                send data to DOS-File
12 ISG X
13 GTO 01
14 1                   set standart setup for LINK PLUS
15 SELECT
16 AUTOIO
17 CLA
18 CLX
19 END
```

For L+RECVR aviod setting the register block size greater than number of data existing inside DOS-File, because than unknown data are transfered to HP-41 main memory. Recalling these unknown data can freeze your HP-41 display for short time. Write exponent numbers without any spaces to DOS-File.

For example 1,23_E-45 is received only as 1,23 and not as 1,23 x 10^{-45}. Mixed Alpha-Number strings represented only as number, for example ABC123 is received only as 123 and ABC are lost (HP-41 ANUM command program line 13) !

```
01 LBL "L+RECVR"      LINK PLUS Receive Data Register Block from DOS-File inside
02 AUTOIO                                                       HP-41 Main Memory
03 5                  loop address #5
04 SELECT             select DOS-File
05 MANIO
06 CF 17              end of line  carry return
07 X<>Y
08 LBL 02
09 CLA
10 INA                read data from DOS-File
11 ENTER^
12 CF 22
13 ANUM
14 FS? 22             if numeric number store it to main memory
15 STO IND Y
16 FC? 22             if alpha string store it to main memory
17 ASTO IND Y
18 RDN
19 ISG X
20 GTO 02
21 1                  set standart setup for LINK PLUS
22 SELECT
23 AUTOIO
24 CLA
25 CLX
26 END
```

For transmitting data between X-Memory and DOS-File you must not copy XM-File contents inside a register block, consuming some main memory space. Next two programs realize exchange between XM- and DOS-File. First create XM-File, than enter file name in Alpha-Register and execute L+SENDF or L+RECVF.

```
01 LBL "L+SENDF"      LINK PLUS Send Data from HP-41 X-Memory Data File to
02 CLX                                                               DOS-File
03 SEEKPTA            select XM-Data File
04 AUTOIO
05 5                  loop address #5
06 SELECT             select DOS-File
07 MANIO
08 CF 17              end of line  carry return
09 LBL 03
10 CLA
```

```
11 SF 25            set error ignore flag
12 GETX             recall data from HP-41 XM-File
13 FC? 25
14 GTO 04           end of XM-File
15 ARCL X
16 OUTA             send data to DOS-File
17 GTO 03
18 LBL 04
19 1                set standart setup for LINK PLUS
20 SELECT
21 AUTOIO
22 CLA
23 CLX
24 END
```

Restrictiones about received data format of L+RECVF same as for L+RECVR above (writing exponent and mixed numeric and alpha strings).

```
01 LBL "L+RECVF"    LINK PLUS Receive Data from DOS-File inside HP-41 X-Memory
                    Data File
02 CLX
03 SEEKPTA
04 AUTOIO
05 5                loop address #5
06 SELECT           select DOS-File
07 MANIO
08 CF 17            end of line  carry return
09 LBL 05
10 CLA
11 INA              read data from DOS-File
12 CF 22
13 ANUM
14 FS? 22           if numeric number store it to X-Register
15 STO X
16 FC? 22           if alpha string store it to X-Register
17 ASTO X
18 SF 25            set error ignore flag
19 SAVEX            save data inside HP-41 XM-File
20 FS? 25           end of XM-File
21 GTO 05
22 LBL 06
23 1                set standart setup for LINK PLUS
24 SELECT
25 AUTOIO
26 CLA
27 CLX
28 END
```

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Mixed numeric- and alpha data transfered by ASCII text files without any restrictions. Use the HP-41 command GETAS and the Link Plus program SENDAS. More informations give the DOS2LIF utility of Link Plus manual appendix.

But not only data transfer is possible by working with LINK PLUS and handheldcomputer : By sending special Escape sequenzes from HP-41 to Link Plus Video Device #3, you change some Link Plus Menü parameter, normally changed by Link Plus menü (see appedix of Link Plus manual).

For example for setting name of DOS-File first select Video Device #3 (execute 3 SELECT). Now enter the following text string inside Alpha-Register :

␛$5NAME$

The decimal value of Escape sign ␛ is 027. You enter it inside Alpha-Register by 27 XTOA or by synthetic programming. 5 is the interface loop address of DOS-File. NAME is the new name of DOS-File. Now read out Alpha-Register by ACA. Switching to Link Plus menü shows you the result of your command sequenze.

With help of I/O-Module we can send special device dependent talker and listener commands to HP-IL↔PC Interface Card. This give HP-41 completely control of parameters. The following example again set DOS- File name, now by I/O-Module :

Enter the Link Plus Device address #5 in X-Register and the new DOS-Filename in Alpha-Register and execute L+NAME. Running this program as subroutine of a main program, we automatic transfer some data blocks from HP-41 to different DOS-Files, set DOS-File pointer position to null, or change the "medium" of Link Plus cassette drive #1 or #2.

```
01 LBL "L+NAME"        LINK PLUS Set File Name
02 AUTOIO
03 SELECT              select loop address # in X-Register
04 MANIO
05 21                  set DOS-File Name
06 DEVL
07 ACA                 Send File Name in Alpha-Register without CR/LF
08 20
09 DEVL
10 UNL
11 1                   set standart setup for LINK PLUS
12 SELECT
13 AUTOIO
14 CLA
15 CLX
16 END
```

Alter program lines 05 to 10, for realizing other examples given in Link Plus manual. For example, next program read the actual DOS-File name into Alpha-Register. First enter loop address into X-Register than execute L+NAME? . Switching to Alpha-Register shows you the result.

```
01 LBL "L+NAME?"            LINK PLUS Read File Name
02 AUTOIO
03 SELECT                   select loop address # in X-Register
04 MANIO
05 21                       read DOS-File Name
06 DEVT
07 INA                      Read File Name into Alpha-Register
08 UNT
09 UNL
10 1                        set standart setup for LINK PLUS
11 SELECT                   without clearing Alpha-Register
12 AUTOIO
13 CLX
14 END
```

Last example changes the Device Accessory ID to 66 like the HP-IL↔RS232 interface : Enter the Link Plus Device address #6 in X-Register and the new Accessory ID 66 in Alpha-Register and execute L+AID.

```
01 LBL "L+AID"              LINK PLUS Set Accessory ID
02 AUTOIO
03 SELECT                   select loop address # in X-Register
04 MANIO
05 22                       Accessory ID
06 DEVL
07 ACA                      Send Accessory ID in Alpha-Register without CR/LF
08 20
09 DEVL
10 UNT
11 UNL
12 1                        set standart setup for LINK PLUS
13 SELECT
14 AUTOIO
15 CLA
16 CLX
17 END
```

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Program Documentation :

Also the documentation for presented programs above is written by help of LINK Plus. First I select the DOS-File at loop address #5 and print the HP-41 program code inside DOS-File by executing PRP "NAME". Than I import the DOS-File as ASCII text file to WinWord document. Last I complete header text and program explanations.

Link Plus Barcodes :

-1- L+SENDR

-2- L+SENDR

-3- L+SENDR

-4- L+SENDR

-1- L+RECVR

-2- L+RECVR

-3- L+RECVR

-4- L+RECVR

-5- L+RECVR

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

-1- L+SENDF

-2- L+SENDF

-3- L+SENDF

-4- L+SENDF

-1- L+RECVF

-2- L+RECVF

-3- L+RECVF

-4- L+RECVF

-5- L+RECVF

-1- L+NAME

-2- L+NAME

-3- L+NAME

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

-1- L+NAME?

-2- L+NAME?

-3- L+NAME?

-1- L+AID

-2- L+AID

-3- L+AID

```
01*LBL "L+SENDR"
02 XEQ 20
03 X<>Y
04*LBL 01
05 CLA
06 ARCL IND X
07 OUTA
08 ISG X
09 GTO 01
10 GTO 30
11*LBL "L+RECVR"
12 XEQ 20
13 X<>Y
14*LBL 02
15 CLA
16 INA
17 ENTER^
18 CF 22
19 ANUM
20 FS? 22
21 STO IND Y
22 FC? 22
23 ASTO IND Y
24 RDN
25 ISG X
26 GTO 02
27 GTO 30
28*LBL "L+SENDF"
29 CLX
30 SEEKPTA
31 XEQ 20
32*LBL 03
33 CLA
34 SF 25
35 GETX
36 FC? 25
37 GTO 30
38 ARCL X
39 OUTA
40 GTO 03
41*LBL "L+RECVF"
42 CLX
43 SEEKPTA
44 XEQ 20
45*LBL 04
46 CLA
47 INA
48 CF 22
49 ANUM
50 FS? 22
51 STO X
52 FC? 22
53 ASTO X
54 SF 25
55 SAVEX
56 FS? 25
57 GTO 04
58 GTO 30
59*LBL "L+SENDT"
60 0
61 SEEKPTA
62 5
63 SELECT
64 MANIO
65 SF 25
66*LBL 05
67 GETREC
68 FC? 25
69 GTO 30
70 OUTA
71 FS? 25
72 GTO 05
73 XEQ 30
74 "HPIL ERR"
75 PROMPT
76 RTN
77*LBL "L+NAME"
78 AUTOIO
79 SELECT
80 MANIO
81 21
82 DEVL
83 ACA
84 20
85 DEVL
86 UNL
87 GTO 30
88*LBL "L+NAME?"
89 AUTOIO
90 SELECT
91 MANIO
92 21
93 DEVT
94 INA
95 UNT
96 UNL
97 1
98 SELECT
99 AUTOIO
100 CLX
101 RTN
102*LBL 20
103 AUTOIO
104 5
105 SELECT
106 MANIO
107 CF 17
108 RTN
109*LBL 30
110 1
111 SELECT
112 AUTOIO
113 CLA
114 CLX
115 END
```

HP-41 → PC Data Upload by Trans 41

Unfortunately Link Plus only runs with slow speed PC's like 286/16 MHz. To overcome this painful limitation I tested the TRANS41 software version 3.0 from Eclipse Logic Inc / Tacit Logic Systems (1989). This is an special add on solution for the ELI41 / CALC41 software, a HP-41CV DOS emulator. It realizes up/downloading and translation of programms between HP-41 and the PC emulator.

Furthermore you can use TRANS41 as a stand alone DOS application : It emulates an IL-Printer and an IL-Cass-Drive. As Link Plus software also TRANS41 has the possibility of uploading data from handheld computer into a DOS ASCII file !

Software installation to PC is easy : Copy contents of floppy disk into harddisc directory. Now execute install.bat. Software generates own TLS directory on same drive. Enter TLS directory and execute trans41.exe for starting the application. Connect HP-41 handheld computer to PC. The HP-IL ↔ PC Interface Card must be the first Device in Interface Loop. Switch on HP-41 and set Flag15 for activating TRANS41 echo-mode. Now any HP-41 activies are printed on left PC screen. Right screen side is reservated for the DOS world.

Now some informations about realizing uploading data from handheld computer into DOS ASCII file : When TRANS41 is running on PC clear Flag15 of your HP-41, than enter the PC keyboard menue sequence F10, Options, Output, Text-File for setting the ASCII file name (default = TXTFILE.LST).

For uploading data I developed four different routines for HP-41 handheld. Execute T+SENDR for uploading a data register block from main memory, T+SENDF for uploading a X-Memory data file or T+SENDM for uploading a CCD-Module matrix file or T+SENDA for uploading a X-Memory ASCII text file into PC DOS file. For T+SENDR first enter the block number bbb,eee in X-Register (bbb = first data register, eee = last data register). For T+SENDF, T+SENDM and T+SENDA first enter the filename in Alpha-Register.

During upload left screen prints transfered data. When upload is finished close TRANS41 with ESC key and view the resulting ASCII file contents by using an editor. Now start with PC data post processing like DOS file import to a special WINDOWS application.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

```
01 LBL T+SENDR
02 AUTOIO
03 1
04 SELECT
05 MANIO
06 CF 17
07 X< >Y
08 LBL 01
09 CLA
10 ARCL IND X
11 OUTA
12 ISG X
13 GTO 01
14 AUTOIO
15 CLA
16 CLX
17 END
```

```
01 LBL T+SENDF
02 CLX
03 SEEKPTA
04 AUTOIO
05 1
06 SELECT
07 MANIO
08 CF 17
09 LBL 02
10 CLA
11 SF 25
12 GETX
13 FC? 25
14 GTO 03
15 ARCL X
16 OUTA
17 GTO 02
18 LBL 03
19 AUTOIO
20 CLA
21 CLX
22 END
```

```
01 LBL T+SENDM
02 1,001
03 IJ=A
04 AUTOIO
05 1
06 SELECT
07 MANIO
08 CF 17
09 LBL 04
10 CLA
11 SF 25
12 C>+
13 FC? 25
14 GTO 05
15 ARCL X
16 OUTA
17 GTO 04
18 LBL 05
19 AUTOIO
20 CLA
21 CLX
22 END
```

```
01 LBL T+SENDA
02 CLX
03 SEEKPTA
04 AUTOIO
05 1
06 SELECT
07 MANIO
08 LBL 06
09 CLA
10 SF 25
11 GETREC
12 FC? 25
13 GTO 07
14 OUTA
15 GTO 06
16 LBL 07
17 AUTOIO
18 CLA
19 CLX
20 END
```

For realizing printing and mass-storage set the HP-41 to AUTOIO mode and use the well known standart commands, TRANS41 works compatible to the existing IL Devices.

TRANS41 software is a key tool for realizing HP-41 data upload to modern PC, you are not fixed to a slow speed PC hardware ! This is the most advantage of TRANS41 for the today PC user ! Uploading data have a high prijority for practical work with HP-41 handheldcomputer and PC : For data logging applications with I/O-Board TRANS41 gives you an easy access to WINDOWS !

BARCODES :

-1- T+SENDR

-2- T+SENDR

-3- T+SENDR

-1- T+SENDF

-2- T+SENDF

-3- T+SENDF

-4- T+SENDF

-1- T+SENDM

-2- T+SENDM

-3- T+SENDM

-4- T+SENDM

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

HP-41 PC Emulator EMU 41 :

Practical work with the HP-41 emulator software for PC´s, ELI41 / CALC41 from Eclipse Logic Inc / Tacit Logic Systems (Version1989 DOS Program) or ttCalc-HP41 from Stefan Seiwerth / Germany (Version1.0 WINDOWS Program) is limited, because only the HP-41CV model is simulated.

The EMU41 from Jean-Francois Garnier / France (DOS Program) is a real emulator not a simulator, and includes CV or alternatively the expanded CX functions. In the CX version you have X-Functions, X-Memory and Time-Module, but last without the real time clock feature.

Furthermore synthetic-programming is possible and loading additional rom-files of HP-41 plug in modules like Math-Module, CCD-Module, Zenrom, and so on. A Floppy Disk exist, containing most of the availlable HP-41 plug in modul rom-files. With help of Zenrom Module and HP-IL ↔ PC Interface Card you have tools for uploading HP-41 plug in modules from handheld to PC and EMU41 dispose of a software utility for installing the rom-files to EMU 41 emulator !

Presently Jean-Francois Garnier works on the implementation of HP-IL commands, for realizing data exchange between HP-41 handheld and PC emulation. A solution for this is using the PC Floppy Drive and the LIF-File format compatible to the IL-Disk Drive. A other solution is using the HP-IL ↔ PC Interface Card for adapting extern IL Devices !

CHAPTER XVI
I/O-BOARD APPLICATION

AUDIO FREQUENCY RESPONSE MEASUREMENT

Introduction	**XVI.01**
Software Function Sets	**XVI.01**
Hardware Sine-Wave-Generator	**XVI.03**
Hardware RMS-Voltage Converter	**XVI.07**
Working with different IL-Devices	**XVI.10**
Working with CCD-Module Matrix Functions	**XVI.10**
Frequency Response Measurement Main Program	**XVI.10**
Controlsoftware Sine-Wave-Generator	**XVI.15**
Controlsoftware RMS-Voltage Converter	**XVI.17**

AUDIO FREQUENCY RESPONSE MEASUREMENT

Store Measurement Data in X-Memory Matrix	XVI.18
Store Measurement Data with Cass-Drive	XVI.20
Measurement Data Output by HP-41 Display	XVI.23
Plotting Frequency Response with HP 7470A Plotter	XVI.25
Printing Measurement Data with Thermal-Printer	XVI.28
Uploading Measurement Data to PC	XVI.31
Mathematic Function Set Software	XVI.33
Smoothing Frequency Response for Acoustic Measurement	XVI.35
Contents of Main Memory Data Register	XVI.39
Example for Measurement	XVI.45

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Introduction :

Up to now I/O-Board manual describes some basic hardware modules and software tools for general applications. You will need them for realizing your own work with HP-41 and I/O-Board. This chapter presents a special I/O-Board application to give an example about flexibility and performance of HP-41 system : Audio Frequency Response Measurement. By using special digital and analog IC's we expand existing I/O-Board plug in module family by two strong hardware modules, a Sine-Wave-Generator and a RMS Voltage Converter.

For the developement of the belonging HP-41 control software we use the curve fitting routines from AEC-Rom. This improves system accuray by software. Furthermore this application is an example for working with some different IL-Devices (including HP7470-Plotter) and for advanced data processing with help of Matrix-Files (CCD-Modul). The following command lists will give you an impression about amazing power of this I/O-Board application :

Basic Function Set :

FGEN	Controls Sine-Wave-Generator Module. Enter frequency value in X-Register and execute FGEN. Frequency ranges from 5Hz to 60KHz. 1Hz stepwide. Resolution 0.5 Hz.
FRMS	Reads AC-Voltages by RMS Voltage Converter Module and 12 bit ADC. Voltage level (dB) in X-Register. Ranges from -80dB to +20dB. 0dB=1V.
FMESS	Frequency response measurement. Clear Flag00 for LOG increment, set Flag00 for LIN increment.
FM	Subroutine for executing frequency response measurement under main program control.
FMAN	Manual input of frequency response data by HP-41 keyboard.
FP	Subroutin for measurement parameter input : Titel text and comment text, start-stop-delta frequency.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Output Function Set :

FDISP	Output of measurement data by HP-41 display
FPRINT	Print measurement data by IL-Thermal-Printer
FPLOT	Plot frequency response by HP 7470A IL-Plotter.

Data Storage Function Set :

FSTOPC	Transfer data to PC. Works with HP-IL↔PC Interface card and Link Plus software.
FSTOM	Store data in X-Memory Matrix-File. Filename in Alpha-Register.
FRCLM	Recall data from X-Memory Matrix-File. Filename in Alpha-Register.
FSTOC	Store data by IL-Cass-Drive. Filename in Alpha-Register.
FRCLC	Recall data from IL-Cass-Drive. Filename in Alpha-Register.

Mathematic Function Set :

FVOLT	Calculates voltage from level value in X-Register and reference-voltage in R20.
FMAX	Find max voltage level (X-Register) and calculates belonging frequency value (Y-Register).
FMOVE	Find max level of frequency data and move it to dB-value in X-Register. Updates reference voltage in R20.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

FSHIFT Shift frequency data level by dB-value in X-Reg. Updates reference voltage in R20.

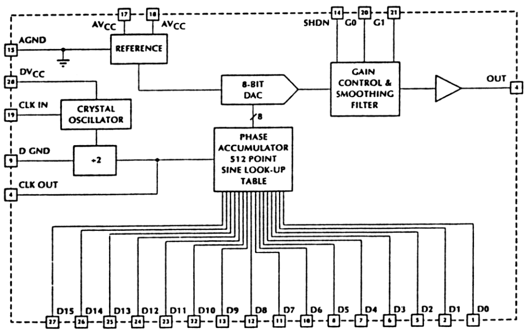
FINV Calculates invers frequency response. Helpful for compensation frequency response of nonlinear measurement equipment (microphon).

FADD Add frequency data file (name in Alpha-Register) to FDATA Matrix-File. Helpful for compensation or for filtering by software.

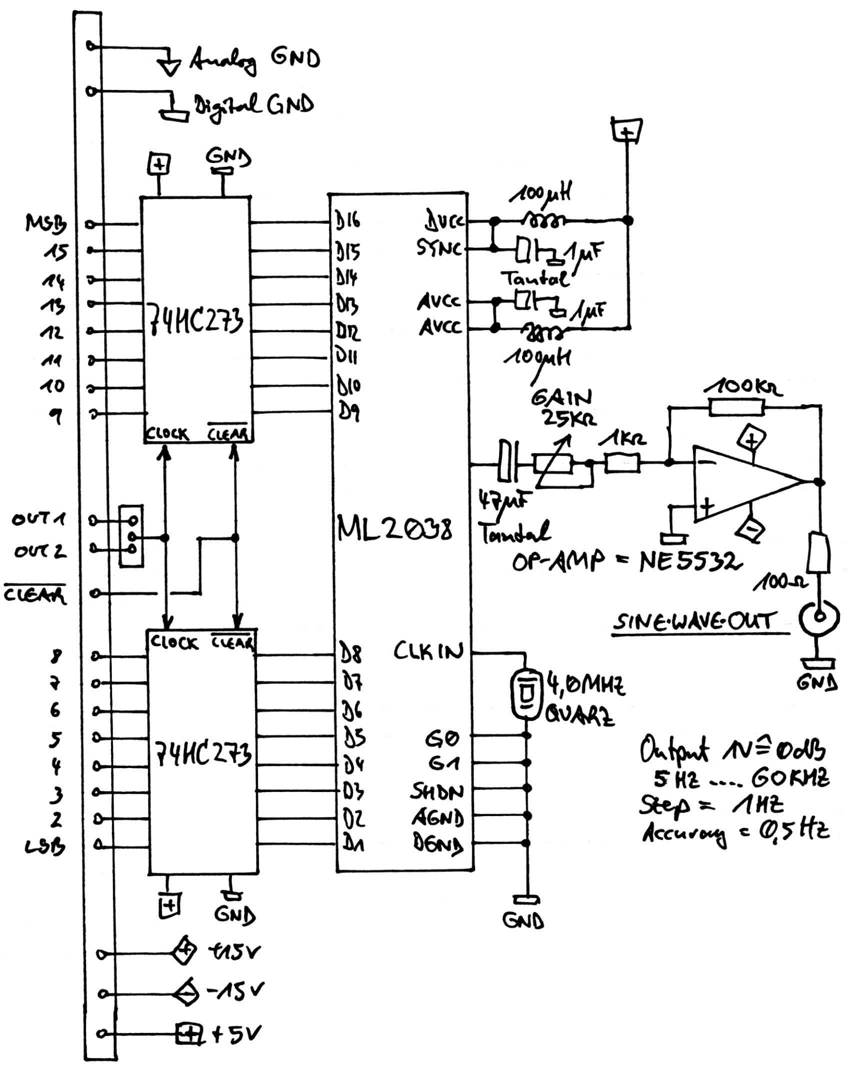
FMEAN Program solution for acoustical measurement. Smoothes resonance peaks and dips of frequency response by mean value calculation. Works with the basic funktions FP and FM as subroutines.

Hardware Sine-Wave-Generator :

For audio frequency measurement we need a Sine-Wave Generator. Using the Micro Linear µL ML 2038 generator chip (distributet by Ineltek/Hamburg), controlled by a parallel 16 bit word, we have minimal hardware expense. ML 2038 works with intern sine wave lookup table stored in rom, followed by 8 bit DAC and outputfilter Op-Amp. With extern 4.0 MHZ quarz oszillator for ML 2038 and special HP-41 software we reach a resolution lower 0,5Hz, and 1Hz stepwide. Frequency ranges from 5Hz to 60kHz. THD lower 1% is adequate for basic audio measurement. We add an OP-Amp for setting voltage level, DC-coupling and buffering output.



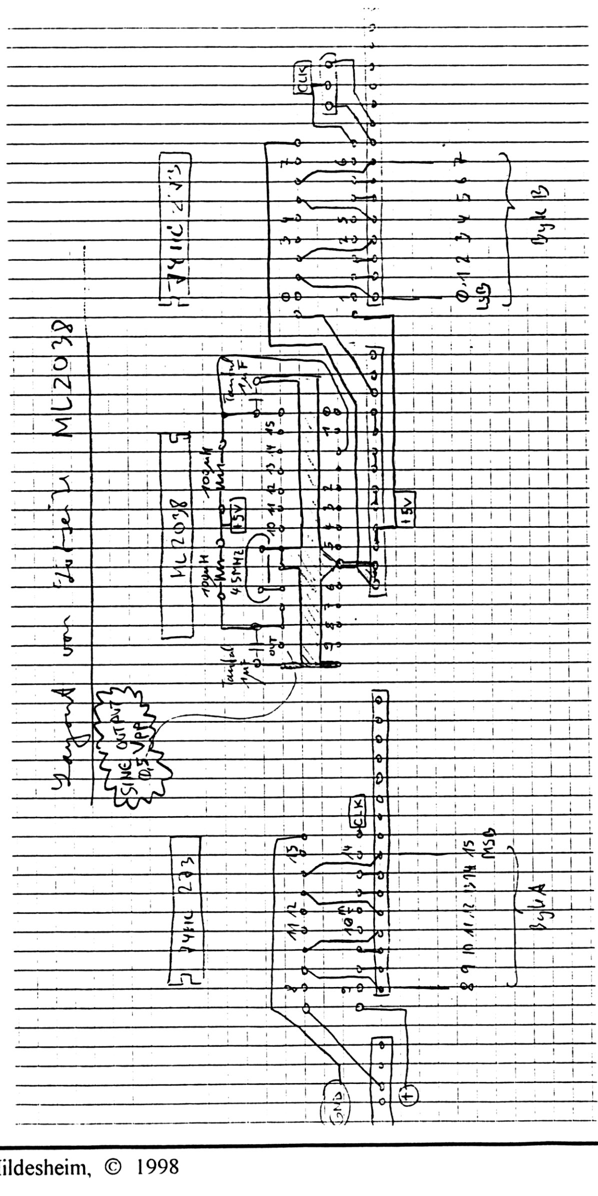
HP 82166 A 16 BIT INPUT / OUTPUT BOARD



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Sine-Wave-Generator :

Presently only wired board prototype sample exist. Layout under development !



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

16 Bit Control Number Sine-Wave-Generator:

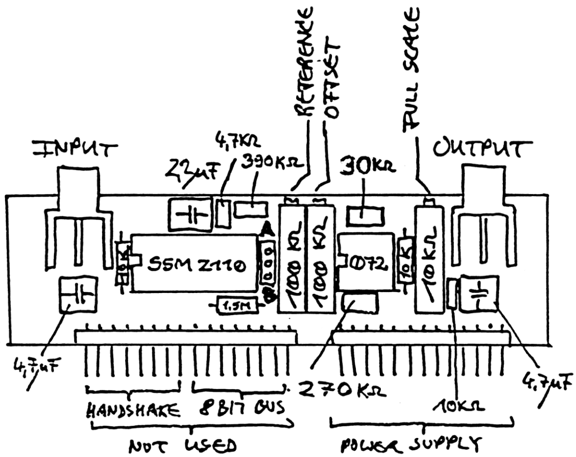
Generator Frequency	16 Bit Number	X-Register	Calculation
4,8 Hz 8,6 Hz	5 9	5 9	+ 0
10,5 29,6 Hz	11 31	10 30	+ 1
31,5 50,6	33 53	31 51	+ 2
52,4 Hz 71,5 Hz	55 75	52 72	+3
73,4 Hz 92,5 Hz	77 97	73 93	+ 4
94,4 Hz 113,5 Hz	99 119	94 114	+ 5
115,4 Hz 1000 Hz 9000 Hz	121 1049 9437	115 1000 9000	Parabola **$Y = a + bX + cX^2$** a = 0,127496354 b = 1,04851542 c = 3,566577679 x 10^{-9}
10 000 Hz 20 000 60 000	10 486 20 971 62 914	10 000 20 000 60 000	x 1,0486

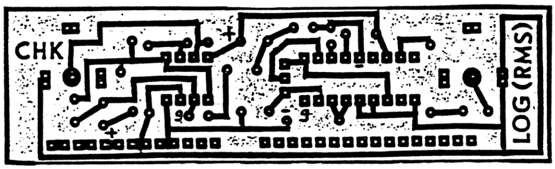
Software calculates from frequency value in X-Register 16 Bit number controlling Sine-Wave-Generator. Calculation in eight frequency zones. Reference measurement done with Rhode&Schwarz Audio-Analyzer UPA3. Curve fitting by HP-41 AEC-Rom.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Hardware RMS-DC Voltage Converter :

For measuring audio AC voltage levels we add the SSM 2110 RMS to DC converter chip from Analog Devices as frontend to the existing 12 Bit ADC. Doing this we create an audio millivoltmeter measurement system. The SSM 2110 have an intern LOG-Converter, input voltage level ranges from -80dB to +20dB (0.1mV to 10V). Additional Op-Amp expands SSM 2110 DC outputvoltage to ± 10V for 12 Bit ADC. With special HP-41 software typical resolution is better 0,5dB.

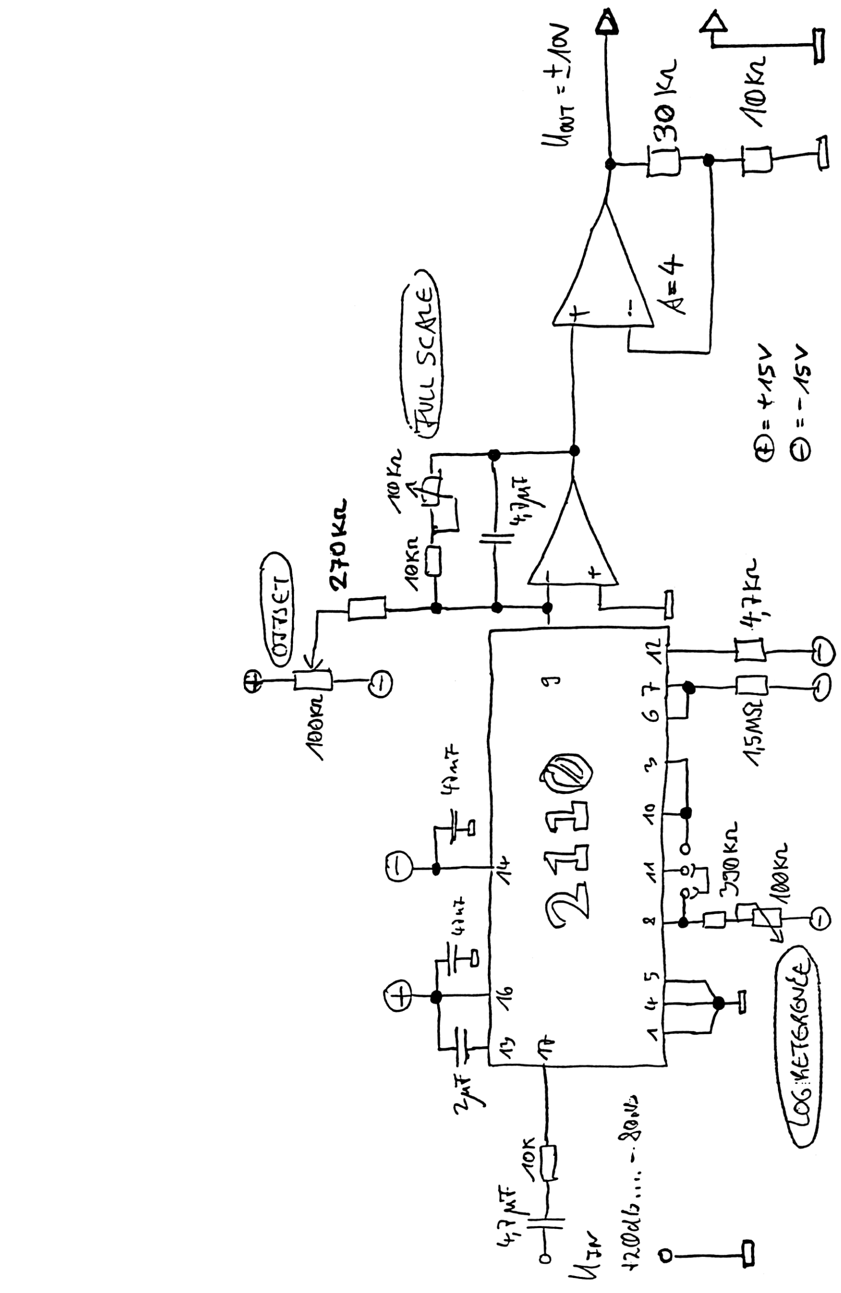




Trimming RMS-DC Voltage Converter :

DC output voltage of SSM 2110 is amplified by OP-Amp to ± 10V range. Trimming output voltage for following 12 Bit ADC, set Jumper to position A (upper position). Adjust output voltage to +2V by Offset-Trim. Now set Jumper to position B (lower position). Supply input terminal of modul with 100mV/1KHz singal from reference sine-wave-generator. Adjust output voltage to +2V by Reference-Trim. Last supply input terminal with 10V/1KHz signal. Adjust output voltage to +10V by Scale-Trim.

HP 82166 A 16 BIT INPUT / OUTPUT BOARD



HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Voltage Level Calculation RMS-DC Voltage Converter :

Input Level (dB)	X 12 Bit Number	Y Input Level + 80	Calculated value (dB)	Error (dB)
-79	2	1	-79	0
-75	194	5	-75,6	0,6
-70	409	10	-70,3	0,3
-65	625	15	-65	0
-60	838	20	-59,8	0,2
-55	1046	25	-54,7	0,3
-50	1249	30	-49,7	0,3
-45	1451	35	-44,7	0,3
-40	1652	40	-39,8	0,2
-35	1852	45	-34,8	0,2
-30	2053	50	-29,9	0,1
-25	2253	55	-25	0
-20	2453	60	-20,1	0,1
-15	2654	65	-15,1	0,1
-10	2857	70	-10,1	0,1
-5	3059	75	-5,2	0,2
0	3262	80	-0,2	0,2
+5	3467	85	+4,9	0,1
+10	3672	90	+9,9	0,1
+15	3880	95	+15	0
+20	4089	100	20,2	0,2

$Y = a + bX + c/X$

a = -3,949630894 / 10
b = 2,459247821 / 100
c = 2,703236445

Software inputs 12 Bit number and calculates voltage level by LIN HYP funktion. Reference measurement done with Rhode&Schwarz Audio-Analyzer UPA3. Curve fitting by HP-41 AEC-Rom.

Working with different IL-Devices :

Software pack for audio frequency measurement is an example for working with HP-41 and some IL-Devices. We use I/O-Board (HP 82166A IL-Converter) for measure data, HP 82161 Cass-Drive for data storage and HP 82162 Thermal-Printer or HP 7470A Plotter for data output. Or HP-IL↔PC Interface card for uploading data to PC. Addressing of IL-Devices is done by their identity numbers (Alpha-Register, FINDID). Beause Cass-Drive and Thermal-Printer have no ID numbers we address them by their Accessory Identity numbers 16 and 32 (X-Register, FINDAID).

Working with CCD-Module Matrix-Functions :

Measurement parameter are stored in Main-Memory data register block, describing frequency range and increment, titel text and comment text, time and date. Measurement data (voltage levels) are stored in FDATA Matrix-File in X-Memory. This make possible a great number of measured data and using the fast mathematic Matrix Functions of CCD-Module (for example find a maximum). FDATA is the working Matrix-File for complete data proccessing with same central funktion like the X-Register.

Also we use X-Memory for storing complete sets of measurement data. Alternatively we can store complete data sets on Cass-Drive. Storing data is realized by interpreting a Main-Memory register block as a Main-Memory matrix, adding the matrix header (synthetic textline) without canceling contents of register. This allows transfer between X-Memory Matrix-File, Main-Memory and Cass-Drive Data-File. Matrix size is not fixed, it depends on number of measured data points and changes dynamical for storage by Cass-Drive.

Frequency Measurement Main-Program :

Software Version 13:56 / 21.01.1998. PLNG = 430 Bytes = 62 Register. Set Flag 00 for LIN frequency increment. Clear Flag 00 for LOG frequency increment. Execute FMESS for measurement with I/O-Board or FMAN for manual data input. FM is label for working with other mainprogram solutions.

```
01 LBL "FMESS"     measurement by keyboard control
02 XEQ "FP"        measurement parameter input
03 XROM "$I/O"     addressing I/O-Board
```

```
04 LBL "FM"          measurement by own main program solution
05 LBL 01
06 RCL 27            recall actual frequency value
07 XEQ "FGEN"        set frequency of Sine-Wave-Generator
08 XEQ "F+"          frequency increment
09 XEQ "FRMS"        read voltage level from I/O-Board to X-Register
10 >C+               store data in FDATA Matrix-File
11 XEQ "F="          actual frequency ≤ stop frequency
12 X<=Y?
13 GTO 01
14 XEQ "F>"
15 RTN

16 LBL "FMAN"        manual input of frequency data with keyboard
17 XEQ "FP"
18 LBL 02
19 CLA
20 RCL 27            display message
21 FIX 0
22 RND
23 ARCL X
24 "⊦_HZ_dB=?"
25 PROMPT
26 >C+               store data in Matrix-File
27 XEQ "F+"          frequency increment
28 XEQ "F="          actual frequency ≤ stop frequency
29 X<=Y?
30 GTO 02
31 XEQ "F>"
32 RTN

33 LBL "FP"          subroutin for entering measurement parameter
34 "TITEL TEXT ?"
35 AON               titel text
36 PROMPT
37 AOFF
38 ASTO 12
39 ASHF
40 ASTO 13
41 ASHF
```

```
42  ASTO 14
43  ASHF
44  ASTO 15
45  "COMM TEXT ?"   comment text
46  AON
47  PROMPT
48  AOFF
49  ASTO 16
50  ASHF
51  ASTO 17
52  ASHF
53  ASTO 18
54  ASHF
55  ASTO 19
56  1               0 dB reference voltage
57  STO 20
58  TIME            measurement time
59  STO 21
60  DATE            measurement date
61  STO 22
62  "START FREQ ?"  start frequency
63  PROMPT
64  STO 23
65  "STOP FREQ ?"   stop frequency
66  PROMPT
67  STO 24
68  "DELTA FREQ ?"  frequency increment value
69  PROMPT
70  STO 25
71  RCL 23
72  STO 27
73  FC? 00
74  XEQ 20
75  FS? 00
76  XEQ 30
77  RCL 26          creates FDATA Matrix-File
78  1,001
79  +
80  "FDATA"
81  MDIM
```

```
82  1,001
83  IJ=A
84  RTN

85  LBL 20          calculates exactly stop frequency for
86  RCL 24          LOG frequency increment
87  LOG
88  RCL 23
89  LOG
90  -
91  RCL 25
92  LOG
93  /
94  FIX 0
95  RND
96  STO 26
97  RCL 25
98  LOG
99  *
100 RCL 23
101 LOG
102 +
103 10^X
104 STO 24
105 RTN

106 LBL 30          calculates exactly stop frequency for
107 RCL 24          LIN frequency increment
108 RCL 23
109 -
110 RCL 25
111 /
112 FIX 0
113 RND
114 STO 26
115 RCL 25
116 *
117 RCL 23
118 +
119 STO 24
```

```
120 RTN

121 LBL "F<"        set Flag 00 dependent of contens of R027
122 "LOG"
123 ASTO X
124 RCL 27
125 X=Y?
126 CF 00
127 "LIN"
128 ASTO X
129 RCL 27
130 X=Y?
131 SF 00
132 CLA
133 CLX
134 RTN

135 LBL "F>"        store LIN/LOG in 027 dependent of Flag 00
136 FC? 00
137 "LOG"
138 FS? 00
139 "LIN"
140 ASTO 27
141 FIX 4           default state
142 CLA
143 CLX
144 AUTOIO
145 RTN

146 LBL F+          frequency increment
147 RCL 25
148 FC? 00          LOG increment
149 ST* 27
150 FS? 00          LIN increment
151 ST+ 27
152 RTN

153 LBL F=          recall stop frequency and actual frequency
154 FIX 0
155 RCL 24
```

```
156 RND
157 RCL 27
158 RND
159 RTN

160 LBL Fa          ARCL 12 ... ARCL 15
161 CLA
162 ARCL 12
163 ARCL 13
164 ARCL 14
165 ARCL 15
166 RTN

167 LBL Fb          ARCL 16 ... ARCL 19
168 CLA
169 ARCL 16
170 ARCL 17
171 ARCL 18
172 ARCL 19
173 END
```

Controlsoftware Sine-Wave-Generator Module :

Software Version 13:57 / 13.01.1998. PLNG = 145 Bytes = 21 Register. Input is frequency value in X-Register. Program calculates 16 bit controll number for Sine-Wave-Generator Module in 8 different frequency zones.

```
01 LBL "FGEN"       frequency value in X-Register
02 FIX 0
03 RND
04 10000
05 X<>Y
06 X<Y?
07 GTO 00
08 1,0486           10 000 Hz ...60 000 Hz
09 *
10 GTO 06
```

```
11  LBL 00
12  115
13  X<>Y
14  X<Y?
15  GTO 01
16  ENTER^              115 Hz ... 10 000 Hz
17  X^2
18  3,566577679
19  *
20  1 E-9
21  *
22  X<>Y
23  1,048515420
24  *
25  +
26  ,127496354
27  +
28  GTO 06

29  LBL 01
30  94
31  X<>Y
32  X<Y?

33  GTO 02
34  5                   94 Hz ... 115 Hz
35  +
36  GTO 06

37  LBL 02
38  73
39  X<>Y
40  X<Y?
41  GTO 03
42  4                   73 Hz ... 94 Hz
43  +
44  GTO 06

45  LBL 03
46  52
```

```
47 X<>Y
48 X<Y?
49 GTO 04
50 3                52 Hz ... 73 Hz
51 +
52 GTO 06

53 LBL 04
54 31
55 X<>Y
56 X<Y?
57 GTO 05
58 2                31 Hz ... 52 Hz
59 +
60 GTO 06

61 LBL 05
62 10
63 X<>Y
64 X<Y?
65 GTO 06
66 1                10 Hz ... 31 Hz
67 +

68 LBL 06           5 Hz ... 10 Hz
69 RND
70 FIX 4            16 bit control number in X-Register
71 XROM "$OUT1X" data output to I/O-Board sine wave generator module
72 END
```

Controlsoftware RMS Voltage Converter & 12 Bit ADC :

Software Version 13:58 / 13.01.1998. PLNG = 70 Bytes = 10 Register. Software for RMS voltage converter and 12 bit ADC. Read 12 bit number from I/O-Board and calculates voltage level from -80dB ...+20dB. Uses curve fitting.

```
01 LBL "FRMS"
02 XROM "$IN1X"    12 bit data input from I/O-Board
03 ENTER^
```

```
04 ENTER^
05 1/X
06 2,703236445
07 *
08 X<>Y
09 2,459247821
10 *
11 100
12 /
13 +
14 3,949630894
15 10
16 /
17 -
18 80
19 -
20 FIX 1
21 RND
22 FIX 4                    - 80 dB ... + 20 dB voltage level in X-Register
23 END
```

Store Measurement Data in X-Memory Matrix-File :

Software Version 13:58 30.01.1998. PLNG = 192 Bytes = 28 register. Store measurement parameter and measurement data in X-Memory Matrix-Files. Input file name in Alpha (maximal six letters) and exectue FSTOM or FRCLM. Storage of measurement data and parameter in two X-Memory Matrix-Files is helpful for realizing math function set.

Attention : MOVE = XROM 09.32 of CCD-Module.

```
01 LBL "FSTOM"      store measurement data / parameter into Matrix-File
02 ASTO 10
03 "FDATA"
04 DIM
05 STO09
06 CLA
07 ARCL 10          create data matrix
08 MDIM
```

```
09 "├ +"
10 16,001
11 MDIM                        create parameter matrix
12 "237 000 001 000 000 016"        synthetic matrix header ="R011"
13 ASTO 11                                                  16,001
14 "R001,"                                                  MDIM
15 ARCL 10
16 "├ +"
17 1,001
18 16,001
19 1,001
20 MOVE                        copy measurement parameter into new matrix
21 "FDATA,"
22 ARCL 10
23 1,001
24 RCL 09
25 1,001
26 MOVE                        copy measurement data into new matrix
27 CLA
28 CLX
29 RTN

30 LBL „FRCLM“                 recall measurement data / parameter from Matrix File
31 ASTO 10
32 DIM
33 STO 09
34 "FDATA"                     resize FDATA Matrix-File
35 MDIM
36 "237 000 001 000 000 016"        synthetic matrix header ="R011"
37 ASTO 11                                                  16,001
38 CLA                                                      MDIM
39 ARCL 10
40 "├ +,R001"
41 1,001
42 16,001
43 1,001
44 MOVE                        copy measurement parameter in main memory
45 CLA
46 ARCL 10
47 "├ ,FDATA"
```

```
48 1,001
49 RCL 09
50 1,001
51 MOVE                    copy measurement data into FDATA Matrix-File
52 CLA
53 CLX
54 END
```

Store Measurement Data with Cass-Drive :

Software Version 13:59 / 13.01.1998. PLNG = 301 Bytes = 43 Register. Store measurement parameter and measurement data in Cass-Drive Data-File. Enter file name in Alpha and execute FSTOC or FRCLC.

Attention : MOVE = XROM 09.32 of CCD-Module

```
01 LBL "FSTOC"
02 XEQ 20
03 XEQ 30
04 XEQ 40
05 RCL 00
06 8
07 *
08 16                    create Data-File on Cass-Drive
09 +
10 CREATE
11 "231 000 001 000 000 008"    synthetic matrix header =    "R003"
12 ASTO 03                                                   8,001
13 1,001                                                     MDIM
14 STO 00                counter
15 XEQ 40
16 0
17 SEEKR                 set Data-File pointer
18 12,027
19 WRTRX                 write measurement parameter to Cass-Drive
20 LBL 01
21 "FDATA,R003"          copy data from FDATA Matrix in
22 1,001                 main memory register block
23 RCL 00
```

```
24 7
25 +
26 RCL 00
27 SF 25                  set Error Flag
28 MOVE
29 FC? 25
30 GTO 50                 end of Matrix-File
31 XEQ 40
32 RCL 00
33 14,999
34 +
35 SEEKR                  set Data-File pointer
36 4,011
37 WRTRX                  store register block to Cass-Drive
38 8
39 ST+ 00                 increase counter
40 GTO 01
41 RTN

42 LBL "FRCLC"
43 XEQ 20
44 XEQ 40
45 0
46 SEEKR                  set Data-File pointer
47 12,027
48 READRX                 read measurement parameter
49 XEQ 30
50 "231 000 001 000 000 008"       synthetic matrix header
51 ASTO 03
52 1,001
53 STO 00                 counter
54 LBL 02
55 XEQ 40
56 RCL 00
57 14,999
58 +
59 SEEKR                  set Data-File pointer
60 4,011
61 SF 25                  set Error Flag
62 READRX                 read data block
```

```
 63 FC? 25          end of Data-File
 64 GTO 50
 65 "R003,FDATA"
 66 RCL 00
 67 8,001
 68 1,001
 69 MOVE            write data block to FDATA Matrix-File
 70 8
 71 ST+ 00          increase counter
 72 GTO 02
 73 RTN

 74 LBL 20
 75 ASTO 01
 76 ASHF
 77 ASTO 02         store Data-File name in R001 + R002
 78 16
 79 FINDAID
 80 SELECT          select Cass-Drive
 81 MANIO
 82 RTN

 83 LBL 30          calculates number of blocks transfered from
 84 RCL 26          FDATA Matrix-File to Main-Memory to Cass-Drive
 85 1
 86 +
 87 8
 88 /
 89 ENTER^
 90 INT
 91 STO 00
 92 RDN             creates FDATA Matrix-File depending on number
 93 FRC             of blocks or resize existing Matrix-File
 94 X=0?
 95 GTO 03
 96 1
 97 ST+ 00
 98 LBL 03
 99 RCL 00
100 8
```

```
101  *
102  0,001
103  +
104  "FDATA"
105  MDIM
106  RTN

107  LBL 40            recall Data-File name to Alpha-Register
108  CLA
109  ARCL 01
110  ARCL 02
111  RTN

112  LBL 50
113  RCL 26
114  1,001
115  +
116  "FDATA"
117  MDIM              resize existing FDATA Matrix-File
118  CLA
119  CLX
120  AUTOIO            default state
121  END
```

Measurement Data Output by HP-41 Display :

Software Version 14:22 / 21.01.1998. PLNG = 117 Bytes = 17 Register. Output of measurement parameter and measurement values by HP-41 Display.

```
01  LBL "FDISP"       data output by HP-41 display
02  XEQ "F<"
03  "FDATA"
04  1,001
05  IJ=A
06  RCL 23
07  STO 27
08  XEQ "Fa"          ARCL 12 .... ARCL 15
09  PROMPT
10  XEQ "Fb"          ARCL 16 .... ARCL 19
11  PROMPT
```

```
12 FIX 3
13 "0dB="
14 ARCL 20
15 "├V"
16 PROMPT
17 FIX 2
18 CLA
19 RCL 21
20 ATIME
21 PROMPT
22 FIX 6
23 CLA
24 RCL 22
25 ADATE
26 PROMPT
..27 61 LBL 03
28 CLA            display message
29 RCL 27
30 FIX 0
31 RND
32 ARCL X
33 "├HZ_"
34 XEQ "F+"       frequency increment
35 C>+            read data from Matrix-File
36 X=0?           for positive value display plus
37 "├+"
38 X>0?
39 "├+"
40 FIX 1
41 ARCL X
42 PROMPT         display frequency and voltage level
43 XEQ "F="       actual frequency ≤ stop frequency
44 X<=Y?
45 GTO 03
46 XEQ "F>"
47 END
```

Plotting Audio Frequency Response with HP7470A Plotter :

Software Version 13:59 / 21.01.1998. PLNG = 331 Bytes = 48 Register. Plot frequency response on prepared paper (grid exist, IL-Plotter adds header text and frequency response). During software development graphic area for frequency response plot was defined by using digitalisation function of Plotter-Rom : LOCATD load grid position into stack. Inserting prepared paper exactly into plotter is assumed for high accuray for position of response plot. X and Y values for plot are generated by subroutines FX and FY : FX calculates the logarithmic frequency scale and FY read data from Matrix-File. FPLOT is an example for working with prepared paper and for controlling IL-Plotter completely by main program !

Attention : MOVE = XROM 17.21 of Plotter-Rom.

```
01 LBL "FPLOT"
02 "HP7470A"
03 FINDID
04 SELECT          select plotter
05 MANIO
06 PINIT           initialise plotter and buffer
07 XEQ "F<"
08 11,5556
09 70,5649
10 MOVE            penposition titel text
11 5
12 LORG            centric text
13 0
14 1
15 10
16 CSIZE           letter size titel text
17 180
18 LDIR            text direction on paper
19 XEQ "Fa"        ARCL 12 .... ARCL 15
20 LABEL           plot titel text
21 0
22 1
23 7
24 CSIZE           letter size coment text
25 21
26 70,5649
```

27 MOVE	pen position comment text
28 XEQ "Fb"	ARCL 16 .... ARCL 19
29 LABEL	plot comment text
30 FIX 3	
31 "0dB_=_"	
32 ARCL 20	
33 "├_V"	
34 LABEL	plott reference voltage
35 0	
36 1	
37 5	
38 CSIZE	letter size time - date
39 CLA	
40 FIX 2	
41 RCL 21	
42 ATIME	
43 "├__"	
44 FIX 6	
45 RCL 22	
46 ADATE	
47 LABEL	plot time - date
48 FIX 4	
49 131,0472	
50 0,9722	
51 82,8611	
52 42,9583	
53 LOCATE	define graphic area on paper for frequency
54 0	response plot
55 235,1	
56 -40	
57 10	
58 SCALE	define plot scala for frequency axis and level axis
59 0	
60 STO 00	X-Min
61 235,1	
62 STO 01	X-Max
63 7911	
64 STO 02	O-Symbol, draw line, left pen
65 -40	
66 STO 04	Y-Min

```
 67  "FX"
 68  ASTO 05            subroutine FX for calculating X-Inc
 69  10
 70  STO 07             Y-Max
 71  "FY"
 72  ASTO 08            subroutine FY for recalling data from Matrix-File
 73  "FDATA"
 74  1,001
 75  IJ=A               set Matrix-File pointer
 76  0
 77  1
 78  1
 79  CSIZE              letter size O-Symbol
 80  RCL 23
 81  STO 27
 82  XROM "PLTUXY" plot routine
 83  RTN


 84  LBL "FX"           subroutine FX for calculating from frequency value
 85 XEQ "F="            X-axis position of logarithmic frequency axis
 86  X>Y?               actual frequency > stop frequency
 87  GTO 99
 88  XEQ "F+"           frequency increment
 89  RDN
 90  LN
 91  309,6990164
 92  *
 93  930,4061628
 94  -
 95  10
 96  /
 97  FIX 1
 98  RND
 99  FIX 4
100  RTN
```

```
101 LBL "FY"          subroutine FY for recalling Y data from Matrix-File
102 SF 25
103 C>+
104 FS? 25
105 RTN

106 LBL 99
107 0
108 PEN               leave pen
109 PCLBUF            remove plot buffer
110 XEQ "F>"
111 STOP
112 GTO "FPLOT"
113 END
```

Printing Measurement Data with Thermal Printer :

Software Version 14:00 / 21.01.1998. PLNG = 260 Bytes = 38 Register. Print measurement data with Thermal-Printer.

```
01 LBL "FPRINT"
02 32
03 FINDAID
04 SELECT             select Thermal-Printer
05 MANIO
06 59                 print CHK label
07 SKPCOL
08 SF 12
09 "247 017 255 190 057 055 110 255"
10 "├ 017 254 015 126 253 224 255"     synthetic text
11 "├ 017 254 015 124 114 110 255"
12 RCL O
13 ACSPEC
14 RCL N
15 ACSPEC
16 RCL M
17 ACSPEC
18 PRBUF
19 CF 12
```

```
20  CLX
21  CLA
22  PRL                 print line
23  XEQ "Fa"            ARCL 12 .... ARCL 15
24  PRA                 print titel text
25  XEQ "Fb"            ARCL 16 .... ARCL 19
26  PRA                 print comment text
27  FIX 3
28  "REFERENCE 0dB ="
29  22
30  RCL 20
31  ACAXY
32  "V"
33  ACA
34  PRBUF               print 0 dB reference voltage
35  CLA
36  FIX 2
37  RCL 21
38  ATIME
39  "├_________"        9 * space
40  FIX 6
41  RCL 22
42  ADATE
43  PRA                 print time - data
44  PRL                 print line
45  XEQ "F<"
46  RCL 23
47  STO 27
48  "FDATA"
49  1,001
50  IJ=A                select FDATA Matrix-File
51  LBL 01
52  CLA
53  FIX 0
54  10000               frequency < 10 000 Hz add 1 * space left
55  RCL 27
56  RND
57  X<Y?
58  "├_"
59  1000                frequency < 1000 Hz add 1 * space left
```

```
60 X<>Y
61 X<Y?
62 "├_"
63 100              frequency < 100 Hz add 1 * space left
64 X<>Y
65 X<Y?
66 "├_"
67 10               frequency < 10 Hz add 1 * space left
68 X<>Y
69 X<Y?
70 "├_"
71 ARCL X
72 "├_HZ"           store frequency text in Alpha-Register
73 FIX 1
74 21               text position of voltage level
75 C>+              recall data from Matrix-File
76 ACAXY            function of CCD-Module
77 "_dB"
78 ACA
79 PRBUF            print one text line
80 XEQ "F+"         frequency increment
81 XEQ "F="         actual frequency ≤ stop frequency
82 X<=Y?
83 GTO 01
84 XEQ "F>"

85 LBL "CF55"       clears printer Flag 55 (from CCD-Module manual)
86 14
87 PEEKB
88 0
89 Cb
90 POKEB
91 END
```

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Uploading Measurement Data to PC :

Software version 12:30 / 21.01.1998. PLNG = 178 Bytes = 26 Register. Uploading measurement data to PC. Needs HP-IL↔PC Interface Card (Interface Loop address #1 ... #6) and Link Plus software.

```
01 LBL "FSTOPC"
02 5
03 SELECT             select PC DOS datafile
04 MANIO
05 CF 17
06 XEQ "F<"
07 0
08 "FDATA"
09 IJ=A               set FDATA Matrix-File pointer
10 RCL 23
11 STO 27
12 CLA
13 FIX 2
14 RCL 21
15 ATIME
16 "├_ _"
17 FIX 6
18 RCL 22
19 ADATE
20 OUTA               transfer time - date
21 XEQ "Fa"           ARCL 12 .... ARCL 15
22 OUTA               transfer titel text
23 XEQ "Fb"           ARCL 16 .... ARCL 19
24 OUTA               transfer comm text
25 "0dB_REF_<V>"
26 OUTA
27 FIX 3
28 CLA
29 ARCL 20
30 OUTA               transfer reference voltage
31 FIX 0
32 "FREQU <HZ>"       frequency data header text
33 OUTA
34 LBL 01
```

```
35 RCL 27
36 RND
37 CLA
38 ARCL X
39 OUTA               transfer data to PCFILE
40 XEQ "F+"           frequency increment
41 XEQ "F="           actual frequency ≤ stop frequency
42 X<=Y?
43 GTO 01
44 "ENDE"             transfer ende text
45 OUTA
46 "LEVEL <dB>"       level data header text
47 OUTA
48 FIX 1
49 LBL 02
50 SF 25              set error flag
51 C>+
52 FC? 25
53 GTO 03             end of Matrix-File
54 CLA
55 ARCL X
56 OUTA               transfer data to PCFILE
57 GTO 02
58 LBL 03
59 "ENDE"             transfer ende text
60 OUTA
61 XEQ "F>"
62 1
63 SELECT             default state
64 CLX
65 END
```

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Mathematic Function Set :

Software version 14:25 / 26.01.1998. PLNG = 326 Bytes = 47 Register. Find maximal voltage level of FDATA-Matrixfile, move and shift frequency response data, calculates invers frequency response and add two responses for realizing compensation or filtering by software. Works with mathematic matrix functions of CCD-Module.

```
01 LBL "FVOLT"     calculate voltage (V) from level value in X-Register (dB).
02 20
03 /
04 10^X
05 RCL 20
06 *
07 RTN

08 LBL "FMAX"      find max voltage level in FDATA Matrix-File and
09 "FDATA"         calculates belonging frequency value.
10 1,001
11 IJ=A
12 MAX             CCD-Module
13 STO 00
14 ?IJ
15 INT
16 1
17 -
18 FC? 00
19 XEQ 10
20 FS? 00
21 XEQ 20
22 FIX 0
23 RND
24 FIX 4
25 STO 01
26 RCL 00
27 X<>Y            frequency in X-Register and level in Y-Register
28 CLA
29 RTN
```

```
LBL 10              Log frequency increment
RCL 25
LOG
*
RCL 23
LOG
+
10^X
RTN

LBL 20              LIN frequency increment
RCL 25
*
RCL 23
+
RTN

LBL "FMOVE"         move max level of FDATA Matrix-File to level value in
"FDATA"             X-Register.
1,001
IJ=A
X<>Y
MAX                 CCD-Module
-

LBL "FSHIFT"        shift data of FDATA file by value in X-Register.
"X,FDATA,FDATA"
M+
20
/
10^X
RCL 20              adapt reference voltage
X<>Y
/
STO 20
CLA
CLX
RTN
```

```
65 LBL "FINV"         calculates inverse frequency response of FDATA
66 "FDATA,X,FDATA"
67 -1
68 M*                 CCD-Module
69 CLA
70 CLX
71 RTN

72 LBL "FADD"               add Matrix-File (name in Alpha -Register maximal
73 "├,FDATA,FDATA"          six letters) to FDATA Matrix-File.
74 M+                       CCD-Module
75 CLA
76 CLX
77 END
```

Smoothing Frequency Response for Acoustic Measurement :

Software version 12:30 / 29.01.1998. PLNG = 316 Bytes = 46 Register. For smoothing frequency response for acoustic measurement (meaning small resonance peaks and dips), hardware of some sine-wave generators working with frequency modulation or have a wobbel funktion.

With help of CCD-Module matrix math functions we realize smoothing feature by software. FMEAN calculates for every center frequency mean voltage levels of seven measurement probes. Neighbouring frequency bands (7 probes) overlapping by three probes. This data reductions are helpful because HP-41 memory is limited. By entering DELTA value you choose measurement resolution : For terz-steps=1,2599 the frequency increment is ½ tone and for full-tone-steps=1,1225 the frequency increment is ¼ tone. This program is an example for working with subroutines for measurement parameter input by FP and for executing measurement under programcontrol by FM.

```
01 LBL "FMEAN"
02 CF 00              set LOG frequency increment
03 XEQ "FP"           subroutin for input of measurement parameter.
04 "R001"
05 3,001
06 MDIM               creates transfer matrix
07 "FDATA"
```

```
08 7,001
09 MDIM                 resize FDATA-Matrix-File. Working file for
10 "FS"                 calculating mean values
11 RCL 26
12 1,001
13 +
14 MDIM                 create FS Matrix-File for storage of terz values
15 23,004005
16 REGMOVE              stores measurement parameter in main memory
17 "FDATA"
18 5,001
19 IJ=A                 set FDATA Matrix-File pointer
20 RCL 04
21 RCL 06
22 SQRT
23 /
24 LASTX
25 SQRT
26 STO 25               frequency increment
27 /
28 STO 23               first start frequency
29 STO 27
30 RCL 04
31 RCL 25
32 /
33 STO 24               first stop frequency
34 2
35 STO 26               step number
36 1,001
37 STO 09               set FS Matrix-File pointer
38 XEQ "FM"             executes subroutin label of FMESS for measurement
39 6                                                              3 probes
40 STO 26
41 RCL 04
42 STO 08               actual frequency
43 LBL 77
44 "FDATA,R001"
45 1,001
46 7,001
47 5,001
```

48	MOVE	shift 3 probes in FDATA Matrix-File by transfer
49	"R001,FDATA"	to R001 Matrix-File
50	1,001	
51	3,001	
52	1,001	
53	MOVE	
54	"FDATA"	
55	4,001	
56	IJ=A	set FDATA Matrix-File pointer
57	RCL 08	
58	RCL 25	
59	*	
60	STO 23	actual start frequency
61	STO 27	
62	RCL 08	
63	RCL 06	
64	*	
65	RCL 25	
66	/	
67	STO 24	actual stop frequency
68	XEQ "FM"	executes subroutin label of FMESS for measurement
69	"FDATA"	4 probes
70	SUM	CCD-Module
71	7	
72	/	calculates mean voltage level of 7 probes
73	"FS"	
74	RCL 09	
75	IJ=A	set FS Matrix-File pointer
76	X<>Y	
77	>C+	store mean voltage level
78	1	
79	ST+ 09	increment FS Matrix-File pointer
80	RCL 06	
81	ST* 08	increment center frequency
82	FIX 0	
83	RCL 05	
84	RND	
85	RCL 08	
86	RND	
87	X<=Y?	actual frequency ≤ stop frequency

88	GTO 77	
89	4,023005	
90	REGMOVE	recall measurement parameter
91	"FDATA"	
92	RCL 26	
93	1,001	
94	+	
95	MDIM	resize FDATA Matrix-File
96	"FS,FDATA"	
97	1,001	
98	X<>Y	
99	1,001	
100	MOVE	copy data from FS in FDATA Matrix-File
101	"FS"	
102	PURFL	purge FS Matrix-File
103	RCL 23	
104	XEQ "FGEN"	set generator to start frequency (tweeter protection)
105	"LOG"	
106	ASTO 27	routine stops with compatible data format for using
107	CLA	existing function set for data storage, data output, or
108	CLX	mathematics (for example microfon frequency response
109	END	compensation).

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Contents of Data Register for FMESS, FM, FMAN, and FDISP, FPRINT, FSTOPC :

Register	Contents	
00		
01		
02		
03		
04		
05		
06		R00 ... R11 not used
07		
08		
09		
10		
11		
12	TITEL TEXT	
13		
14		
15		
16	COMM TEXT	Measurement Parameter
17		
18		
19		
20	0 dB Reference	
21	TIME	
22	DATE	
23	START	
24	STOP	
25	DELTA	
26	number of steps	
27	LIN-LOG-FREQU	

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Contents of Data Register for FSTOM and FRCLM :

Register	Contents	
00		
01		
02		
03		
04		R00 ... R08 not used
05		
06		
07		
08		
09	DIM	
10	NAME	
11	Matrix Header	
12		
13	TITEL TEXT	
14		
15		
16		
17	COMM TEXT	Measurement Parameter
18		
19		
20	0 dB Reference	
21	TIME	
22	DATE	
23	START	
24	STOP	
25	DELTA	
26	number of steps	
27	LIN-LOG-FREQU	

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Contents of Data Register for FSTOC and FRCLC :

00	Counter	
01	NAME	
02	NAME	
03	Matrix Header	
04		
05		
06		
07		R04 ... R11= Transfer Block
08		
09		
10		
11		
12		
13	TITEL TEXT	
14		
15		
16		
17	COMM TEXT	Measurement Parameter
18		
19		
20	0 dB Reference	
21	TIME	
22	DATE	
23	START	
24	STOP	
25	DELTA	
26	number of steps	
27	LIN-LOG-FREQU	

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Contents of CASS-DRIVE Data-File :

00		
01		
02		
03		
04		
05		
		Measurement Parameter
12		
13		
14		
15		
16		
17		
18		
19		
20		Block 1
21		
22		
23		
24		
25		
26		
27		Block 2

HP 82166 A 16 BIT INPUT / OUTPUT BOARD

Contents of Data Register for FPLOT :

Register	Contents	Remark
00	X-MIN	
01	X-MAX	
02	PARAMETER	
03		
04	Y-MIN	
05	X-LABEL	
06		R00...R11 used by Plotter Rom
07	Y-MAX	
08	Y-LABEL	
09		
10		
11		
12		
13	TITEL TEXT	
14		
15		
16		
17	COMM TEXT	Measurement Parameter
18		
19		
20	0 dB Reference	
21	TIME	
22	DATE	
23	START	
24	STOP	
25	DELTA	
26	number of steps	
27	LIN-LOG-FREQU	

Contents of Data Register for FMEAN :

00	Matrix Header	
01	1	
02	2	transfer matrix
03	3	
04	START	
05	STOP	measurement parameter
06	DELTA	block for main program
07	STEPS	
08	FREQU	
09	FS Matrix Pointer	
10		not used
11		not used
12		
13	TITEL TEXT	
14		
15		
16		
17	COMM TEXT	Measurement Parameter
18		
19		
20	0 dB Reference	
21	TIME	
22	DATE	
23	START	
24	STOP	changed for executing
25	DELTA	FM subroutine
26	number of steps	
27	LOG-FREQU	

Example for Frequency Response Measurement :

End of Chapter XVI gives you an practical example for frequency response measurement. Test object is an active OP-Amp filter circuit, a 6 KHz Tschebyscheff Low Pass Filter (Slope = 24 dB/Octave, Rippel = 0,5 dB).

For HP-41 configuration we need IL-Module, I/O-Module, X-Memory and CCD-Module. For working with IL-Plotter we need the HP-41 Plotter-Rom. Complete software of Chapter XVI works with SIZE 028. Depending on available IL-Devices we load belonging software of Chapter XVI into HP-41 Main-Memory.

Sine-Wave-Generator is pluged in I/O-Board and addressed by Jumper to $OUT1. Output terminal of generator is wired to input of Tscheby-Filter. RMS-Converter and 12 Bit ADC inserted in I/O-Board and last is addressed by Jumper to $IN1. Output of Tscheby-Filter is wired to input terminal of RMS-Converter, output of RMS-Converter is wired to input terminal of 12 Bit ADC.

We start measurement with initialising I/O-Board by $CHK. For LOG frequency increment we clear Flag 00 (default for acoustic measurement). After executing FMESS follows Alpha text input for titel and comment, than we enter start-frequency = 100Hz, stop-frequency = 16000HZ and for delta = 1,1225 (full tone increment). Program set generator frequencys and reads 45 measurement probes (voltage levels) in FDATA Matrix-File.

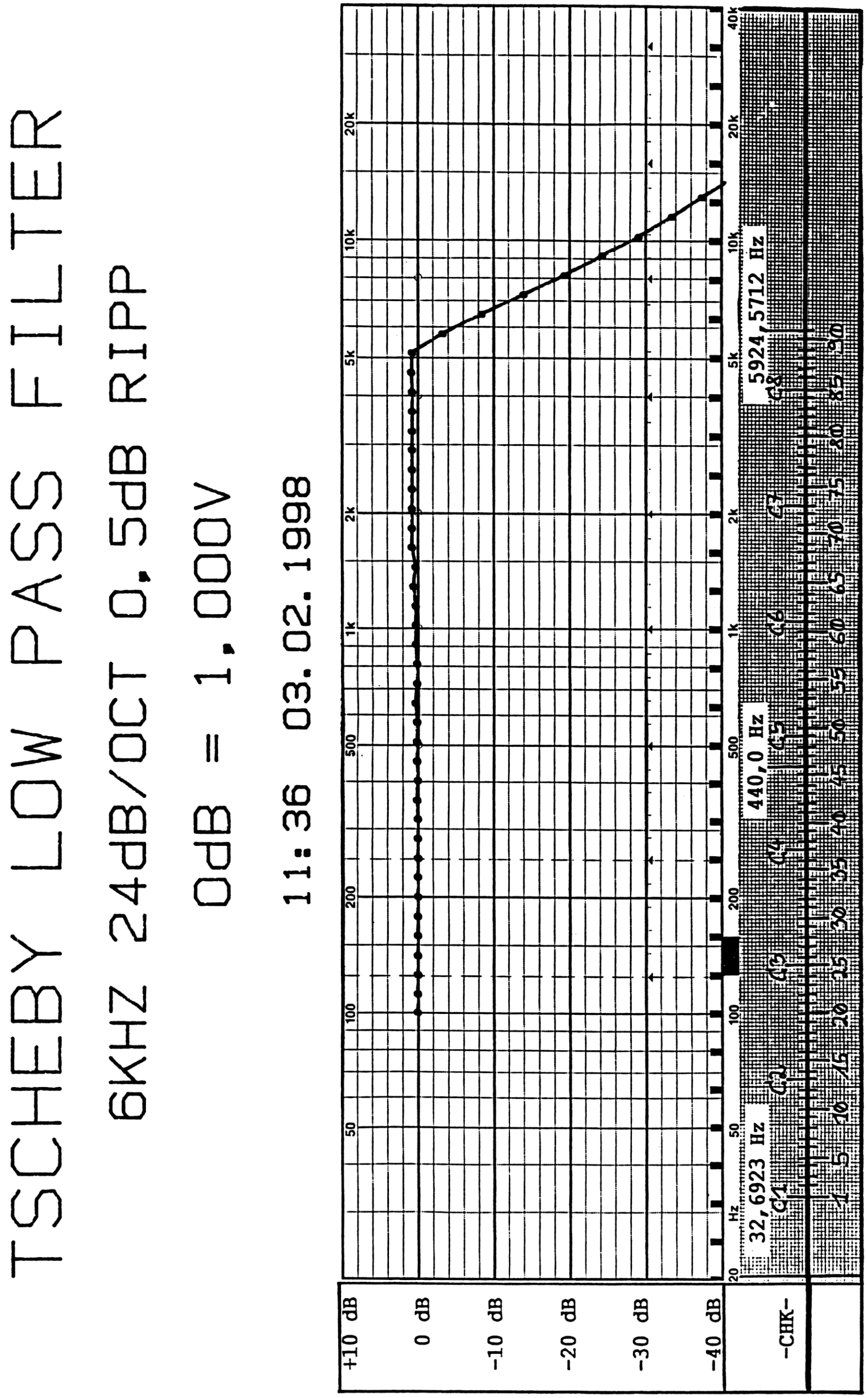
For post processing we output data by HP 7470A IL-Plotter, Thermal-Printer and transfer them to PC in a DOS-File. The following three pages presents you this results. Furthermore storage in X-Memory and by Cass-Drive or working with math functions is possible.

Attention :

Do not drive low impedance loads (like loudspeakers) directly by Sine-Wave-Generator output terminal. Worke with power amp !

Do not feed high voltages to input of RMS-Converter. Maximal AC voltage level is +20dB = 10V. In case of high levels protect the input by working with additional resistance networks !

Example→ Tscheby Low Pass Filter FPLOT



Example→ Tscheby Low Pass Filter FPRINT

CHK

TSCHEBY LOW PASS FILTER
6KHZ 24dB/OCT 0,5dB RIPP
REFERENCE 0dB = 1,000V
11:36 03.02.1998

----

100 HZ	-0,1 dB
112 HZ	-0,1 dB
126 HZ	-0,1 dB
141 HZ	-0,1 dB
159 HZ	-0,1 dB
178 HZ	-0,1 dB
200 HZ	-0,1 dB
225 HZ	-0,1 dB
252 HZ	-0,1 dB
283 HZ	-0,1 dB
318 HZ	-0,1 dB
356 HZ	0,0 dB
400 HZ	-0,1 dB
449 HZ	0,0 dB
504 HZ	0,0 dB
566 HZ	0,0 dB
635 HZ	0,2 dB
713 HZ	0,0 dB
800 HZ	0,0 dB
899 HZ	0,2 dB
1009 HZ	0,2 dB
1132 HZ	0,2 dB
1271 HZ	0,5 dB
1427 HZ	0,2 dB
1601 HZ	0,7 dB
1797 HZ	0,7 dB
2018 HZ	0,7 dB
2265 HZ	0,7 dB
2542 HZ	0,7 dB
2854 HZ	0,7 dB
3203 HZ	0,7 dB
3596 HZ	0,7 dB
4036 HZ	0,7 dB
4531 HZ	0,8 dB
5086 HZ	0,7 dB
5709 HZ	-3,3 dB
6408 HZ	-8,4 dB
7193 HZ	-13,9 dB
8074 HZ	-19,2 dB
9063 HZ	-24,1 dB
10173 HZ	-28,8 dB
11419 HZ	-33,2 dB
12818 HZ	-37,1 dB
14388 HZ	-41,2 dB
16151 HZ	-45,0 dB

Example→ Tscheby Low Pass Filter FSTOPC

11:36 03.02.1998
TSCHEBY LOW PASS FILTER
6KHZ 24dB/OCT 0,5dB RIPP
0dB REF <V>
1,000

FREQU <HZ>	LEVEL <dB>
100	-0,1
112	-0,1
126	-0,1
141	-0,1
159	-0,1
178	-0,1
200	-0,1
225	-0,1
252	-0,1
283	-0,1
318	-0,1
356	0,0
400	-0,1
449	0,0
504	0,0
566	0,0
635	0,2
713	0,0
800	0,0
899	0,2
1009	0,2
1132	0,2
1271	0,5
1427	0,2
1601	0,7
1797	0,7
2018	0,7
2265	0,7
2542	0,7
2854	0,7
3203	0,7
3596	0,7
4036	0,7
4531	0,8
5086	0,7
5709	-3,3
6408	-8,4
7193	-13,9
8074	-19,2
9063	-24,1
10173	-28,8
11419	-33,2
12818	-37,1
14388	-41,2
16151	-45,0
ENDE	ENDE

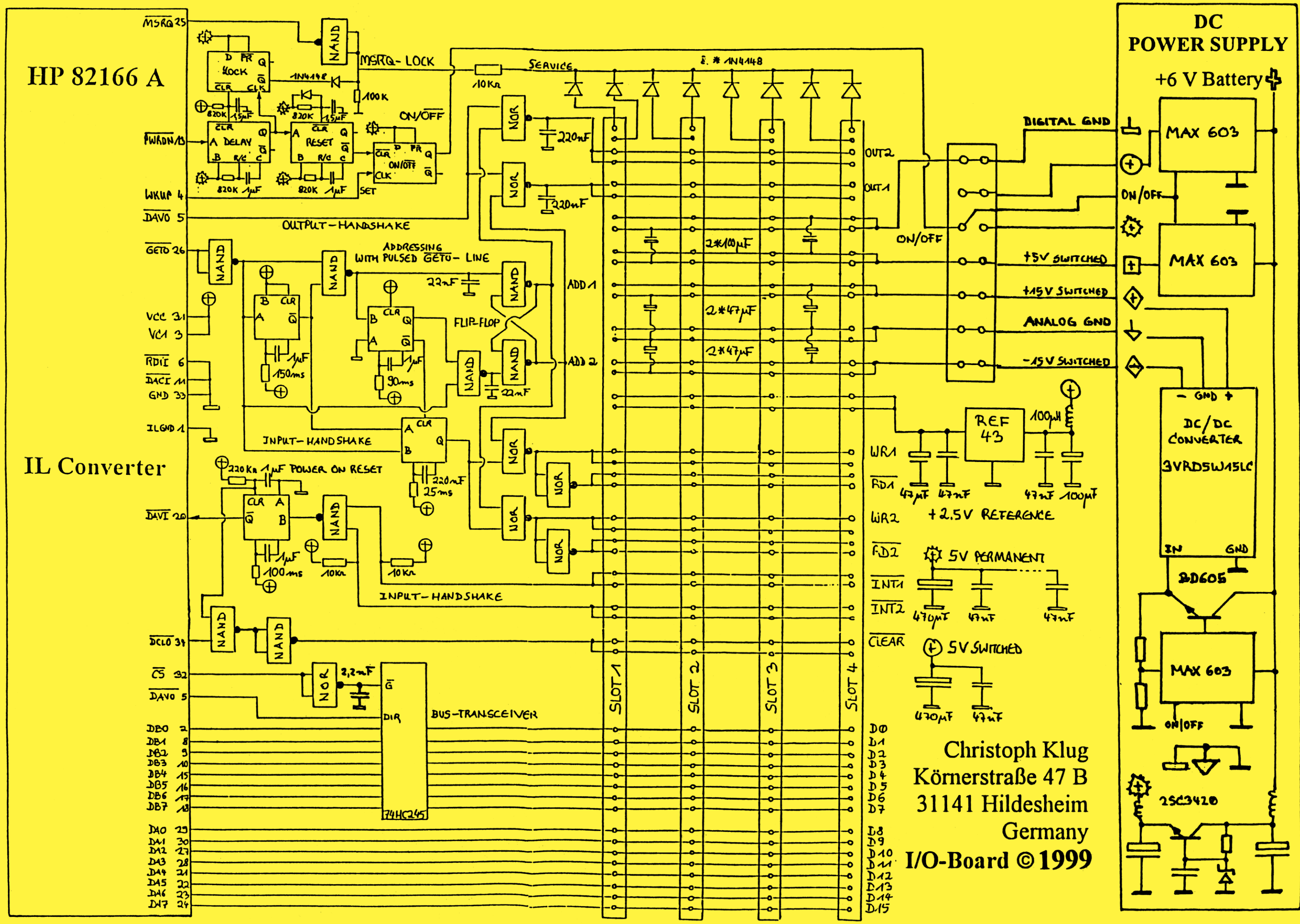
Future Chapters ....

Some ideas exist about writing additionally chapters. Presently the I/O-Board manual only have a one side print because copy process is much easier. For more chapters a change to a double side print must occure because used spiral binding reaches now maximally size.

One future project is realizing more analog I/O Ports (12 bit resolution) working with Quad DAC circuits from Burr&Brown and a multiplexer IC as frontend for the existing ADC. This solution includes a software routine for splitting the 16 bit output into 12 bit data and 4 bit sub-address word .....

Second future project is presenting a complete weather station application, to give an example about interfacing different physical sensor systems (wind speed, wind direction, temperature, humidy, pressure, amount of rain fall, light intense....) to I/O-Board. For this application I will use some existing sensor systems from consumer weather stations..... A solution for temperature measurement exist, using some software calibrated Siemens KTY sensors (heat flow measurement in a solar collector system for heating water)....

This days the development of the IL-2000 project is running. The existing I/O-Board is a fantastic tool for working on the work bench, but the complete modular hardware concept do not including a mechanicall housing for easy transport, used for mobile applications in the field. Furthermore presently I/O-Board is completely hand build and wired like a prototype system...... Now the IL-2000 project will connecting nostalgic HP-41 handheld computer system to future ! The complete I/O-Board hardware circuits are layouted to a small 2/3 size double side printed Euro Board, realized with surface mounted electronic parts. The new concept includes an easy bus design and different solutions for mechanically housing, including a 19 zoll rack case.


HP 82166 A
IL Converter
DC
POWER SUPPLY
+6 V Battery
MAX 603
DC/DC CONVERTER
3VRD5W15LC
BD605
2SC3420
OUTPUT-HANDSHAKE
INPUT-HANDSHAKE
ADDRESSING WITH PULSED GETO-LINE
FLIP-FLOP
POWER ON RESET
BUS-TRANSCEIVER
74HC245
MSRQ-LOCK
SERVICE
ON/OFF
DIGITAL GND
+5V SWITCHED
+15V SWITCHED
ANALOG GND
-15V SWITCHED
REF 43
+2.5V REFERENCE
5V PERMANENT
5V SWITCHED
SLOT 1
SLOT 2
SLOT 3
SLOT 4
Christoph Klug
Körnerstraße 47 B
31141 Hildesheim
Germany
I/O-Board © 1999