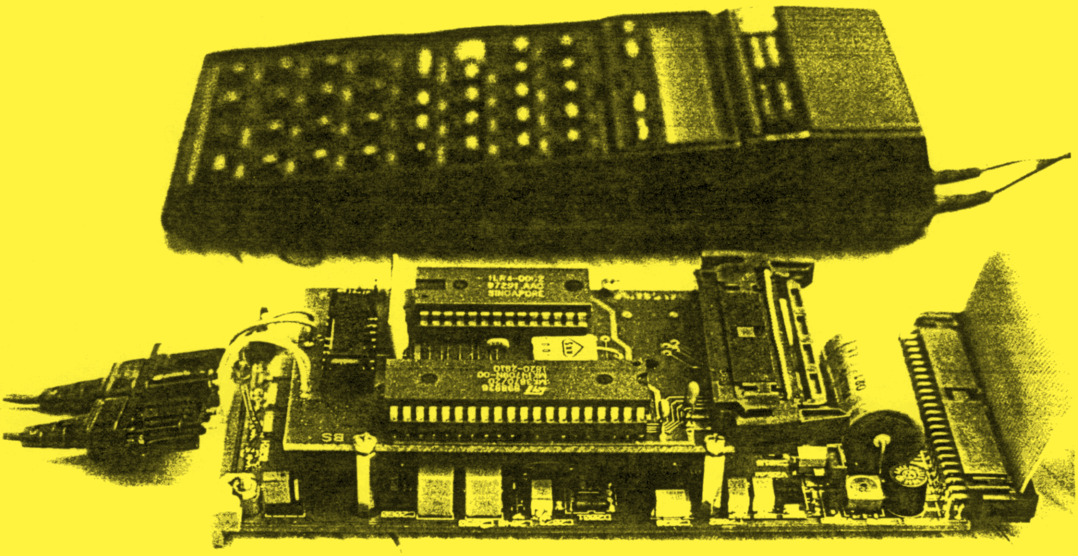
IL 2000

Modular Interface System
for
HP-41 Handheld Computer
and
HP 82166A IL-Converter



Compatible to
I/O-Board Interface System

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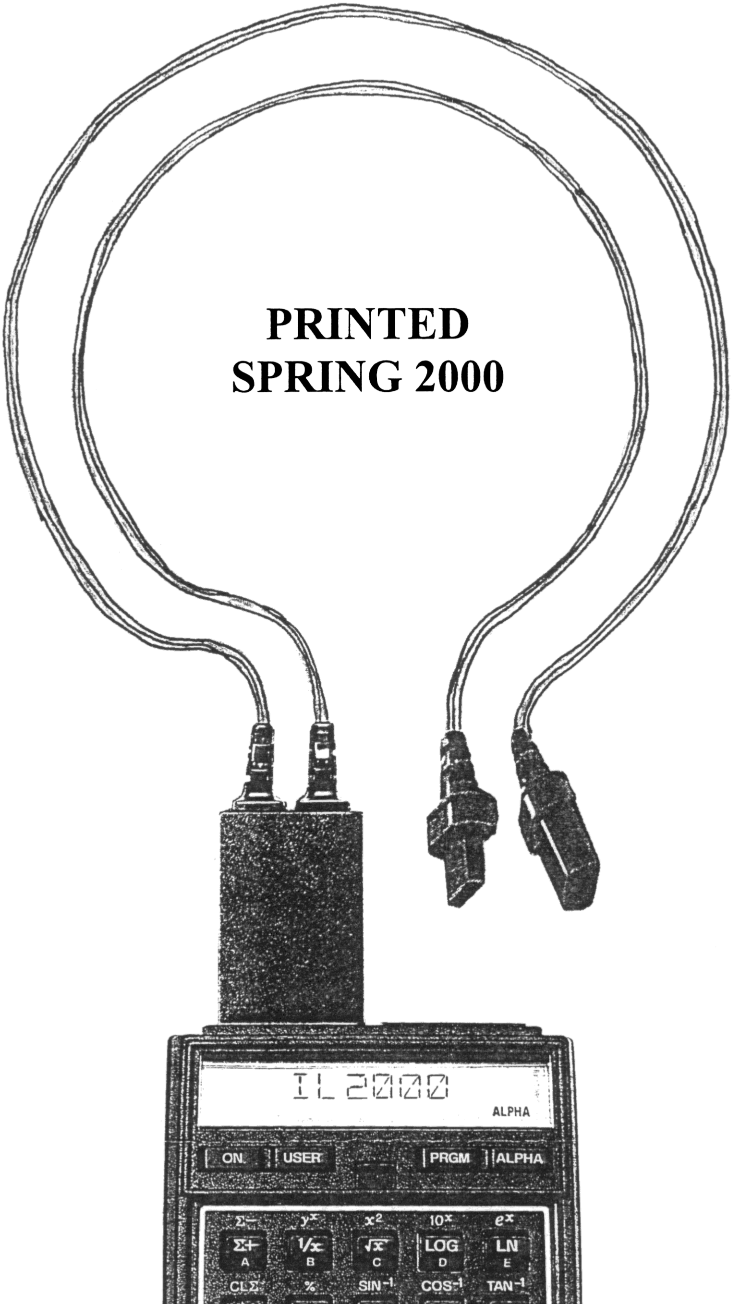
IL 2000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Modular Interface System for use with HP-41 Handheld Computer and HP 82166A IL-Converter

Compatible to I/O-Board Interface System

Designed By

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PART I :

PREFACE

by Gary Friedman

I published my first book, "Control the World with HP-IL", in 1987. This book showed, in a tutorial style, how to interface Hewlett Packard handheld computers to the outside world. For me it was a very exciting endeavour, because in a world which was dominated by large, immobile, clunky DOS-based IBM PC's, I was playing with Hewlett Packard's little wonders - The HP 41 calculator, and the even more powerful HP-71 handheld computer. I call them "little wonders" because they were so far ahead of their time in terms of portability, power consumption, user interface, number crunching abilities, and programmability (the HP-71 could be programmed in 3 different language environments, all of which could call each other!). And while the rest of the world was impressed with 1 parallel and 1 serial port that came with their bulky PC's, HP's innovative HP-IL interface could allow my pocket device to access 31 connected pheripherals (normal addressing) or almost 1000 pheripherals (extended addressing) simultaneously!

I was doing things with these little wonders that most technical people could never do with their PC's: I hooked up my 41 to my 35mm camera so I could take nighttime "time exposure" images of increasing duration while I stayed warm inside. I completely automated my photographic darkroom using my 41 - from negative analyzer to enlarger timer to developer/bath timer. (This allowed me to concentrate on creative darkroom pursuits instead of being consumed by the 'dog work'.) I used my HP 71 computer to measure distances ultrasonically, re-dial phone numbers automatically until someone answered, and control multimedia shows, including a "dissolve unit" controlling 2 slide projectors. For my final project before earning a degree in Electrical Engineering, I turned my 41 into an interactive telephone answering machine, complete with speech synthesis and Touch Tone (r) decoding. The book described how to build each of these projects in detail; and as a foundation it taught the basics of how to turn things on and off and perform basic real-world measurements.

What enthralled me most about working with the HP handheld computers is that this was my first inkling that technology could actually set you free. The vast majority of what I built could be carried with me and used anywhere. (The camera controller mentioned above, for example, was always in my camera bag, ready to do work for me while I was far from civilization.) I could set it up as a data logger and have it wake up, take a measurement, and shut off again all on its own. Because all the IL peripherals ran on batteries, the controller could power up all peripheral devices, print something out, save some data to tape, and shut everything off again until the next measurement cycle.

And all the units had their own keyboard and display, so software development and testing could be done interactively, without a bulky and constraining development system. And since it was an open-ended interface, there was virtually no limit to the amount of I/O that could be performed with this handheld device - just add another peripheral or 16-bit parallel port to the loop! Compared to the non-portable, power-hungry, limited I/O Personal Computer, HP's calculators were lightyears ahead of the accepted world standard.

Much has changed since those exciting days. Hewlett Packard had dropped support of HP-IL due to low market demand. Their Subsequent calculator models re-focused their feature set toward sophisticated symbolic math processing and away from Test, Measurement, and Control. Like the 3-stripe Technicolor process, Sony's Beta video format, the Curta mechanical calculator, Symbolics' LISP-based Artificial Intelligence systems, and Cyclomates, the HP-IL enabled handhelds remain unrivaled to this day in terms of portability, versatility, expandability, power consumption, and 'self-containability'.

But all is not lost. Several years ago I was delighted to learn that Christoph Klug has been "carrying the torch", and building upon my published work in interfacing the HP-41 to the outside world. In 1990 he created a modular I/O board which utilized address decoding and allowed users to control a wide mix of peripherals simultaneously utilizing only one HP82166A HP-IL Converter. Modules he designed include digital in/out, opto-isolated out, digital/analog converters, (and its compliment), digital counter, and even an ADC multi-plexer. Christoph's work had made HP-41 I/O interfacing and experimentation easier for the plethora of enthusiasts who wanted their calculators to "do useful things". Each year he has been adding to his work; expanding the I/O modules available for his board, and translating his now 300-page documentation book into English language.

The IL 2000 project, the documentation of which you now hold in your hand, is the latest step in this continuously evolving development platform saga, and embraces the original portable spirit of the HP-41 system. This new interface board is considerably smaller, more self-contained, and travels better than its larger predecessor. It will enable the rapid development of extremely portable field measurement and control, and will once again allow many others to experience the enthusiasm that had struck me more than a decade earlier: Technology can set us free. Imagination can make us soar.

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PREFACE

by Christoph Klug

During secondary school I was member of the last course, starting with slide rule calculation. One year later we change to handheld computer, my first machine was the non programmable TI-35. I enter college in 1980 and import my first HP-41C handheld computer directly from USA (for saving money). This time most students used TI-58 or TI-59 handhelds, only some worke with the HP-65. When I start with HP-41 handheld, I don´t know that using this nice machine will inspire me up to 20 years later ! For realizing extensive software applications needed for math or electronic course I expand HP-41 system with Card Reader and two Memory-Modules, later follows the Quad Memory Module for saving plug in ports. I write own math software solutions for polynomial division and differential / integral calculus. This time (the first PC´s entered the market) the portable HP-41 handheld computer system fascinates much people and members of handheld computer clubs worldwide, some third party supplyers produce special add on accessories for expanding features of this "world´s best" machine.

I never work with the upgraded HP-41 CV model and when I start with job at Bosch / Blaupunkt Company 1985, I sold the HP-41C and get the fantastic HP-41CX. For Blaupunkt acoustics and loudspeaker development department I create a 8 KByte HP-41 software pack including determining loudspeaker parameter, calculating Thiele/Small vented box alignment charts and calculating speaker cabinet transfer functions. Same time I started with first hardware interface projects, using HP-IL Interface Loop and HP 821266A IL-Converter. A detailed history about this work you find inside I/O-Board manual on pages IIX.19 to IIX.27 . Because it was possible expanding HP-41CX by powerfully add on devices like CCD-Module or X-Memory Modules, there was no reason changing from HP-41 IL System Controller to HP-28 or later HP-48 (without any HP-IL capabilities).

Creating own hardware projects with HP-IL is a fascinating work : Interfacing physical sensors for measurement applications, or connecting the handheld to "real world" for realizing control applications ! Working with Time-Module or interrupt circuit for waking up handheld by an extern event make possible advanced interface applications ! Using the EXT-I/O Module or Development Module and later the powerfull Eramco Ram-Box or the small Zeprom-Module gives calculator the performance I need for extensive measurement and control applications. By adding some IL-Devices (data storage and plotting) portable HP-41 handheld computer mutates to a complex organism. Fortunately solutions exist, for transfering HP-41 data and importing them to modern PC applications, including an efficient HP-41 emulation running on PC (see I/O-Board manual Chapter XV). Using this key-technologies adapts HP-41 to today PC world !

IL 2000

Working with HP-41 computer system and developing interface hardware solutions is only one activity, an other nice activity is exchange of knowledge with handheld computer enthusiasts : First I was member in the German handheld computer club CCD and publish articles about interfacing in belonging Prisma Journal. When CCD closed I enter to the Great Britain Handheld and Portable Computer Club HPCC. From exchange with today HP-41 fans worldwid results writing articles for HPCC Datafile Journal. The hardware interface activities are published in the 300 page I/O-Board manual and now continued with this second book about the IL2000 system.

The IL2000 project gives you an imagination about progress of hardware development : The new electronic design with some expanded features needs less space by working with surface mounted components. The belonging mechanical design includes practical plug in hardware modules and a handy box, making portable applications easy. IL2000 system is compatible to I/O-Board, an adapter board make possible employment of existing I/O-Board plug in module family. By using IL2000 interface hardware platform and developing own hardware modules you finish individual applications in short time. IL2000 system connects the proved HP-41 handheld computer including HP-IL Interface Loop to future !

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PREFACE

by Dr. Tony Duell

Ever since I built my first microcomputer back in 1977, I have been fascinated by using them to measure and control real world events. I want to link them to more than the standard "keyboard, monitor and printer". Nothing annoys me more than sitting in front of a digital measuring instrument, taking readings, and typing them into a computer. The computer should be linked to that measuing instrument, and should take the readings itself, thus freeing me up for more useful tasks.

The idea of using a handheld computer to do this is even more interesting. Imagine a pocket-sized sytem that can be linked to an experiment. That can record the results, process them, and then control the experimental conditions automatically. And while doing that, it's recording the results to be printed or uploaded to my workstation later on.

I first did this in 1985 using a Sharp PC1500 pocket computer. I managed to fit an 8-bit analogue-to-digital converter inside one of the interface modules for that machine. The result was a 4 channel digital voltmeter with 4-colour plotter, RS232 interface that could be programmed in BASIC or machine code. And that I could drop in my pocket.

Soon afterwards I discovered the wonders of Hewlett-Packard calculators. Unfortunately the first models I used were not ideal for real-world interfacing, but I soon progressed to the HP-48 series and started using those for real world control via the RS232 port.

In 1996, I started designing a "Universal" interface for the HP-48 series using the Philips I^2C standard to link to peripherals. This enabled me to make simple input/output control and measurement modules for that machine. My interface system, for the HP-48, is described in a manual available from the Handheld and Portable Computer Club HPCC.

But I'm skipping over a lot of history here. Over 10 years before I designed the above system, Hewlett-Packard had done something similar using their own interface standard, HP-IL (Hewlett-Packard Interface Loop). Here is an interface that allows almost 1000 devices to be linked to a handheld calculator (like the HP-41C series) or computer (like the HP-71B). Alas, this wonderful interface has been discontinued by Hewlett-Packard, and only lives on due to some dedicated enthusiasts around the world like Christoph Klug.

Hewlett-Packard did sell digital measuring instruments and real-world control interfaces for this machine, but they are expensive and hard to find today. But they are not needed if you follow the information in this book.

In this book, Chistoph Klug describes a versatile modular measuring system that can be linked to an HP-IL interface using the relatively easy to find GPIO (General-Purpose Input/Output) module : The HP82166A. Using his modules, an HP-41 calculator fitted with an HP-IL module linked to the GPIO interface can make measurements, and monitor and control real-world events.

This is necessarily a book for electronic experimenters. The system (like all good designs) can be extended in ways that Christoph could never have imagined. But all the necessary information to make the "standard" modules is here - it's up to you to use them.

I wish Christoph Klug every sucess with a novel use of these amazingly powerful calculators.

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PART II :

Connecting HP-IL Interface Loop to Future :

The existing modular hardware system of I/O-Board (IL-Converter, motherboard, power supply board, lead cell battery, some different plug in modules ...) is ideally for use on workbench, for evaluation and prototyping interface solutions for measurement and control hardware applications with HP-41 handheld computer system.

But for mobile and portable applications the I/O-Board system do not have a practical housing like a closed case or a handy box. Furthermore producing of I/O-Board and belonging Power-Supply unit is a mixture of working with printed boards plus additionally hand wiring much lines and components. To overcome this wake points, now I start the IL2000 project :

IL2000 project transfers complete proved I/O-Board technologie into a nice handy box. Some interface- and power supply features expanded, like addressing more ports or a solar cell charger option. The new modular mechanical design is realized by 10 inch rack case parts. Some parts are modified for reaching the nice slim line box height of only 88 mm. By expanding box width up to 19 inch size, extensive hardware configurations are possible !

IL2000 interface board + IL-Converter + POW2000 power supply board stacked together, forming the basic hardware module, placed to right side of 10 inch rack case. A flat ribbon wire power- and data bus is connected to additionaly plug in moduls : I/O2000 is the adapter solution for inserting existing I/O-Board plug in module family. DIG2000 make possible general 16 Bit digital I/O applications.

HP-41 software used for IL2000 system is compatible to I/O-Board. Refer to I/O-Board manual Chapter II and Chapter VII . Only addressing additional input- and output ports needs expanded software. Like I/O-Board also IL2000 interface board works with pulsed GETO-Line (IL-Converter trigger signal) for port addressing.

IL2000 system is the multi-purpose interface soltuion for expanding HP-41 handheld computer system by advanced input/output applications. The portable, battery powered design is helpfully for today HP-41 fans and enthusiasts, for handheld computer collectors, and for electronic professionals. The modular hardware concept make possible configuration of IL2000 interface system to every task you want. Developing special modules for you own applications and hardware projects is possible in short time. IL2000 system continues proved I/O-Board design, and both systems are fantastic IL-Devices for implementing your ideas quickly !

IL2000 Board :

Complete I/O-Board hardware circuits designed to a professional double sided printed board, working with surface mounted components. IL2000 board dimensions are 66mm x 150mm. The IL2000 board includes a 34 pin connector plus 3 mounting holes for stacking the IL-Converter. On rear side exist a 50 pin connector for power-, data-, and handshake bus lines. By working with flat ribbon wire and belonging standard connectors, you create in short time a bus system to different I/O modules.

Compared with I/O-Board, IL2000 includes some nice feature extensions : Maximal safety for belonging IL-Converter by 125 mA fuse (reverse polarity protection) and +5V regulator, complete data bus lines (including IL-Converter Bus A) now buffered. On front side a three colour diagnostic LED displaying the interface state. Port address hardware is expanded for addressing maximally 8 sixteen bit I/O ports (I/O-Board addresses only 2 sixteen bit I/O ports) !!!

POW2000 Board :

Like IL2000 belonging POW2000 power supply board have nice advanced features, compared with existing I/O-Board power supply unit : With same dimensions as IL2000 board, it generates some different voltages from a +6V lead cell : +5V/500mA, two adjustable voltages like +3,3V/500mA or +5V/500mA, ±15V/±100mA, optional symmetric voltages ±5V/±300mA or ±12V/±125mA or ±15V/±100mA.

Furthermore exist a +2,5V reference voltage, a low bat indicator circuit including low current Power-LED, and an optional high efficiency voltage regulator for loading +6V lead cell by a solar pannel. Three existing mounting holes make possible stacking the POW2000 board to IL2000 board and IL-Converter. On rear side exist a 26 pin connector with control lines and power supply lines.

I/O2000 Adapter Board :

Presently two digital Input/Output modules (supporting the new 50 pin bus) completing IL2000 system. Take them for realizing your own hardware solutions and individual applications in short time :

First module, called I/O2000; is the adapter solution for employing I/O-Board plug in slot modules. The extensive I/O-Board plug in module family gives you much proved circuit examples. Inserting two 16 Bit, or four 8 Bit plug in modules is possible. Adapter card size is 220mm x 66mm.

DIG2000 Interface Board :

Second module, called DIG2000, is an universal digital I/O card (16 Bit input plus 16 Bit output). Like IL2000 this board works with surface mounted parts. Additionally evaluation board area with ground-plane gives you some space for placing own hardware circuit extensions. Mounting holes make possible staking modules or add on boards. Modul size is expanded to 220mm x 66mm. By cutting board you reache IL2000 and POW2000 board size (150mm x 66mm).

10 Inch Rack Case :

One practical reason of IL2000 development was optimicing housing for reaching a better handling for mobile applications. For this IL2000 components are mounted inside a small box by using 10 inch rack parts from ISEL Automation KG / Germany. Some parts are modified for reaching standard height of only 88mm.

Using a 10 inch rack case for IL2000 project continues the mechanical design of IL-Rack (I/O-Board manual page IIX.21) and IL- Messlab (I/O-Board manual page IIX.25). Like I/O-Board and belonging plug in modules also IL2000 case desing gives you the advantage of inserting different hardware modules.

IL2000 board + IL-Converter + POW2000 board stacked together, forming the basic hardware module, placed to right side of 10 inch rack case. Flat ribbon wire power- data- and handshake bus connect additional I/O hardware modules left beside IL2000 board. Rear pannel of slim line box holds the +6V lead cell and terminals for AC-charger and solar pannel.

Resulting box solution is handy and practically for mobile applications, and standard 10 inch rack width gives you enought space for placing your hardware for typical interface applications (from 2 up to 6 sixteen bit I/O ports).

19 Inch Rack Case :

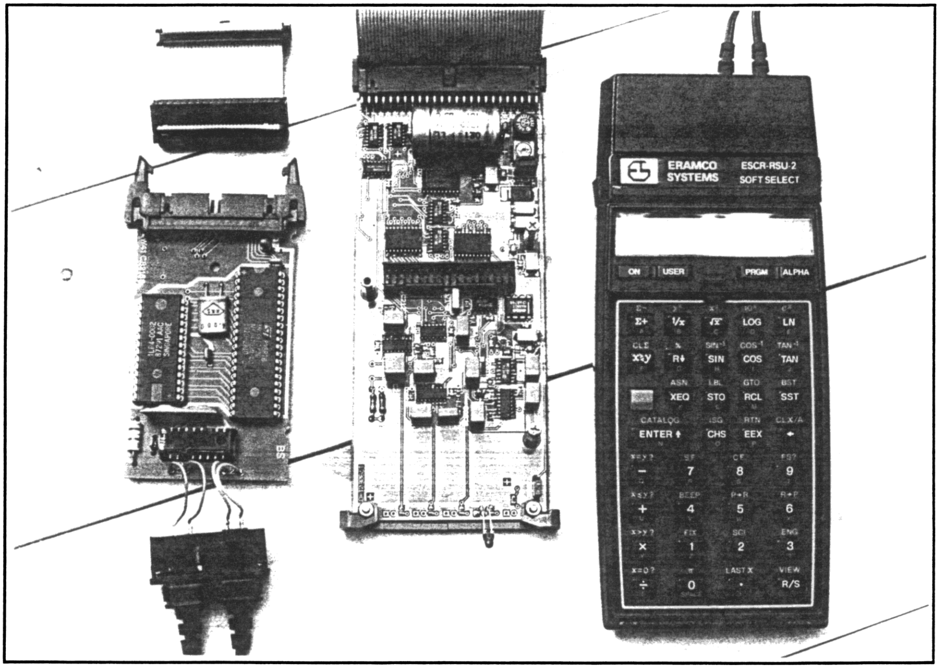
For extensive interface applications (from 4 up to 8 sixteen bit I/O ports), mounting some more hardware modules is possible by enlarging box width up to standard 19 inch rack size (slim line box design) !

For minimal interface applications (IL2000 + IL-Converter + Pow2000 + DIG2000) which need no modular design, it is possible stacking boards with some bolts and mounting the resuting block inside a small box.

IL2000 Hardware Feature List :

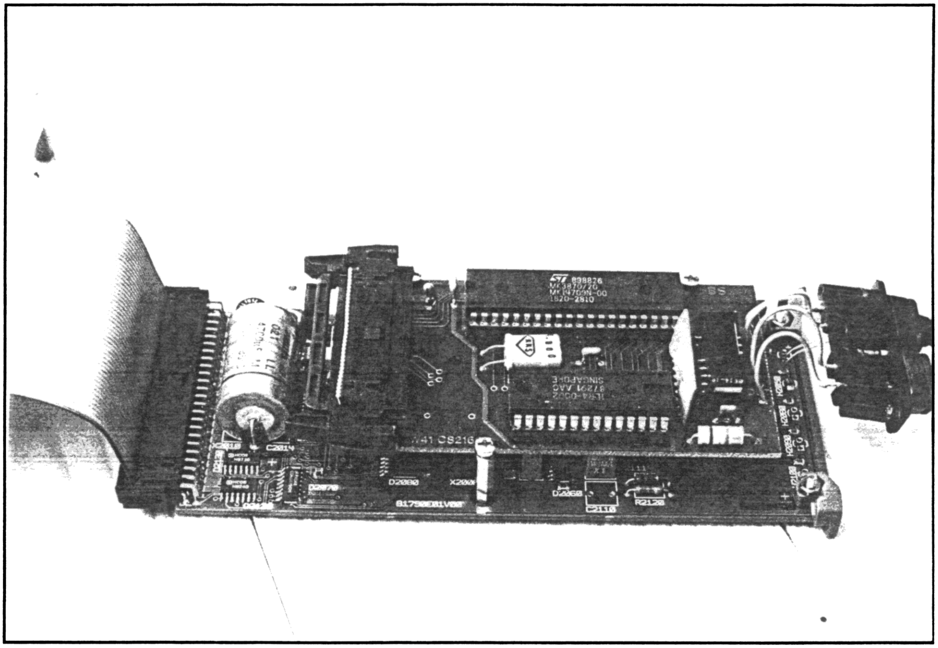
- External 220V AC Charger Unit
- External Solar Pannel Option and internal Solar Charger Circuit
- DC Power Supply working with +6V / 4Ah Lead Cell
- Reverse Polarity Protection and Fuses
- Regulated +5V Digital Supply and $\pm$15V Analog Supply
- Optional Adjustable Voltages
- Optional Symmetric Supply Voltages
- +2,5V Reference Voltage
- Low Battery Indicator with Power LED
- Power Up/Down Modus
- Power On Reset- and Clear Function
- Ribbon wire Handshake- Data- and Power Bus (50 lines)
- Complete Databus (A+B) buffered
- Extended Port Addressing with pulsed GETO-Line
- Maximal 8 Hardwareaddressed 16 Bit Input- and Output Ports
- Maximal 16 Softwareaddressed 8 Bit Input- and Output Ports
- Three Coulor Diagnostic LED
- MSRQ (Manual Service Request) Signal
- MSRQ – Power Down Lock
- Modular Design - working with Plug In Hardware Modules
- Adapter for inserting I/O-Board Plug In Module family
- Handy Case (10 Inch / 88 mm) for portabel applications
- Enlarging Case up to 19 Inch wide possible

Walcher IL-Converter, IL2000 Board and HP-41 :



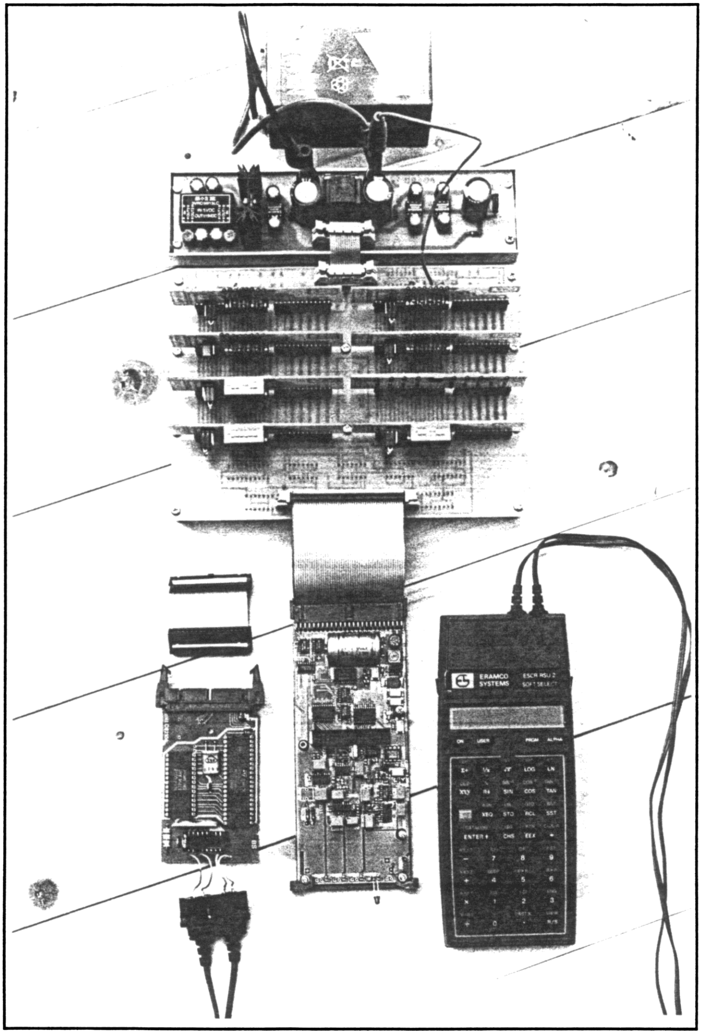
Picture shows the IL-Converter from Walcher / Germany, compatible to HP 82166A IL-Converter, the IL 2000 Board and HP-41 handheld computer with RSU Ram Storage Unit from ERAMCO / Netherlands.

Stacking IL-Converter & IL2000 Board :



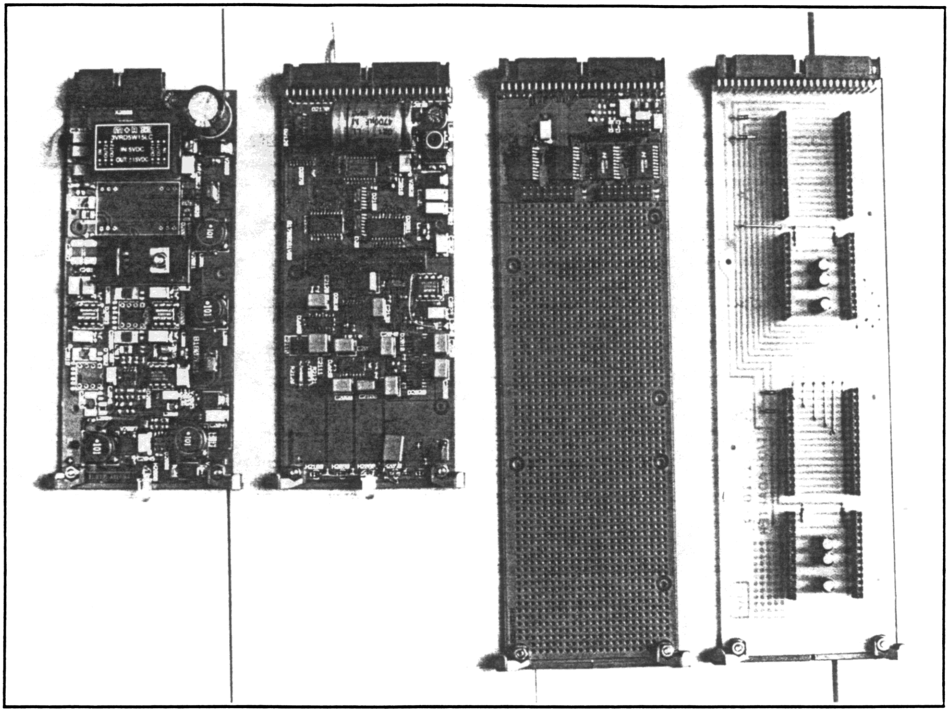
Three mounting holes and bolts make possible stacking IL-Converter and IL 2000 Board. Furthermore you can add belonging POW 2000 power supply board. This compact hardware block is the basic interface solution for your own digital and analog I/O applications with HP-41 handheld computer.

Testing IL2000 Board :



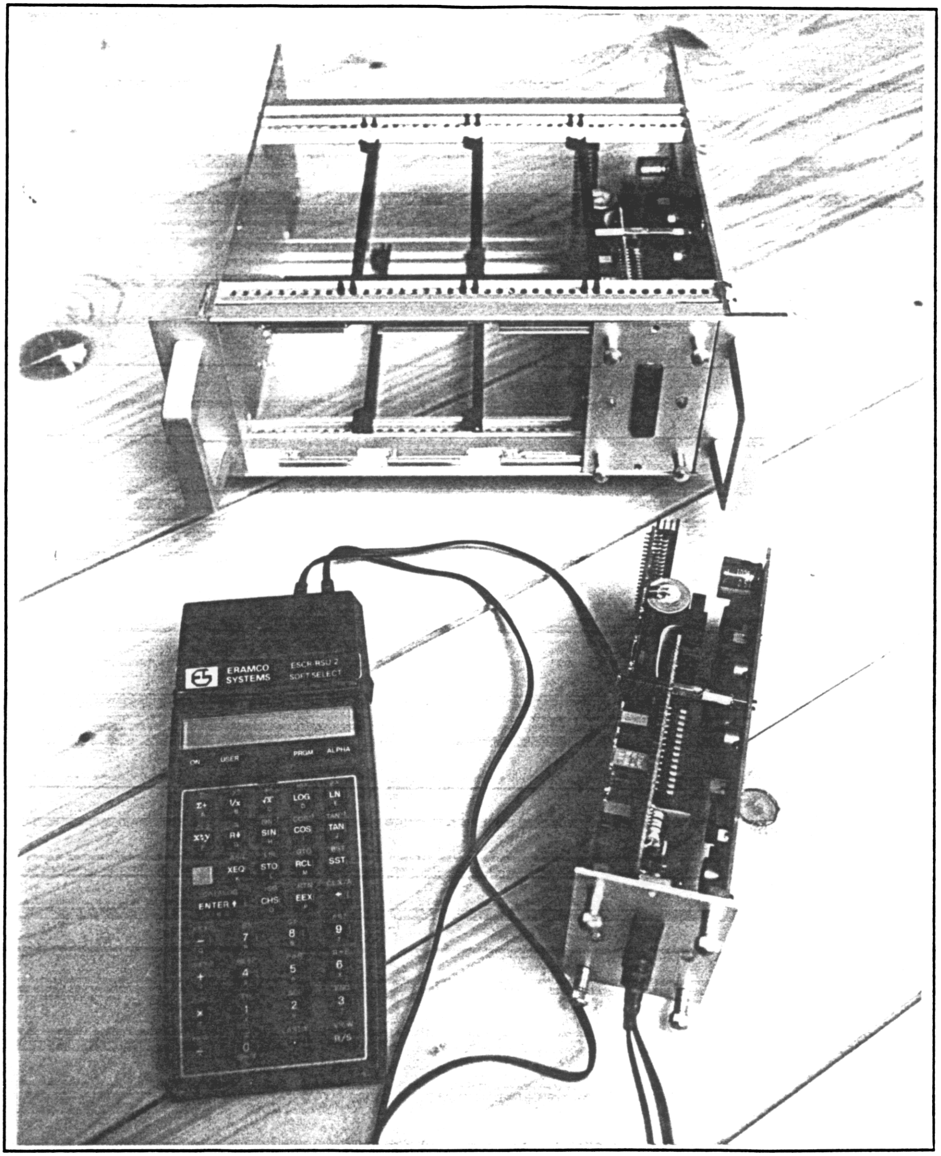
For testing hardware and checking function of IL 2000 Board I work with a modified I/O-Board (wired for adapting digital I/O plug in modules) and I/O-Board power supply unit.

IL2000 System Boards



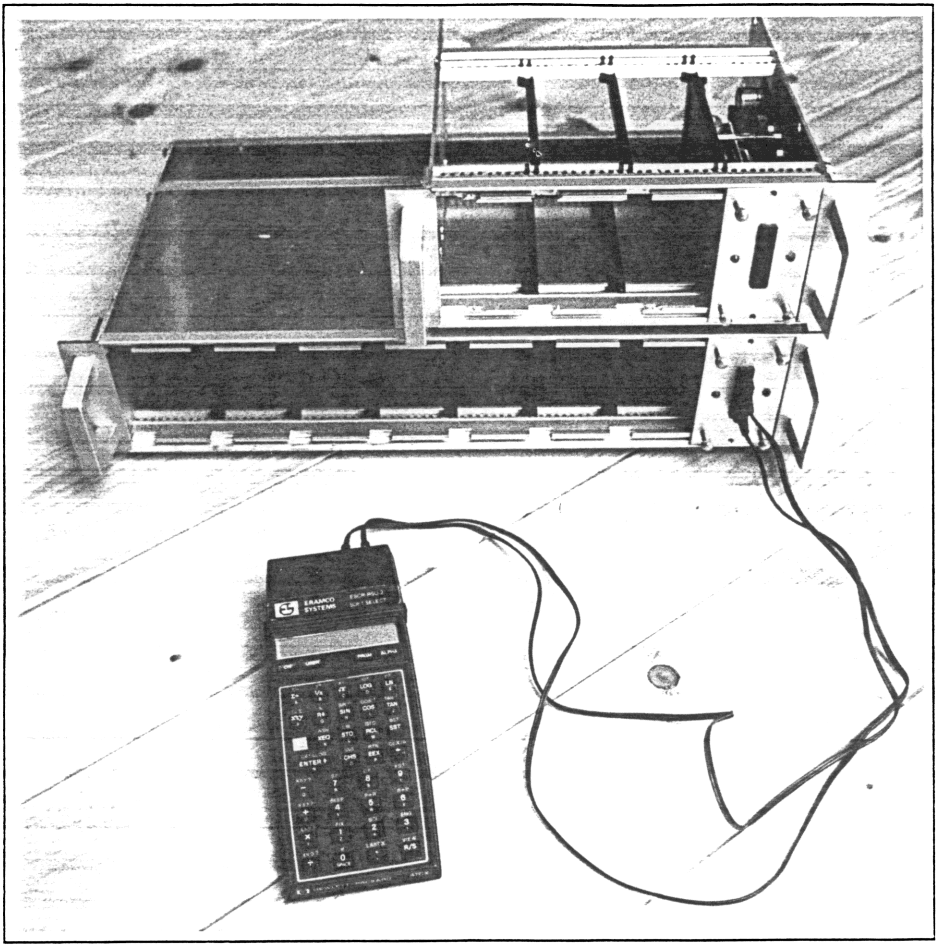
Presently IL2000 system includes four printed boards : POW2000 power supply board for generating some digital and analog supply voltages, low battery indicator circuit and optional solar charger circuit. IL2000 interface board for adapting IL-Converter to 50 pin data- and handshake bus and addressing up to 8 hardware modules for you own input/output applications. This two boards forming the basic hardware block of IL2000 system. Additionaly DIG2000 board make possible 16 bit digital input/output solutions, I/O2000 board is an adapter for inserting existing I/O-Board plug in modul family.

IL2000 Basic Hardware Block :



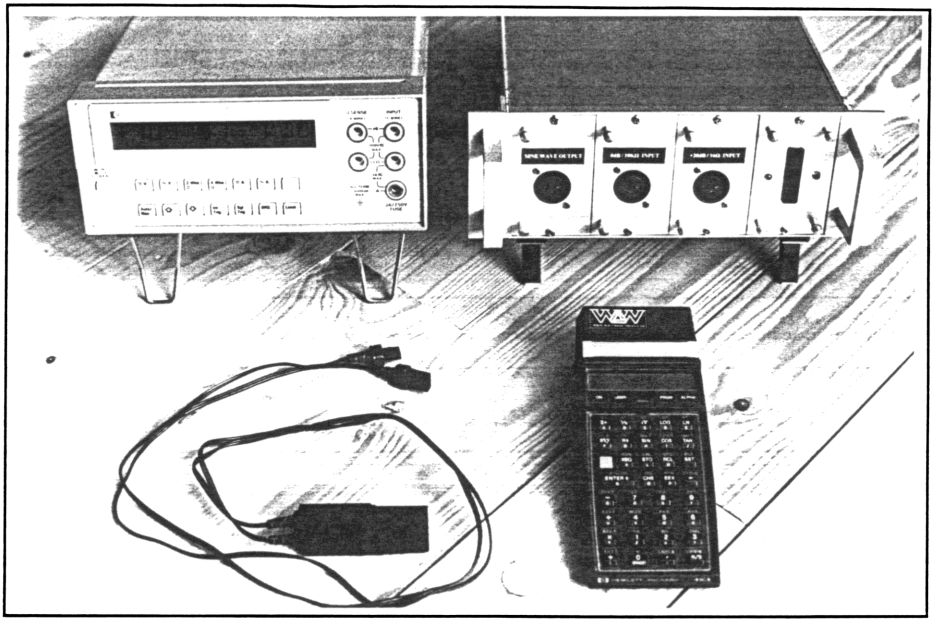
Picture shows 10 inch case (frame) and basic hardware block of IL2000 system. IL2000 board, IL-Converter and POW2000 board generating data- and handshake signals and power supply signals, needed for portable and mobile interface applications with HP-41 handheld computer.

Mechanical Design :



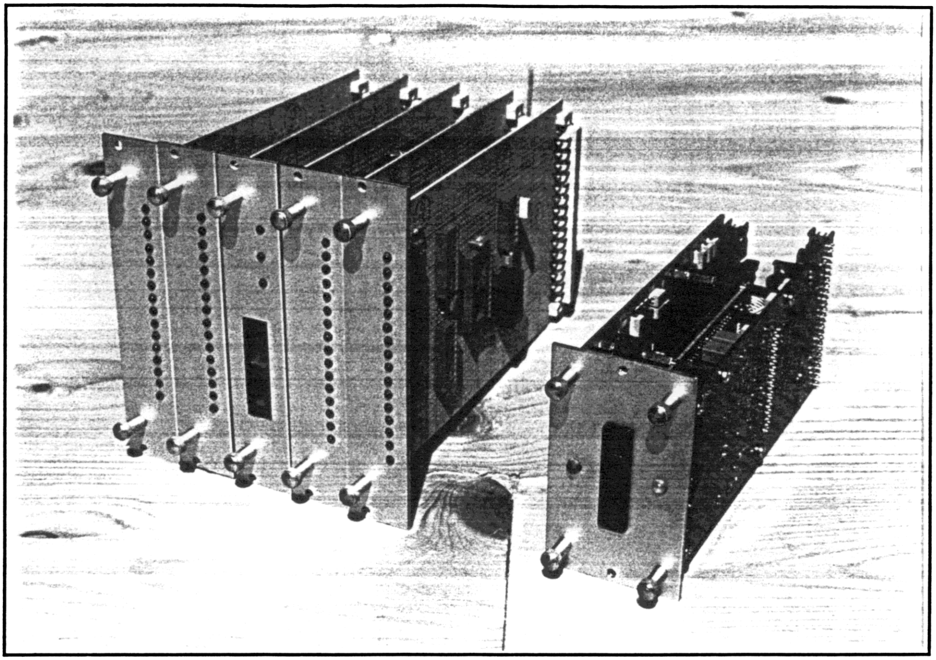
IL2000 hardware components are mounted inside a small 10 inch rack case. This gives interface system a practical handling for mobile applications. For extensive hardware applications, working with some plug in modules, enlarging box size up to 19 inch case width is possible. I take standard 10 inch and 19 inch rack parts from ISEL Automation KG / Germany. Some parts are modified for reaching only 88mm height. From this results the nice slim line box design !

HP 3468B Multimeter & IL2000 System:



Picture shows HP 3468B Digital Multimeter and IL2000 System (with audio frequency response measurement hardware modules). Both IL-Devices are battery powered and have nearly same handy size - allowing portable measurement applications with HP-41 handheld computer system.

Progress of Developing Hardware for HP-IL :

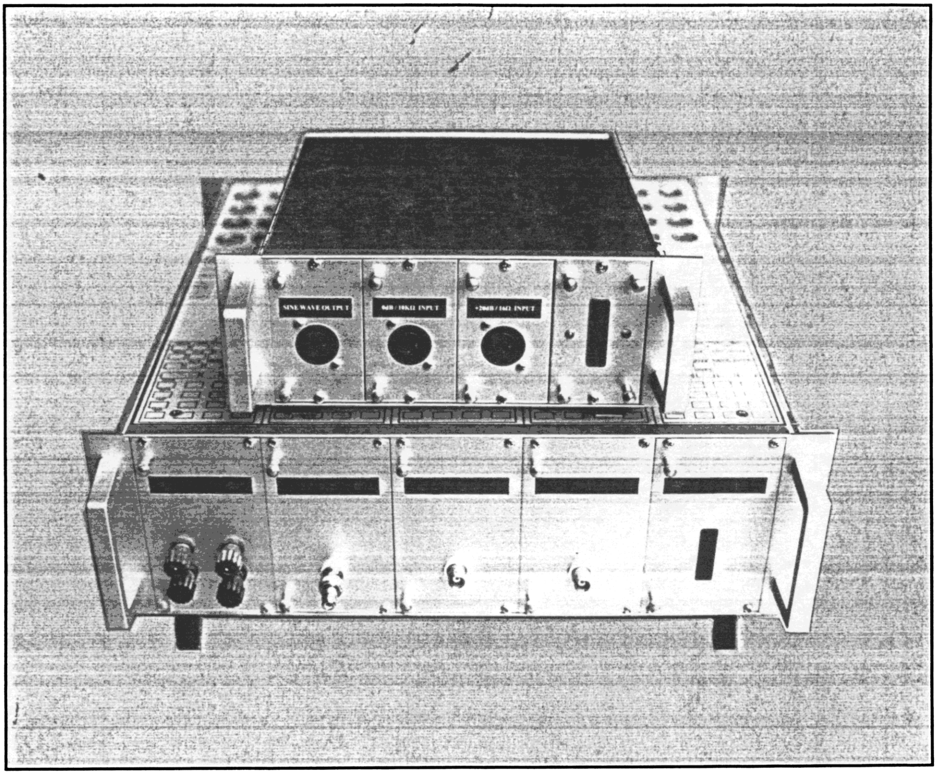


I/O-Board manual chapter IIX contains some details about developing some generations of interface hardware systems for HP-IL Interface Loop. The picture above make plain progress of reducing mechanical size and expanding features, improving mobile and portable applications :

Left side of picture views interface core of IL-Rack (I/O-Board manual page IIX.21). Some boards needed for driving input- and output bus lines, for address decoding and for generating handshake signals including wake up / power down. Full address- and bus lines displayed by some LED´s. Power supply block is not shown, this have same size as interface core. Because of great mechanical dimensions and internal 220V/50Hz AC power supply IL-Rack only usable for stationary applications.

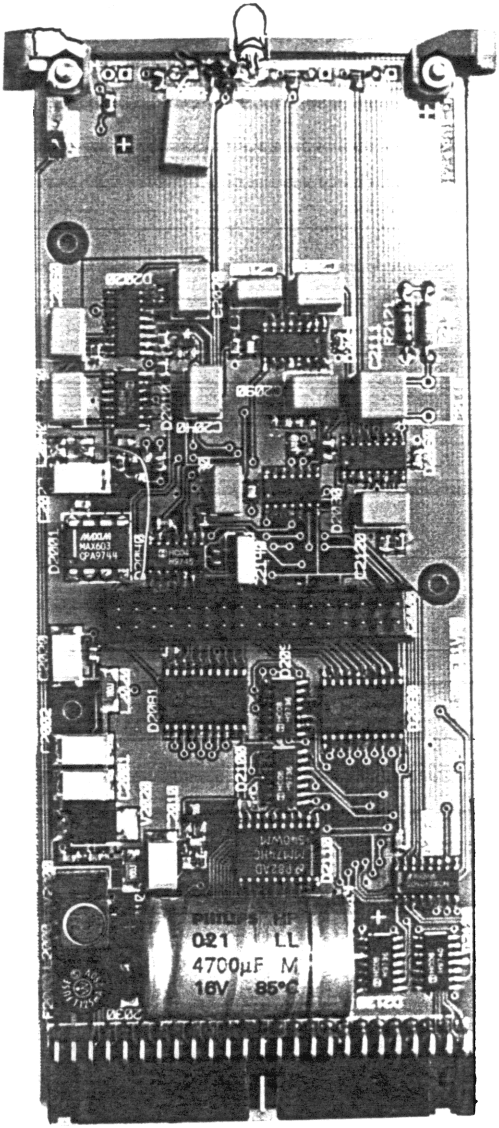
Right side of picture views stacked IL2000 board, IL-Converter and POW2000 board. This compact block is the basic hardware, making availlable complete bus-, handshake- and power supply lines. Like IL-Rack and later I/O-Board also IL2000 system works with additionally plug in modules. This make possible fast hardware changes for different applications with HP-41 handheld computer system.

IL-Messlab & IL2000 System :



IL2000 System continues mechanical design of IL-Rack (I/O-Board manual page IIX.21) and IL-Messlab (I/O-Board manual pages IIX.25 and IIX.26). The heavy IL-Messlab is designed for stationary use on workbench, the portable and battery powered IL2000 System make possible mobile applications.

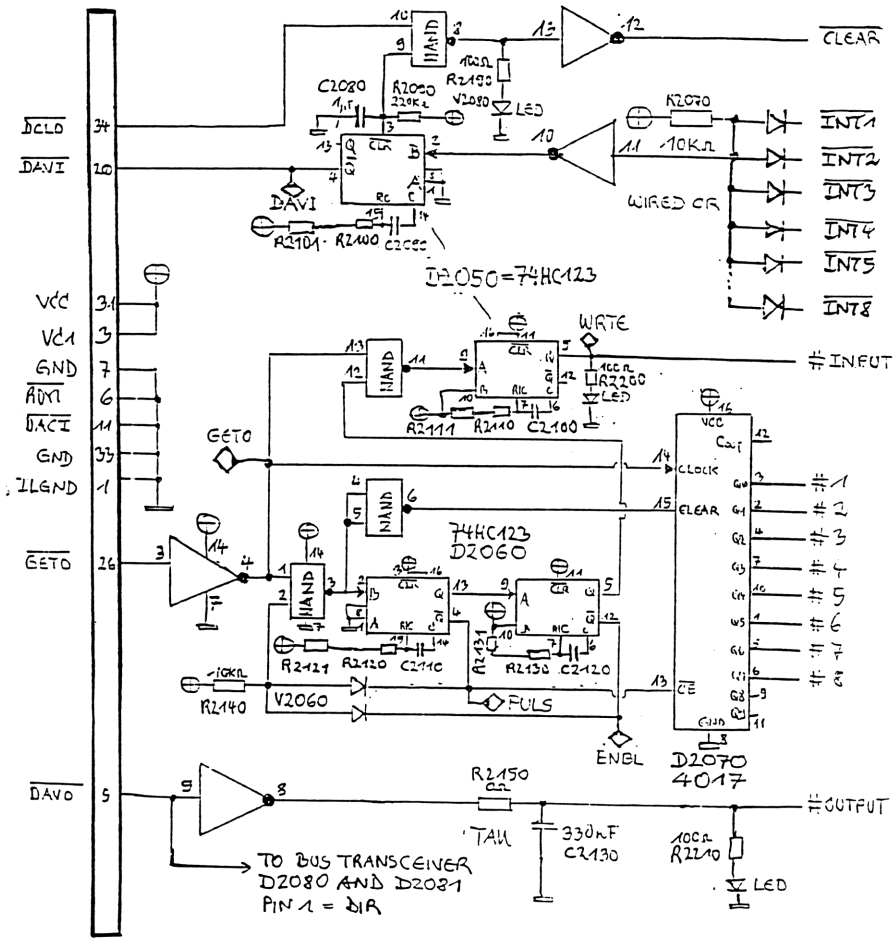
IL2000
Interface Board



Extended Port Addressing :

I/O-Board works with pulsed GETO line, addressing two 16 Bit Input Ports and two 16 Bit Output Ports. Also IL2000 works with pulsed GETO line for port addressing, but address hardware is expanded by D2070 (CMOS 4017 Decade Counter) making availlable address lines #1 ... #8. This make possible addressing up to eight 16 Bit Input Ports and up to eight 16 Bit Output Ports !

Address lines #1 ...#8 and two handshake control lines #INPUT and #OUTPUT wired to And Gates 74HC08 and Octal Inverter 74HC540 for generating maximal eight WR/RD and OUT signals. For saving port pins INT signal is realized as Wired-OR, working with external diodes switched to active low level.



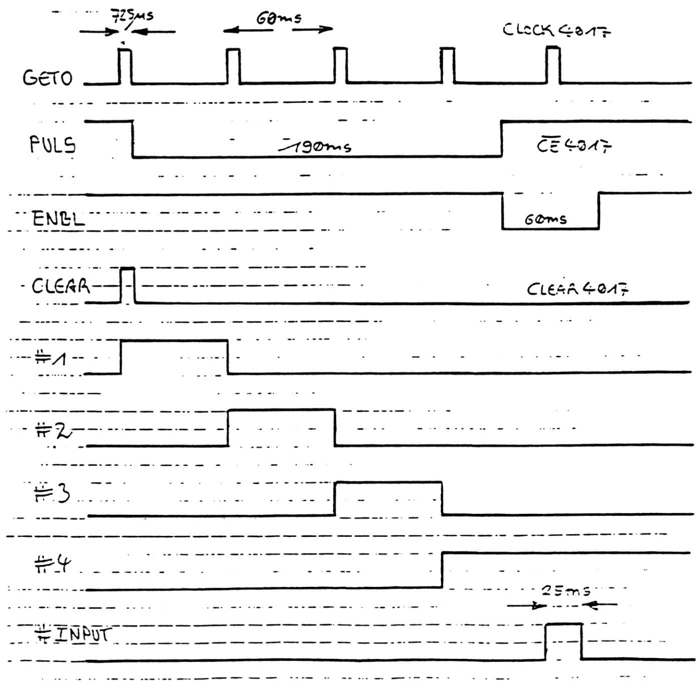
Setting Number of Ports :

PULSE time of D2060 defines number of availlable ports. IL2000 default port number is two, compatible to I/O-Board. By changing value of R2120 + R2121 you alter number of availlable 16 Bit I/O ports. I/O-Board manual CHAPTER III page III.03 – III.05 gives you much details and practical tips about resistance alignment.

Typical GETO puls repeat time is 60ms (control software setting GETO trigger line is running in HP-41 main memory). If control software is stored in RSU Ram-Box or in Zeprom-Module, typical GETO puls repeat time is shorten to 50ms. In practice it is possible setting only one PULSE time interval, independently of software is running in HP-41 main memory, in RSU Ram Box or Zeprom-Module !

For setting default port number to two, needed PULSE time interval is 80ms. R2120 22kΩ and R2122≈3,3kΩ - valid for used MM74HC123A monostable multivibrators produced by National Semiconductore. Below diagram shows you the expanded hardware timing belonging to four 16 Bit I/O Ports :

Port addressing is done with pulsed GETO trigger line : First trigger command clears 4017 Decade Counter (#1). If following three trigger commands exist, they increment 4017 Decade Counter (#2, #3, #4). Fivth trigger command is used for generating #INPUT signal. For addressing four 16 Bit I/O Ports set Pulse time interval to 190ms.



HP-41 Control Software :

For controlling IL-Converter like power up/down , initalisation, MSRQ, work with HP-41 software presented in I/O-Board manual. Only if you expand IL2000 port number from default number of two, you need additional software change, concerning number of TRIGGER commands.

For sending out two Bytes (16 Bit) from Alpha-Register to four output-ports, you need the following HP-41 control program :

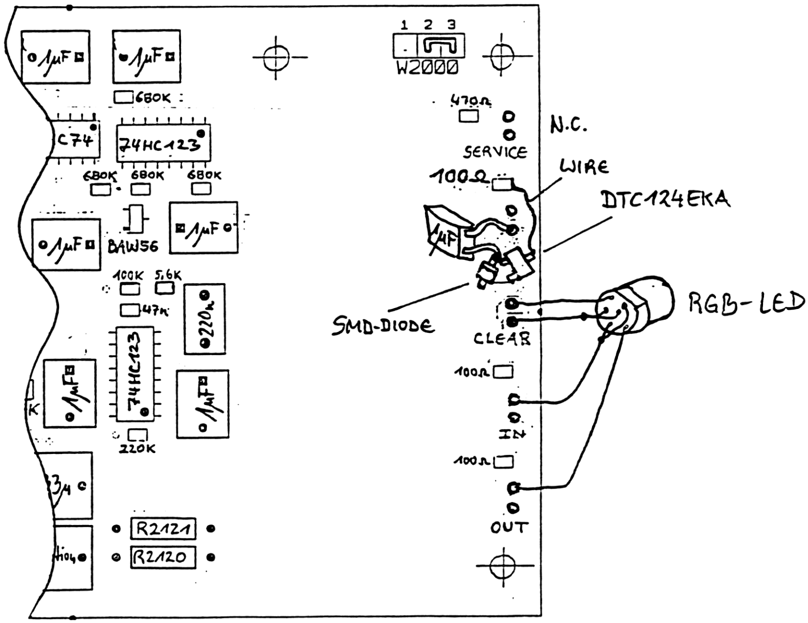
LBL OUT1	LBL OUT2	LBL OUT3	LBL OUT4
TRIGGER	TRIGGER	TRIGGER	TRIGGER
2	TRIGGER	TRIGGER	TRIGGER
OUTAN	2	TRIGGER	TRIGGER
CLX	OUTAN	2	TRIGGER
RTN	CLX	OUTAN	2
	RTN	CLX	OUTAN
		RTN	CLX
			RTN

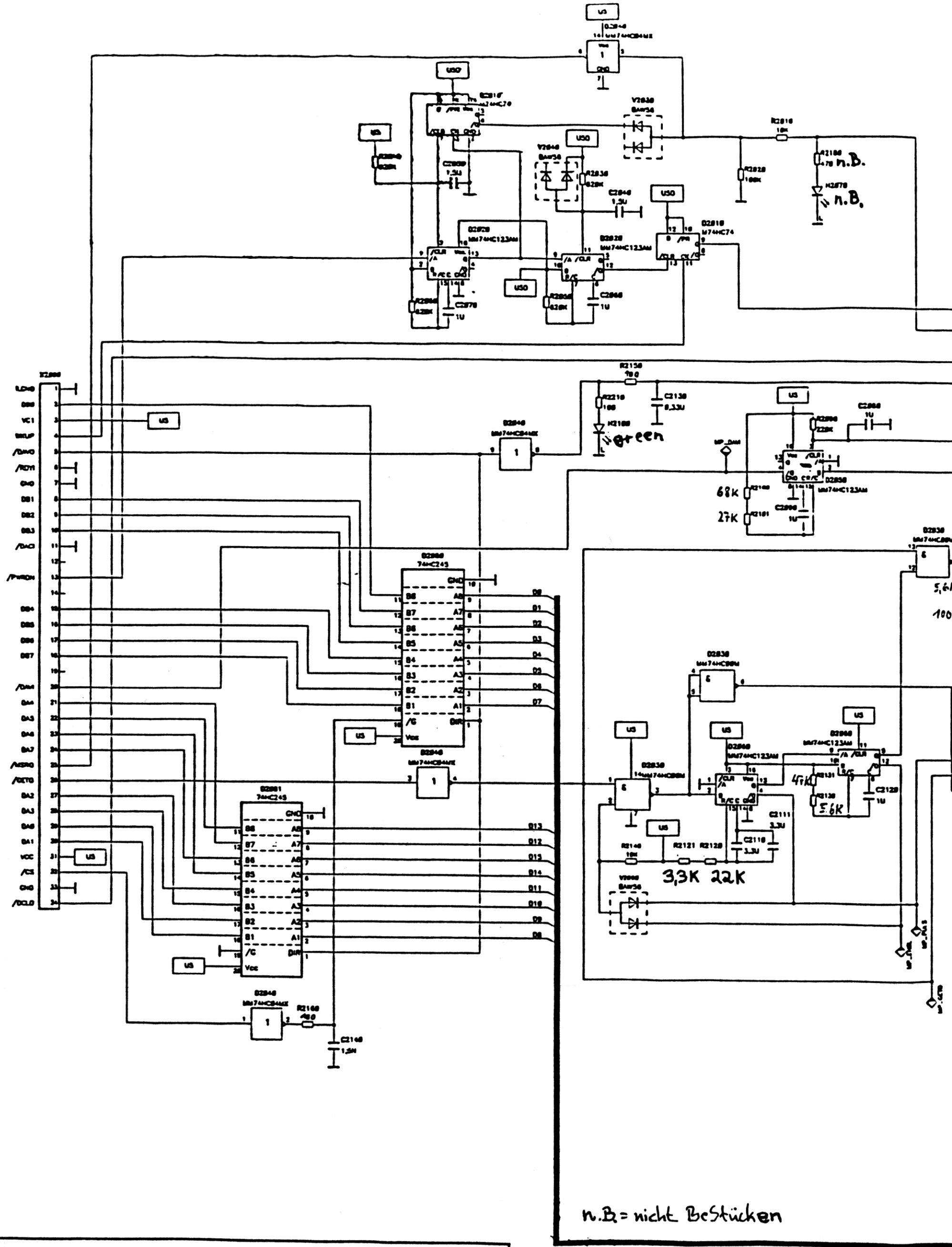
For reading two Bytes (16 Bit) from four input-ports to Alpha-Register, you need the following HP-41 control program. For NOP (No OPeration) enter X< >X two times generating 60 msec delay.

LBL IN1	LBL IN2	LBL IN3	LBL IN4
TRIGGER	TRIGGER	TRIGGER	TRIGGER
NOP	TRIGGER	TRIGGER	TRIGGER
NOP	NOP	TRIGGER	TRIGGER
NOP	NOP	NOP	TRIGGER
TRIGGER	TRIGGER	TRIGGER	TRIGGER
2	2	2	2
INAN	INAN	INAN	INAN
CLX	CLX	CLX	CLX
RTN	RTN	RTN	RTN

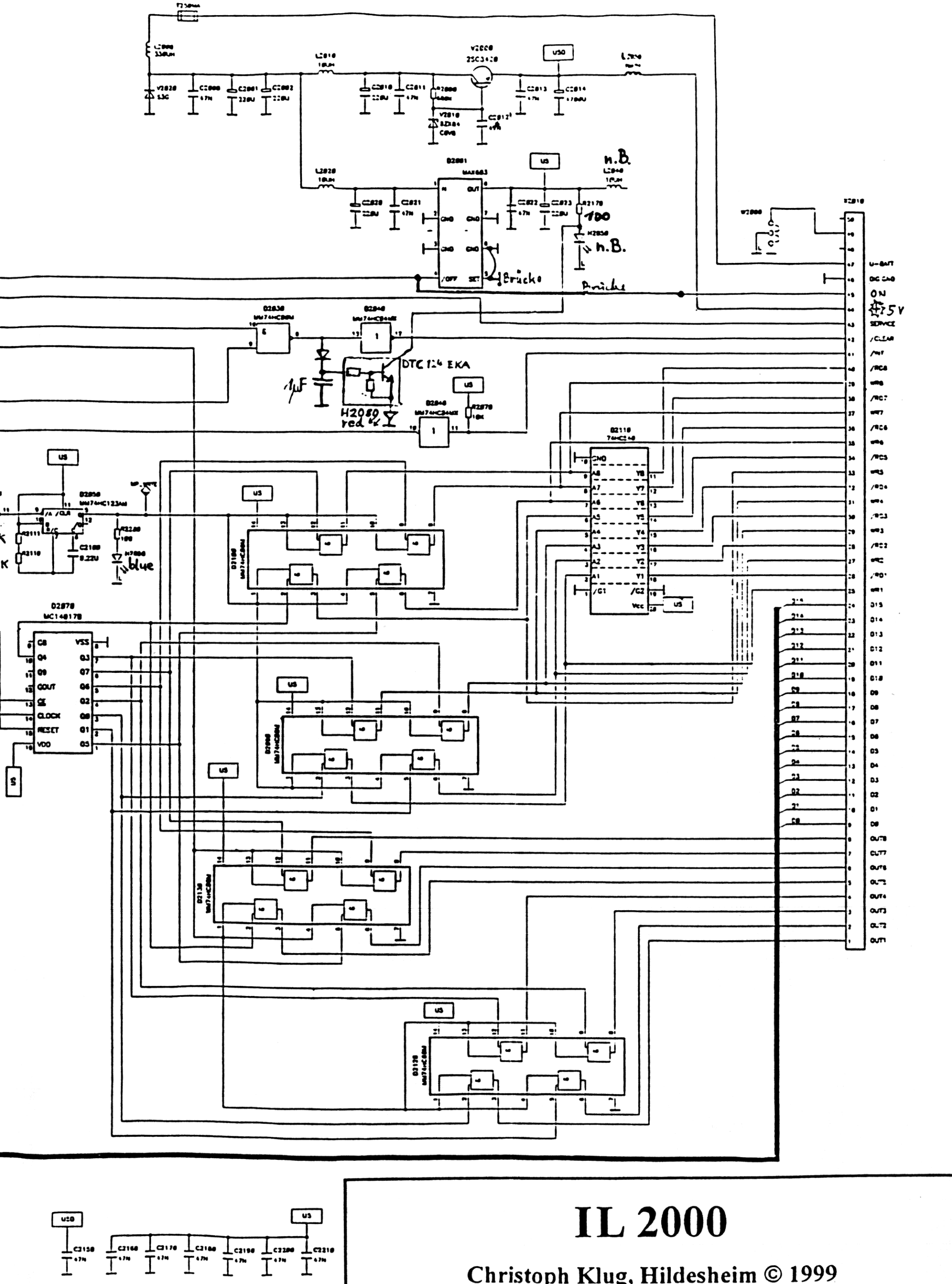
Three Colour Diagnose LED :

For displaying operation activity of IL2000 board with only one Diagnose LED insert a multi-colour RGB-LED LF59EMBGMBW : Flashing red indicates Power On Reset or CLEAR. Flashing green indicates data output, and flashing blue indicates data input. A small hardware modification expands Clear pulse for driving the red LED. Replace R2190 with SMD diode and DTC124 transistor. For R2170 insert 100Ω. Follow the wiring diagram below. Active MSQR signal and +5V of IL2000 power supply are not displayed.





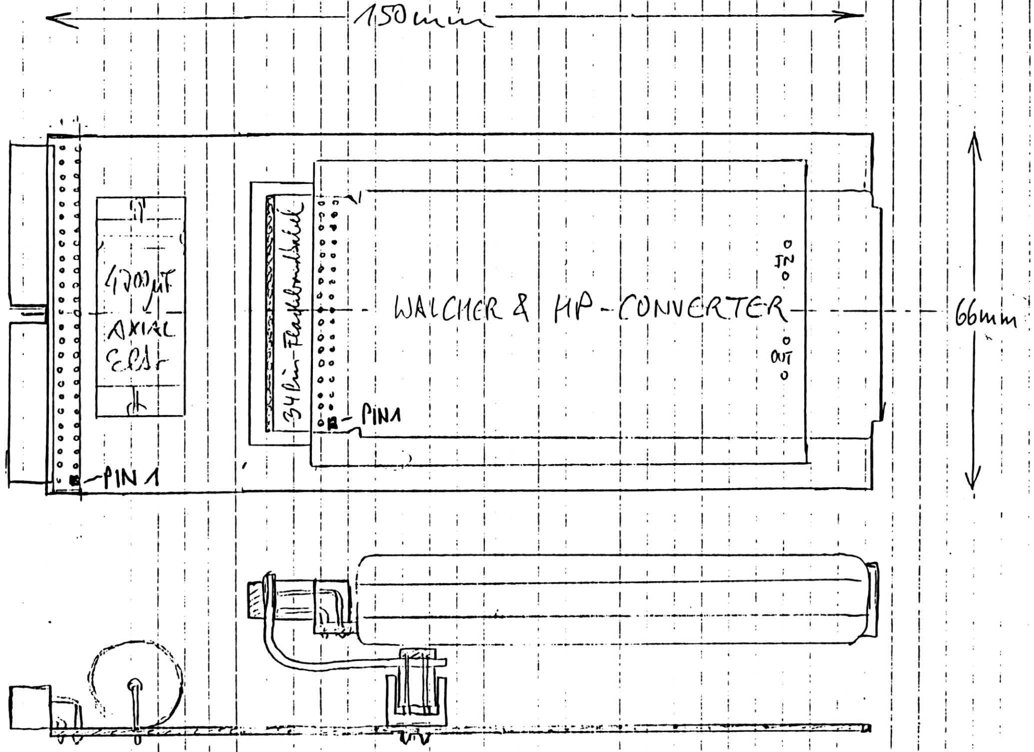
Durch Einstellen der Pulslänge mittels R2120 und R2121 wird die Anzahl der addressierten 16 Bit I/O festgelegt. Die Voreinstellung ist 2 x 16 Bit I/O. maximal sind 8 x 16 Bit I/O möglich.



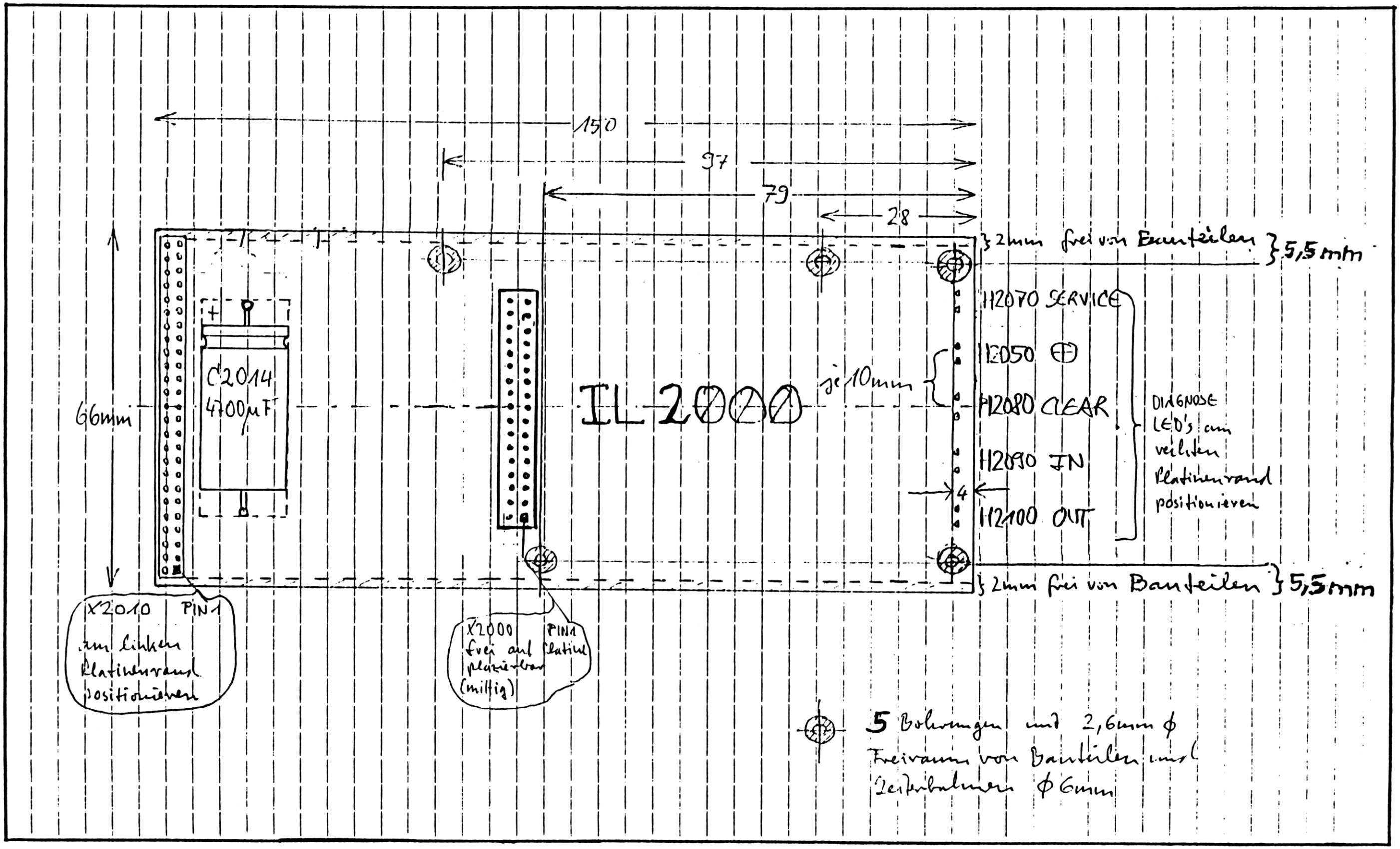
IL 2000

Christoph Klug, Hildesheim © 1999

IL 2000

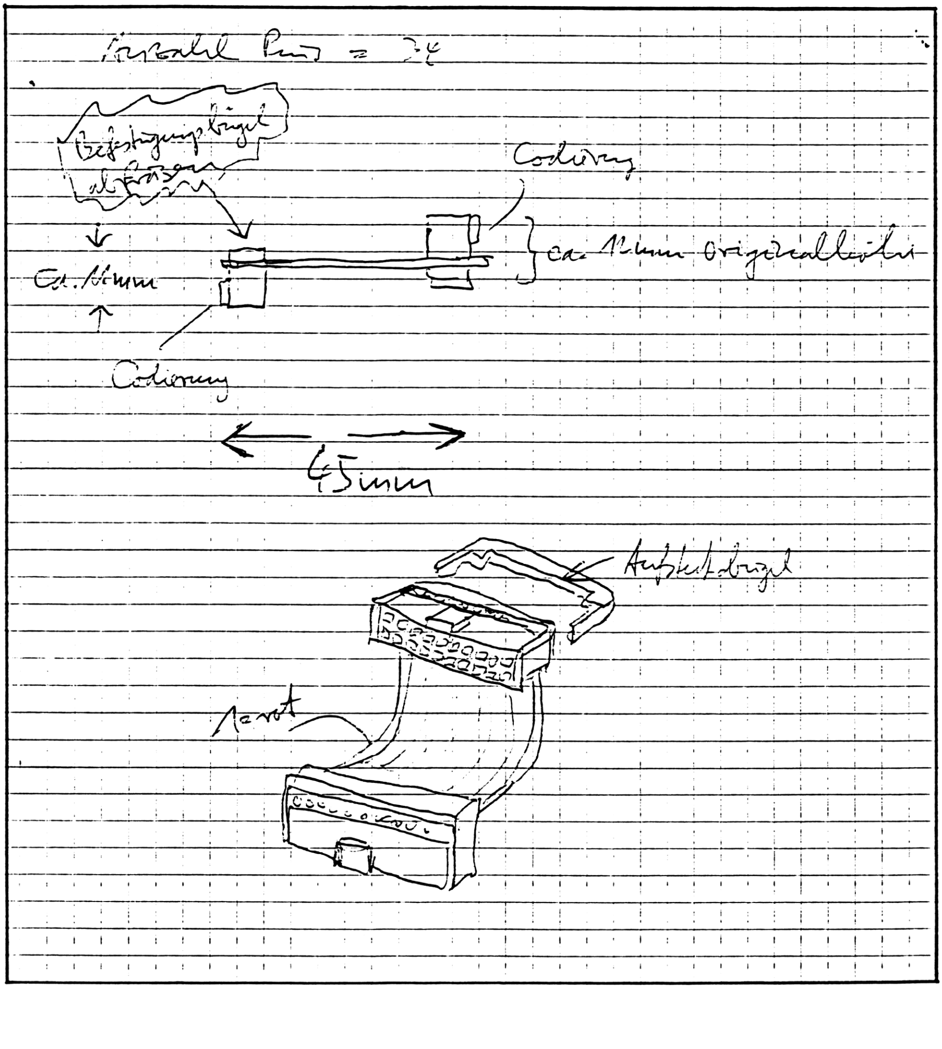

150mm
66mm
WALCHER & HP-CONVERTER
IN
OUT
PIN1
34Pin-Flachbandkabel
4700µF
AXIAL
PIN 1

IL 2000



150
97
79
28
2mm frei von Bauteilen
5,5mm
2mm frei von Bauteilen
5,5mm
66mm
C2014
4700µF
IL 2000
je 10mm
H2070 SERVICE
H2050
H2080 CLEAR
H2090 IN
H2100 OUT
4
DIAGNOSE LED's am rechten Platinenrand positionieren
X2010 PIN1
am linken Platinenrand positionieren
X2000 PIN1
frei auf Platine plazierbar (mittig)
5 Bohrungen mit 2,6mm ϕ
Freiraum von Bauteilen und Leiterbahnen ϕ 6mm

34 Pin Ribbon Wire IL-Converter :



34 Pin IL-Converter Connector :

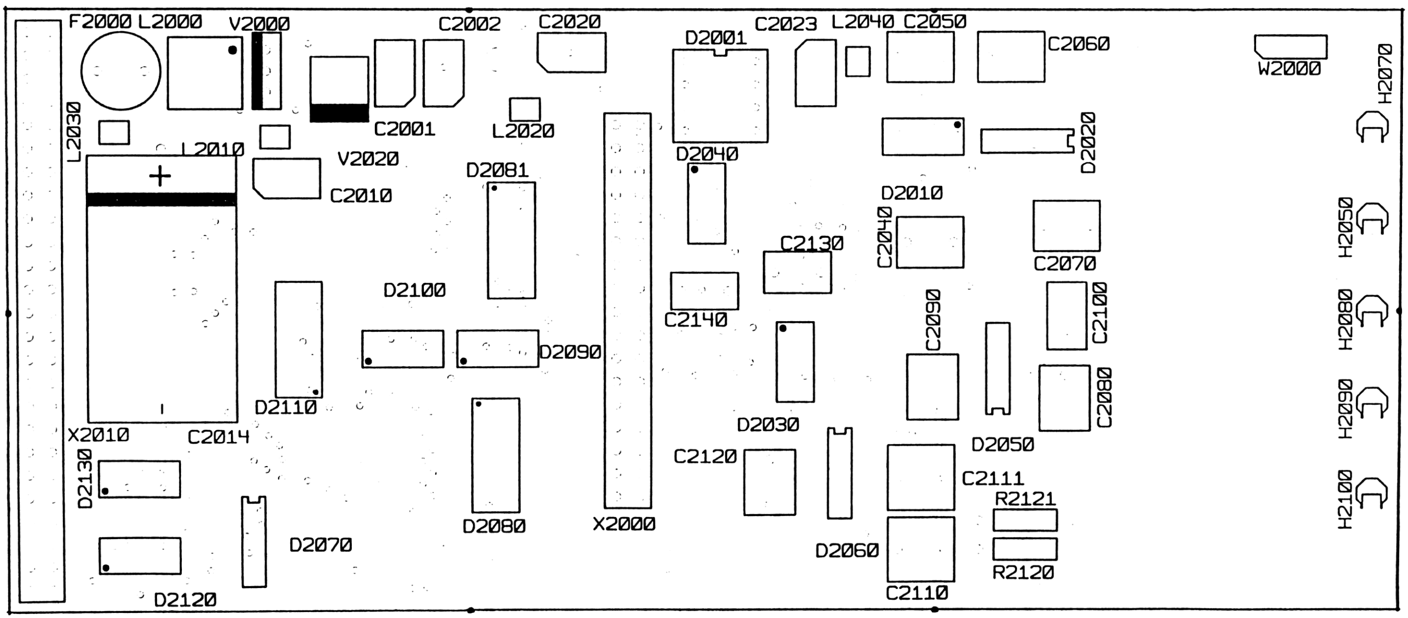
pinning shown from component side
2 x 17 Pin   2,54mm

Device Clear Output	$\overline{\text{DCLO}}$	34	33	GND	Ground
Internal Chip Select	$\overline{\text{CS}}$	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	$\overline{\text{GETO}}$	26	25	$\overline{\text{MSRQ}}$	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	$\overline{\text{PWDN}}$	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

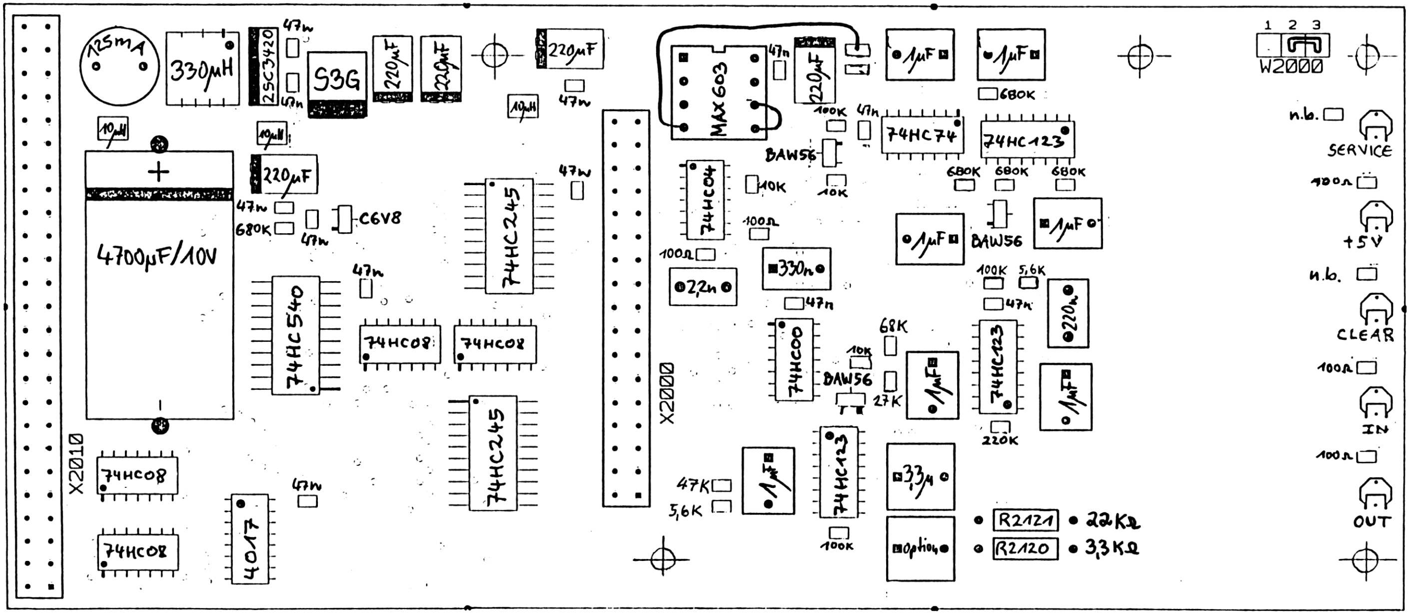
Bauteil	Wert	Gehäuse	Bemerkung
C2000	47 nF	Chip 0805	
C2001	220uF 10V	Tantal Chip	
C2002	220uF 10V	Tantal Chip	
C2010	220uF 10V	Tantal Chip	
C2011	47 nF	Chip 0805	
C2012	47 nF	Chip 0805	
C2013	47 nF	Chip 0805	
C2014	4700uF Axial-Elko	RM 31mm x 16 mm	mit Kaptonfolie abkleben
C2020	220uF/10V	Tantal Chip	
C2021	47 nF	Chip 0805	
C2022	47 nF	Chip 0805	
C2023	220uF/10V	Tantal Chip	
C2040	1 uF	Wima	
C2050	1 uF	Wima	
C2060	1 uF	Wima	
C2070	1 uF	Wima	
C2080	1 uF	Wima	
C2090	1 uF	Wima	
C2100	220 nF	Wima	
C2110	3,3 uF	Wima	
C2111	XXX	Wima	Option / nicht bestücken
C2120	1 uF	Wima	
C2130	330 nF	Wima	
C2140	2.2 nF	Wima	
C2150	47 nF	Chip 0805	
C2160	47 nF	Chip 0805	
C2170	47 nF	Chip 0805	
C2180	47 nF	Chip 0805	
C2190	47 nF	Chip 0805	
C2200	47 nF	Chip 0805	
C2210	47 nF	Chip 0805	
D2000	MAX 603	Regler DIP 8polig	Masse-Brücke von Pin5 auf Pin6
D2010	74HC74	SO 14 Flip Flop	
D2020	74HC123A	SO 16 Monoflop	
D2030	74HC00	SO 14 Nand	
D2040	74HC04	SO 14 Inverter	
D2050	74HC123A	SO 16 Monoflop	
D2060	74HC123A	SO 16 Monoflop	
D2070	CMOS 4017	SO 16 Counter	
D2080	74HC245	SO 20 Tranceiver	
D2081	74HC245	SO 20 Tranceiver	
D2090	74HC08	SO 14 And	
D2100	74HC08	SO 14 And	
D2110	74HC540	SO 20 Oct Invert	
D2120	74HC08	SO 14 And	
D2130	74HC08	SO 14 And	
F2000	250 mA	Kleinsicherung	
H2050	LED +5V	RM 2,54 bedrahtet	n.B.

Bauteil	Wert	Gehäuse	Bemerkung
H2070	LED SERVICE	RM 2,54 bedrahtet	n.B.
H2080	LED CLEAR	RM 2,54 bedrahtet	RGB-LED flashing red
H2090	LED IN	RM 2,54 bedrahtet	RGB-LED flashing blue
H2100	LED OUT	RM 2,54 bedrahtet	RGB-LED flashing green
L2000	330 uH	SMD Spule	
L2010	10 uH	SMD Spule 1210	
L2020	10 uH	SMD Spule 1210	
L2030	10 uH	SMD Spule 1210	
L2040	nicht bestücken	Brücke an MAX603 Pin4 = ON-Signal	
MP GETO	Meßpunkt	GETO = Trigger-Signal von IL-Converter	
MP PULS	Meßpunkt	Pulsdauer bestimmt die mögliche Anzahl der 16 Bit I/O	
MP ENBL	Meßpunkt	WR Enable 60ms	
MP WRTE	Meßpunkt	WRITE 25ms	
MP DAVI	Meßpunkt	DAVI 100ms	
R2000	680 KOhm	Chip 0805	
R2010	10 KOhm	Chip 0805	
R2020	100KOhm	Chip 0805	
R2030	680KOHM	Chip 0805	
R2040	680KOhm	Chip 0805	
R2050	680KOhm	Chip 0805	
R2060	680KOhm	Chip 0805	
R2070	10 KOhm	Chip 0805	
R2090	220 KOhm	Chip 0805	
R2100	68KOhm	Chip 0805	Tau= 100 ms
R2101	27KOhm	Chip 0805	Tau= 100 ms
R2110	100KOhm	Chip 0805	Tau= 25 ms
R2111	5,6KOhm	Chip 0805	Tau= 25 ms
R2120	22KOhm	bedrahtet ¼ Watt	Addressierung für 2 x 16 Bit I/O
R2121	3,3KOhm	bedrahtet ¼ Watt	Addressierung für 2 x 16 Bit I/O
R2130	47KOhm	Chip 0805	Tau= 60 ms
R2131	5,6KOhm	Chip 0805	Tau= 60 ms
R2140	10 KOhm	Chip 0805	
R2150	100 Ohm	Chip 0805	
R2160	100 Ohm	Chip 0805	
R2170	100 Ohm	Chip 0805	Resistance driving RGB-LED
R2180	n.B.	Chip 0805	
R2190	n.B.	Chip 0805	SMD-Diode driving RGB-LED
R2200	100 Ohm	Chip 0805	Resistance driving RGB-LED
R2210	100 Ohm	Chip 0805	Resistance driving RGB-LED
V2000	2SC3420	10W/25 TO 126	
V2010	C6V8 Z-Diode	SOT23	
V2020	S3G	Verpolschutzdiode	
V2030	BAW56 Doppeldiode	SOT23	
V2040	BAW56 Doppeldiode	SOT23	
V2060	BAW56 Doppeldiode	SOT23	
W2000	3polig, RM 2,54m	Stiftleiste für Jumper	
X2000	34polig, RM 2,54m	Stiftleiste zweireihig	
X2010	50polig, RM 2,54m	Steckerwanne zweireihig	

IL2000 Interface Board

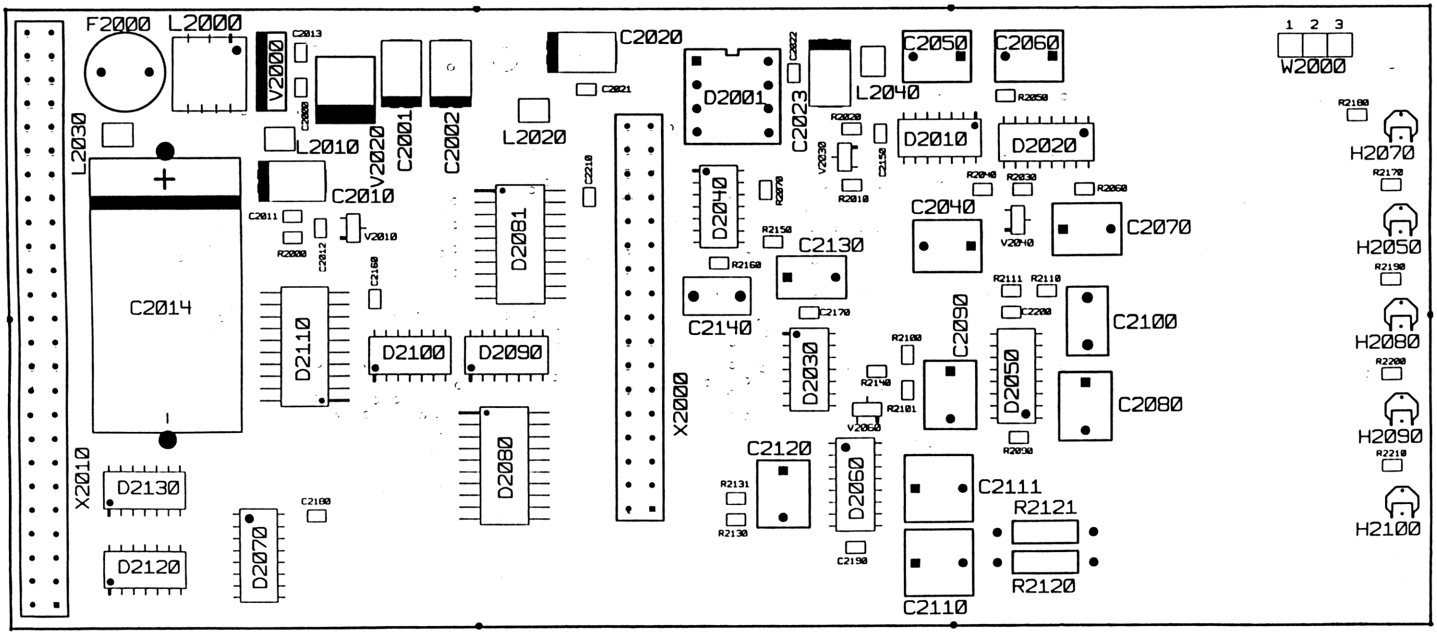


IL2000 Interface Board



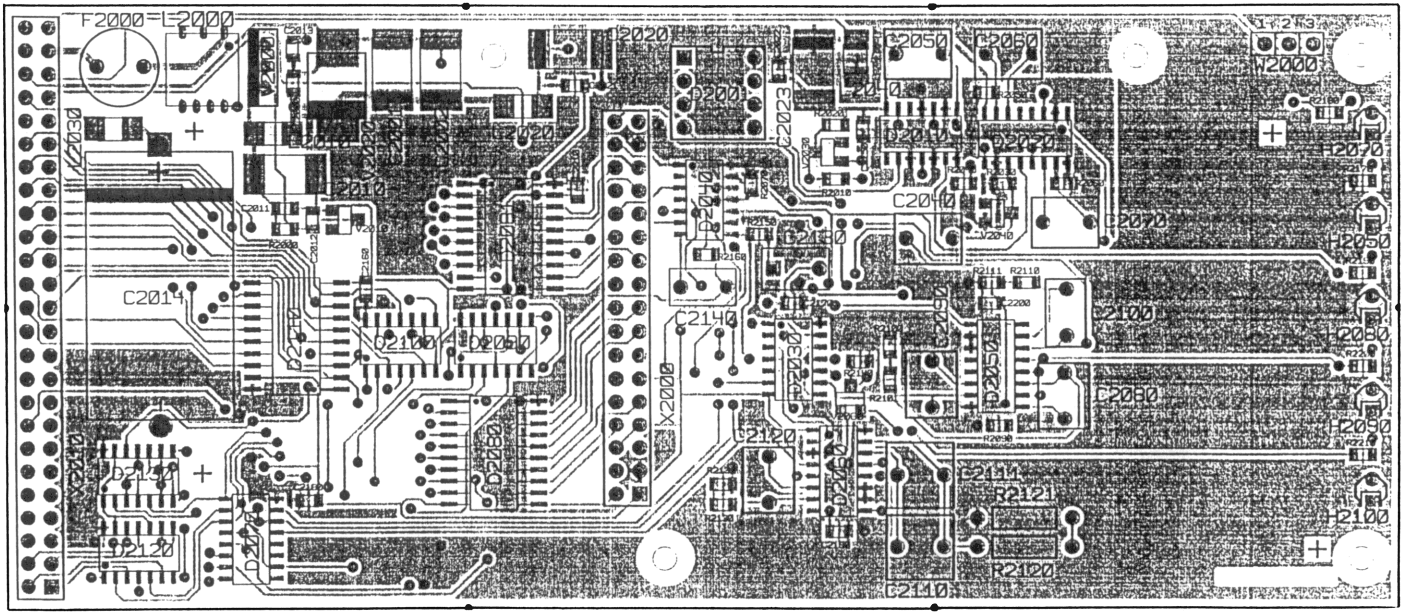
IL 2000

IL2000 Interface Board



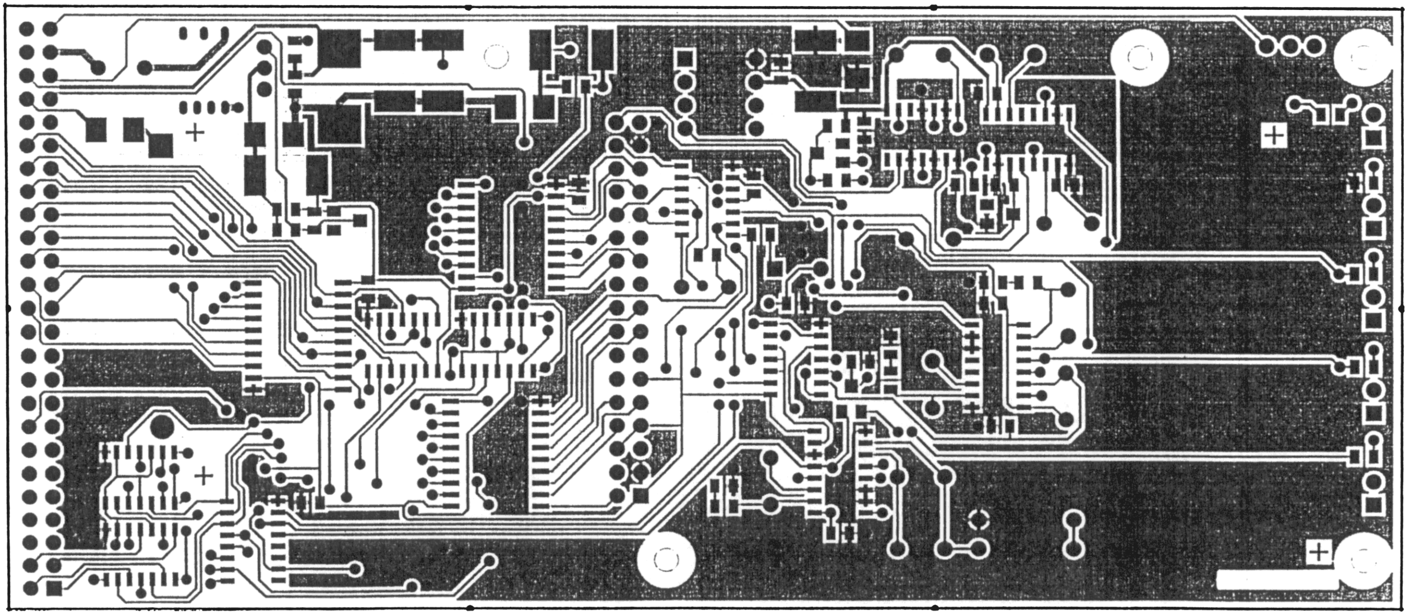
IL 2000

I L2000 Interface Board



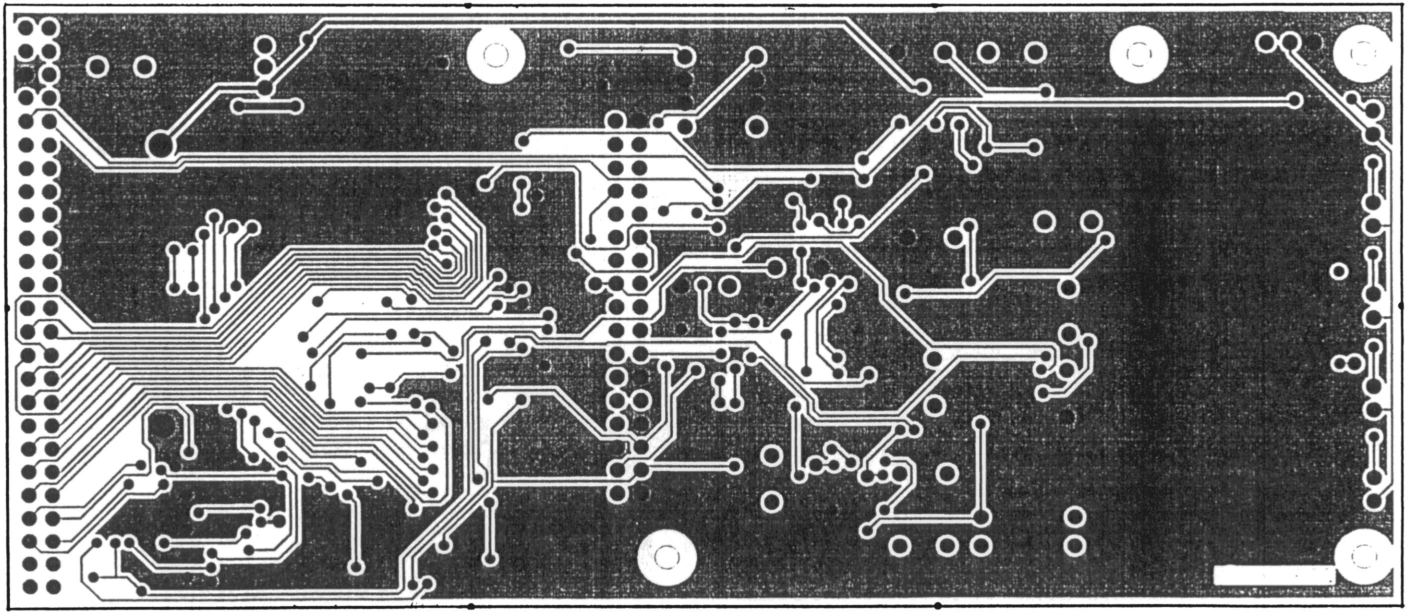
IL 2000

I L2000 Interface Board

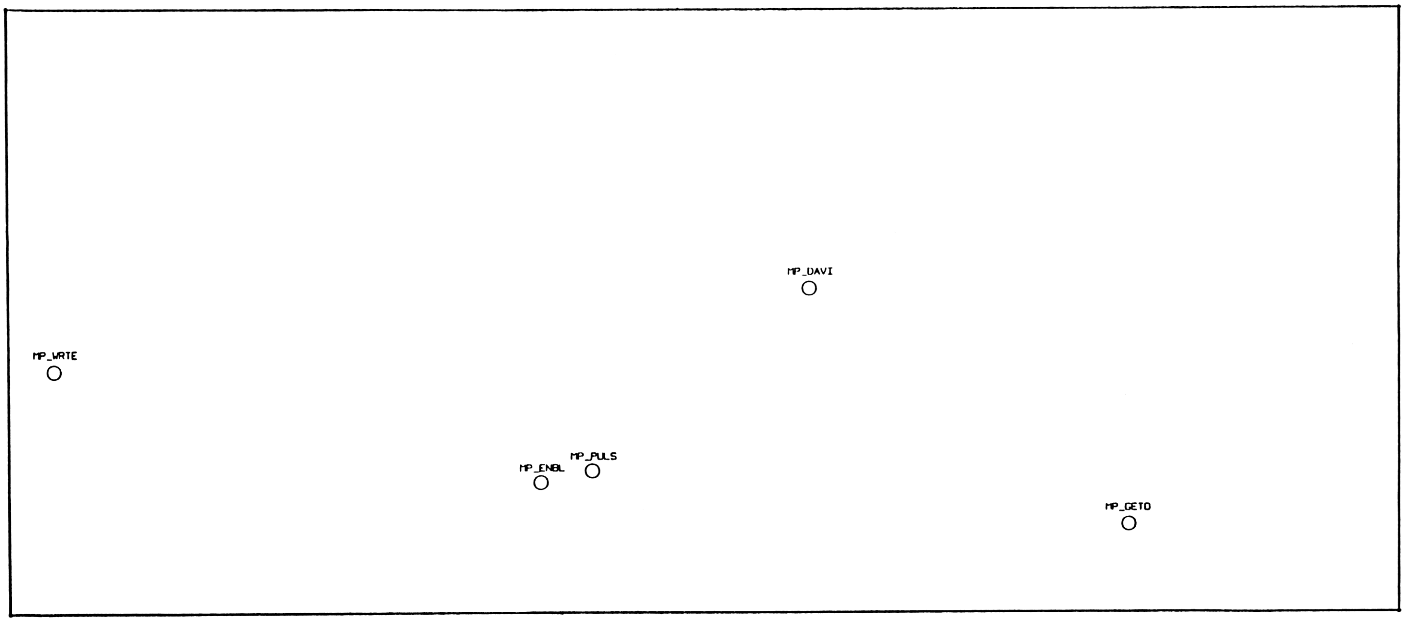


IL 2000

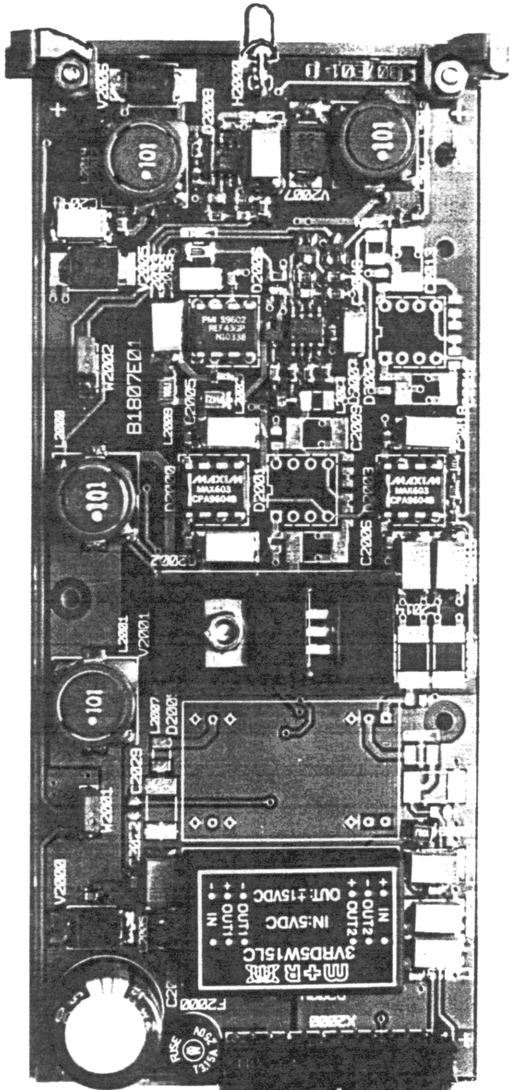
IL2000 Interface Board



IL2000 Interface Board



POW2000
Power Supply Board



POW2000 Board :

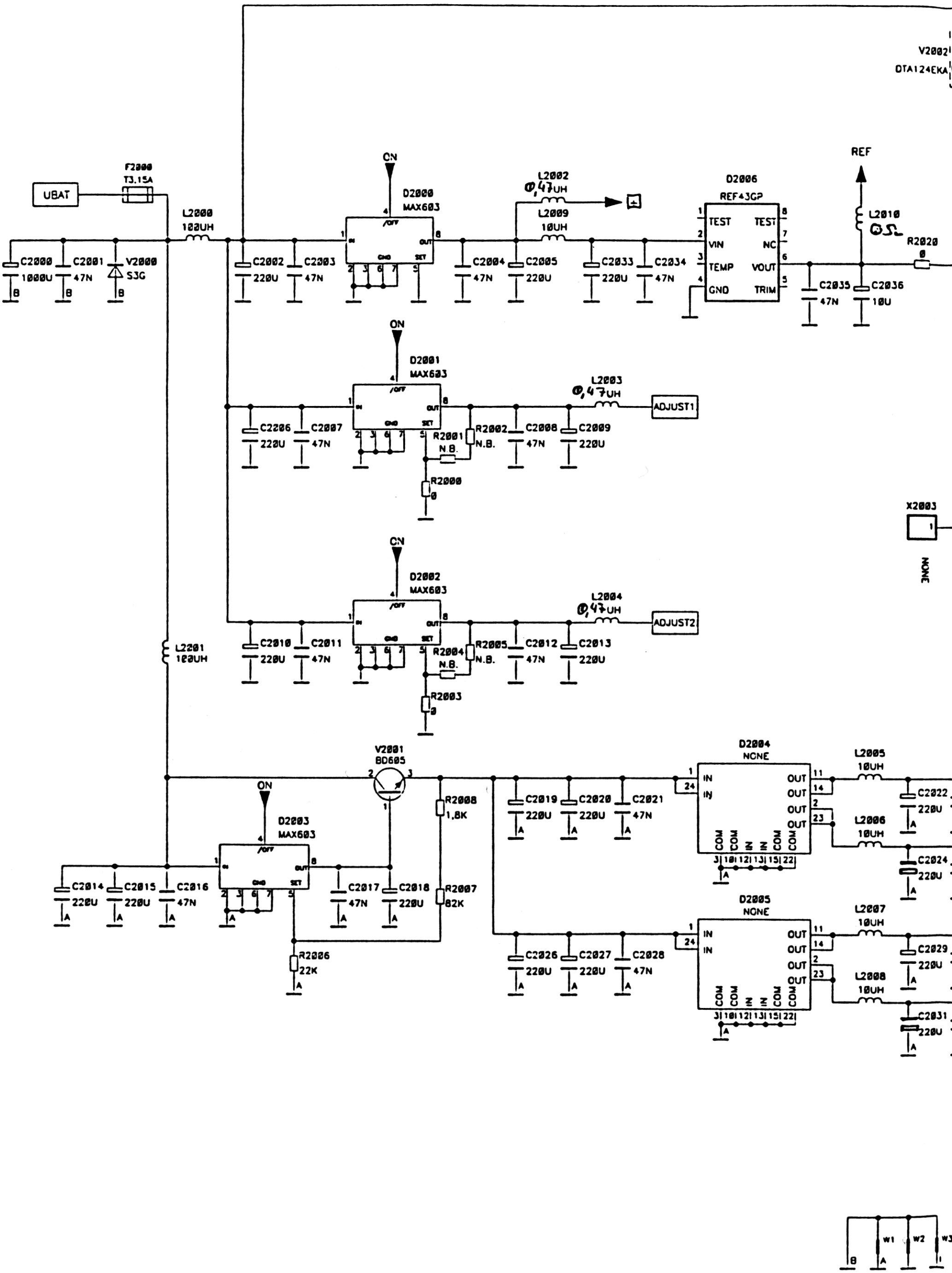
POW2000 board generates some different supply voltages from an external +6V lead cell : Input line is protected by 3.15A fuse F2000 and reverse voltage polarity protection diode V2000. L2000 + C2002,C2006,C2010 and L2001 + C2014,C2015 attenuates external spikes from supply line. Low drop voltage regulator D2000 generates +5V/500mA. Voltage regulator D2003 and transistor V2001 limiting input voltage and switching on/off DC/DC-Converter D2004, generating ±15V/±100mA.

This basic supply voltages expanded by following optional voltages : Two adjustable voltages like +3,3V/500mA or +5V/500mA generated by voltage regulators D2001 and D2002. For adjusting voltages set resistor networks R2000,R2001+R2002 and R2003,R2004+R2005. Symmetric voltages ±5V/±300mA or ±12V/±125mA or ±15V/±100mA generated by optional DC/DC-Converter D2005.

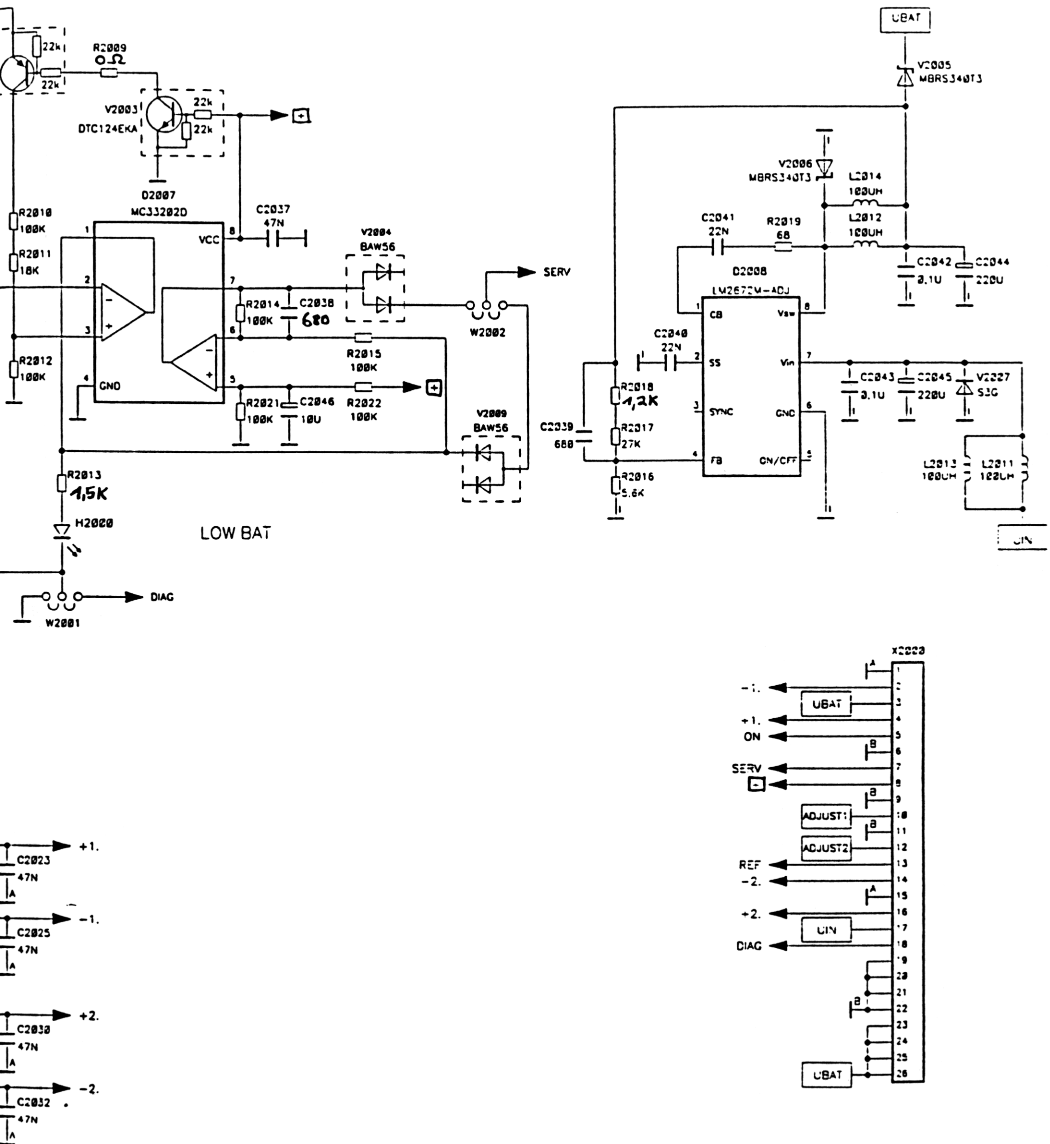
Furthermore exist a +2,5V reference voltage (D2006), a low bat indicator circuit (comparator D2007) including low current Power-LED H2000. LED is grounded by Jumper W2001, or external by grounding DIAG line. For H2000 insert a red low current LED HLMP-D155 and enlarge R2013 to 1,5KΩ. If battery voltage is lower than +5,5V, low bat indicator circuit sets MSRQ line (Jumper W2002) and switches off LED.

For mobile long time applications exist an optional high efficiency voltage regulator D2006 (step down converter) for loading +6V lead cell by external solar pannel. Solar pannel input is protected by reverse voltage polarity diode V2007 and filter L2013 + C2045.

Three existing mounting holes make possible stacking the POW2000 board to IL2000 board and IL-Converter. On rear side exist a 26 pin connector with control lines and power supply lines.

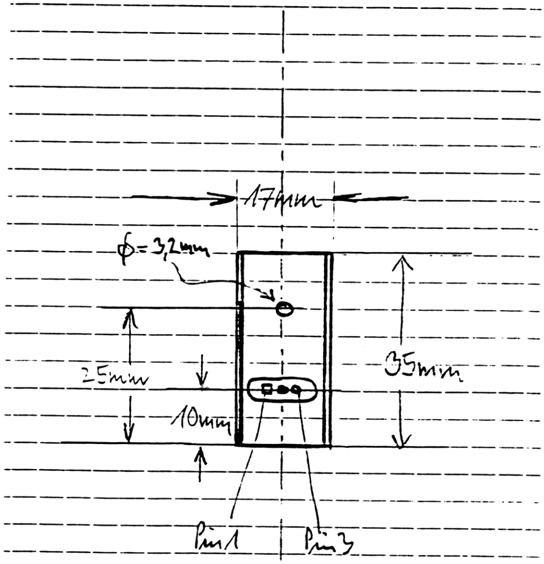


V2002
DTA124EKA
REF
UBAT
F2000
T3.15A
L2000
100UH
ON
D2000
MAX603
L2002
0,47UH
L2009
10UH
D2006
REF43GP
TEST
VIN
TEMP
GND
NC
VOUT
TRIM
L2010
0Ω
R2020
0
C2000
1000U
C2001
47N
V2000
S3G
C2002
220U
C2003
47N
C2004
47N
C2005
220U
C2033
220U
C2034
47N
C2035
47N
C2036
10U
D2001
MAX603
L2003
0,47UH
ADJUST1
C2006
220U
C2007
47N
R2001
N.B.
R2002
N.B.
C2008
47N
C2009
220U
R2000
0
X2003
NONE
D2002
MAX603
L2004
0,47UH
ADJUST2
L2201
100UH
C2010
220U
C2011
47N
R2004
N.B.
R2005
N.B.
C2012
47N
C2013
220U
R2003
0
V2001
BD605
D2003
MAX603
R2008
1,8K
R2007
82K
R2006
22K
C2014
220U
C2015
220U
C2016
47N
C2017
47N
C2018
220U
C2019
220U
C2020
220U
C2021
47N
D2004
NONE
IN
OUT
COM
L2005
10UH
L2006
10UH
C2022
220U
C2024
220U
D2005
NONE
C2026
220U
C2027
220U
C2028
47N
L2007
10UH
L2008
10UH
C2029
220U
C2031
220U
W1
W2
W3



POW 2000

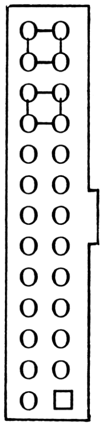
Christoph Klug, Hildesheim © 1999



heat sink V2001

26 Pin Power Bus Connector :

pinning shown from component side
2 x 25 Pin   2,54mm



	26	25	UBATT
	24	23	
	22	21	BATT GND
	20	19	
DIAG	18	17	UIN
+2	16	15	Analog GND
-2	14	13	REF
Adjust 1	12	11	Digital GND
Adjust 2	10	9	Digital GND
+	8	7	SERVICE
Digital GND	6	5	ON / OFF
+1	4	3	UBATT
-1	2	1	Analog GND

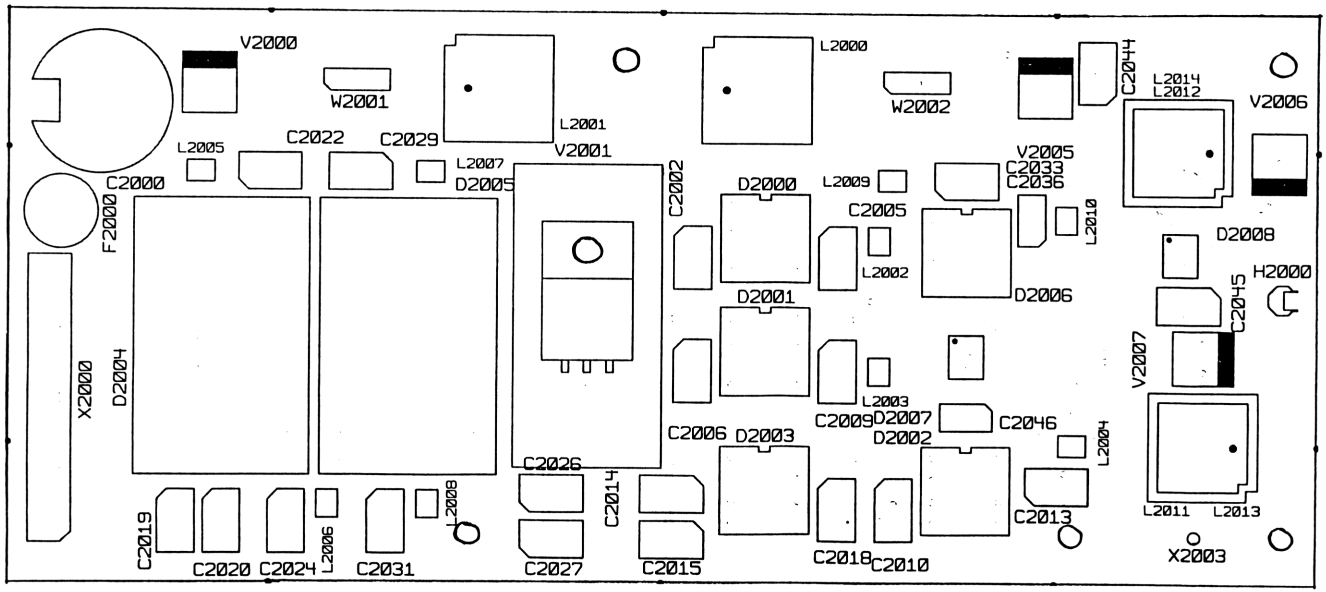
IL 2000

Bauteil	Wert	Bemerkung
X2000	Stiftleiste 2 x 13 Pin RM 2,54mm	
X2001	Jumper 3 Pin RM 2,54mm	
X2002	Jumper 3 Pin RM 2,54mm	
X2003	Stiftleiste 1 Pin	
C2000	1000uF	Elko stehend
C2001	47nF	
C2002	220uF	
C2003	47nF	
C2004	47nF	
C2005	220uF	
C2006	220uF	
C2007	47nF	
C2008	47nF	
C2009	220uF	
C2010	220uF	
C2011	47nF	
C2012	47nF	
C2013	220uF	
C2014	220uF	
C2015	220uF	
C2016	47nF	
C2017	47nF	
C2018	220uF	
C2019	220uF	
C2020	220uF	
C2021	47nF	
C2022	220uF	
C2023	47nF	
C2024	220uF	
C2025	47nF	
C2026	220uF	
C2027	220uF	
C2028	47nF	
C2029	220uF	
C2030	47nF	
C2031	220uF	
c2032	47nF	
C2033	220uF	
C2034	47nF	
C2035	47nF	
C2036	10uF/16V	
C2037	47nF	
C2038	1pF	
C2039	680pF	
C2040	22nF	
C2041	22nF	
C2042	100nF	
C2043	100nF	
C2044	220uF	
C2045	220uF	40 Volt / Elko
D2000	MAX303	8 Pin DIP

IL 2000

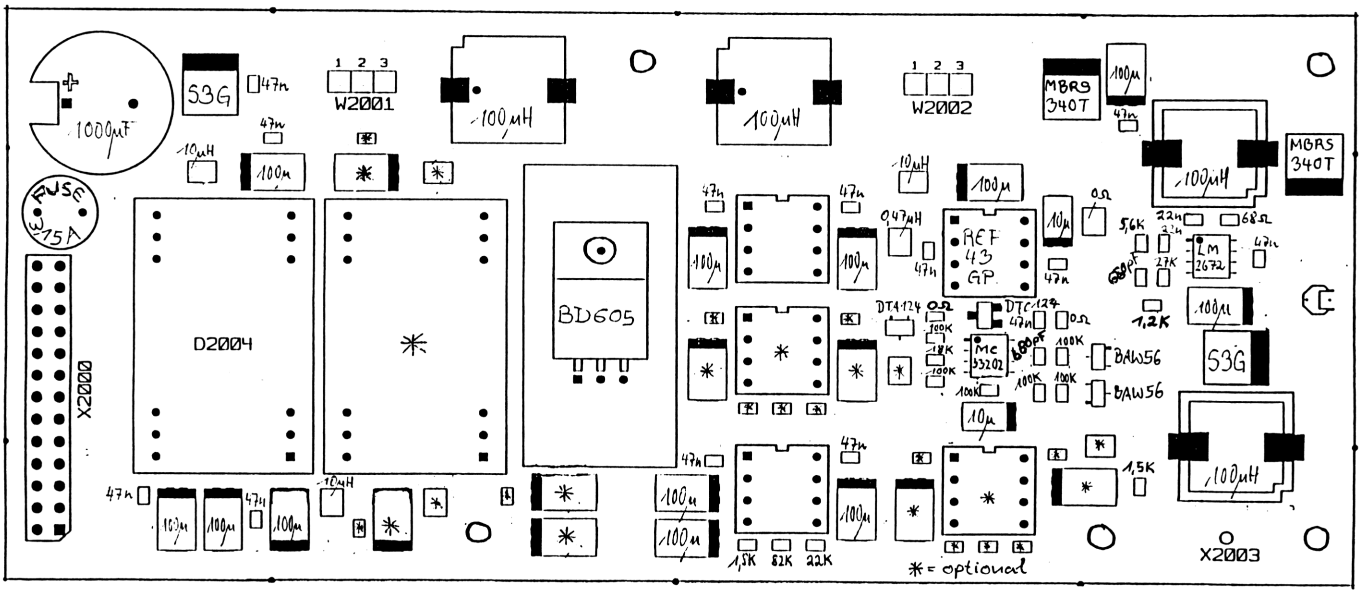
Bauteil	Wert	Bemerkung
D2001	MAX303	8 Pin DIP
D2002	MAX303	8 Pin DIP
D2003	MAX303	8 Pin DIP
D2004	3VRD5N15M	DC/DC Converter
D2005	3VRD5N15M	DC/DC Converter
D2006	REF43GP	8 Pin DIP
D2007	MC33202D	8 Pin SO Operationsverstärker
D2008	LM2672ADJ	8 Pin SO Schaltregler
H2000	LED red 5mm	RM 2.54mm low current
L2000	100uH	Imax=1,6A
L2001	100uH	Imax=1,6A
L2002	0,47uH	Imax=450mA
L2003	0,47uH	Imax=450mA
L2004	0,47uH	Imax=450mA
L2005	10uH	Imax=150mA
L2006	10uH	Imax=150mA
L2007	10uH	Imax=150mA
L2008	10uH	Imax=150mA
L2009	10uH	Imax=150mA
L2010	0 Ohm	Brücke
L2010	100uH	Bestückungsvariante möglich
L2011	100uH	Bestückungsvariante möglich
R2000	0 Ohm	
R2001	n.B.	
R2002	n.B.	
R2003	0 Ohm	
R2004	n.B.	
R2005	n.B.	
R2006	22k	
R2007	82k	
R2008	1,8k	
R2009	100k	
R2010	100k	
R2011	18k	
R2012	100k	
R2013	1,5k	
R2014	100k	
R2015	100k	
R2016	5,6k	
R2017	27k	
R2018	680 Ohm	
R2019	68 Ohm	
S2000	3,15A	
V2000	S3G	Verpolschutz
V2001	BD605	TO220 RM 2,54mm liegend, mit Kühlkörper !!!
V2002	DTA124EKA	
V2003	DTC124EKA	
V2004	BAW56	
V2005	MBRS340T3	Diode
V2006	MBRS340T3	Diode
V2007	S3G	Verpolschutz
V2008	BAW56	

POW2000 Power Supply Board



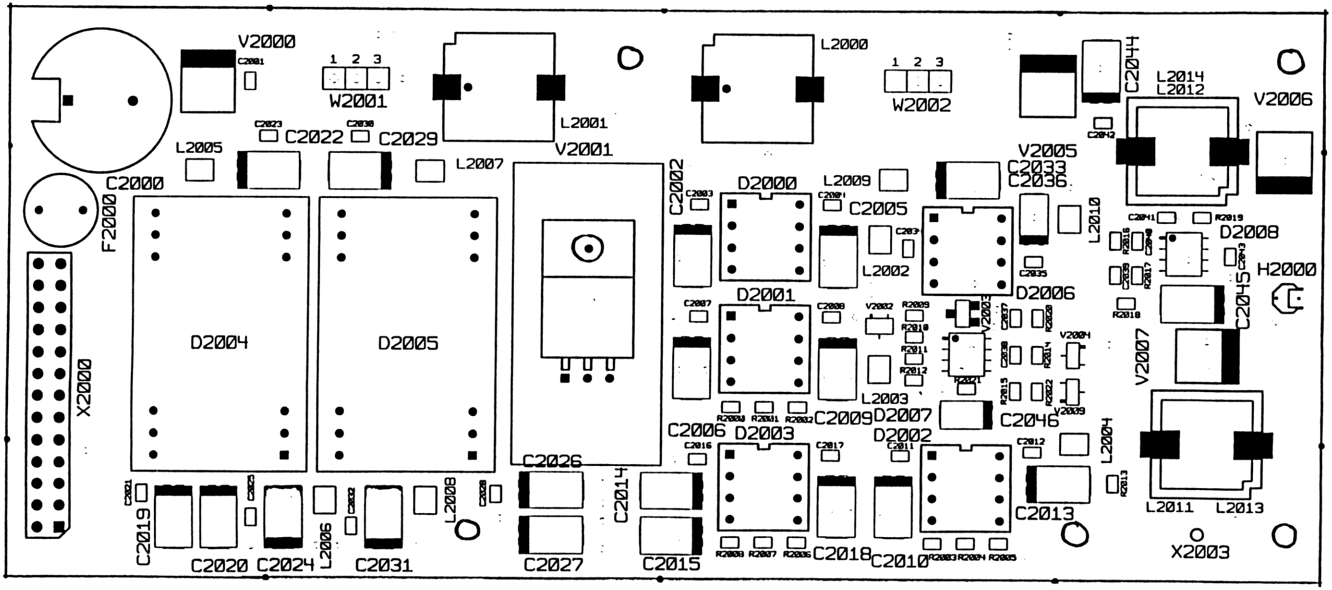
IL 2000

POW2000 Power Supply Board

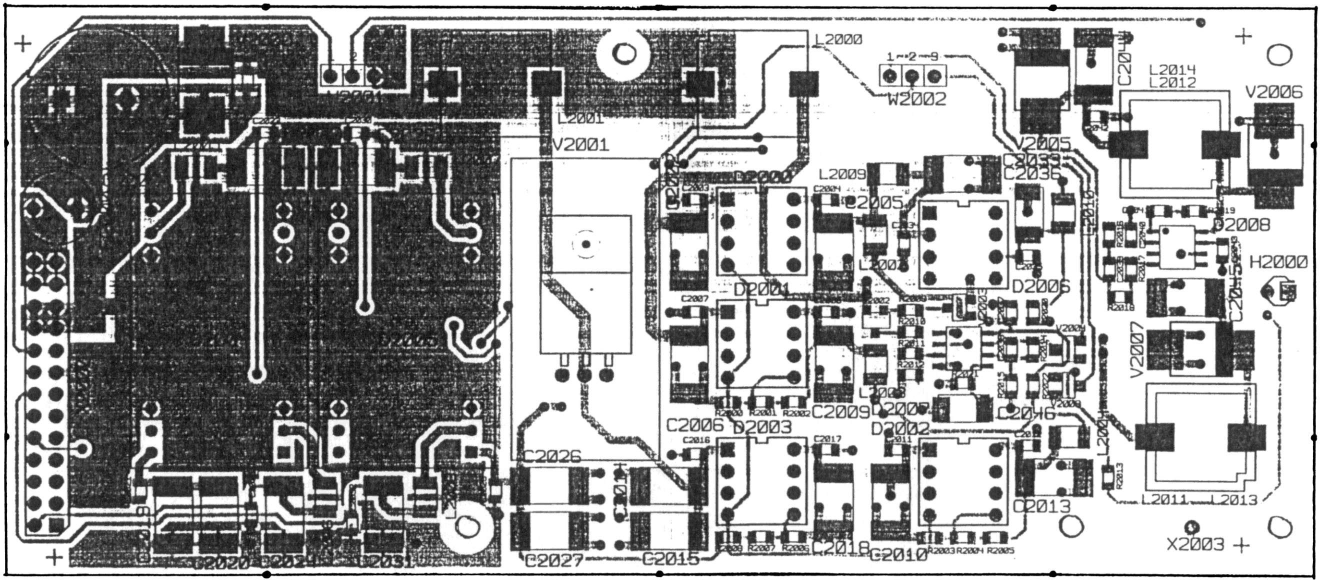


IL 2000

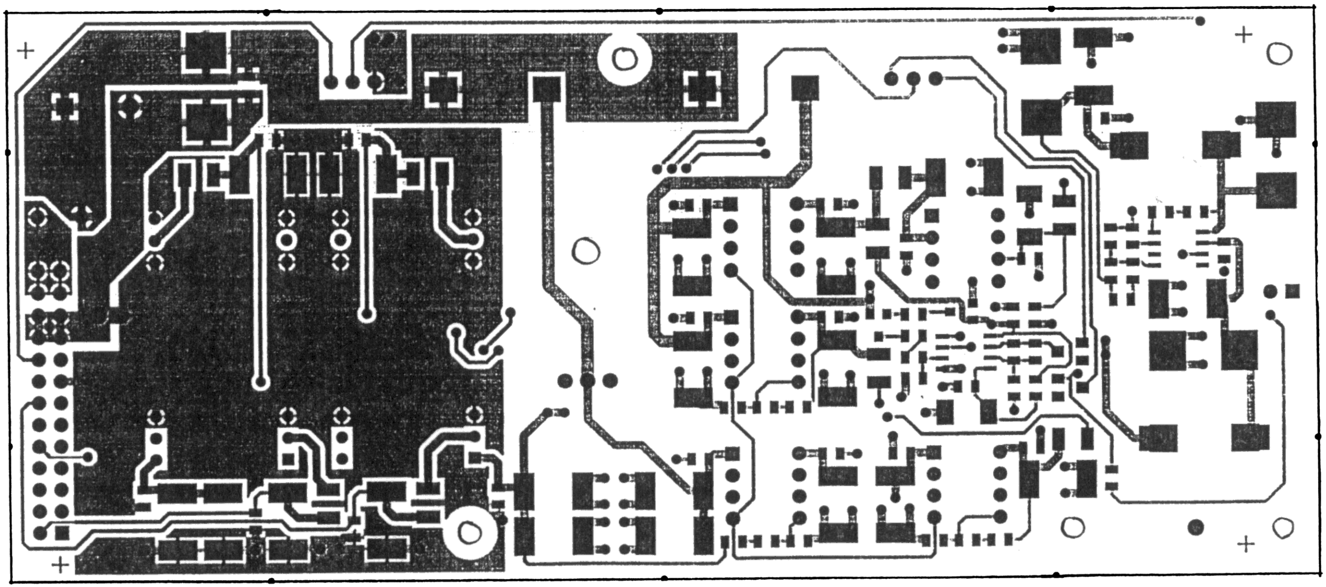
POW2000 Power Supply Board



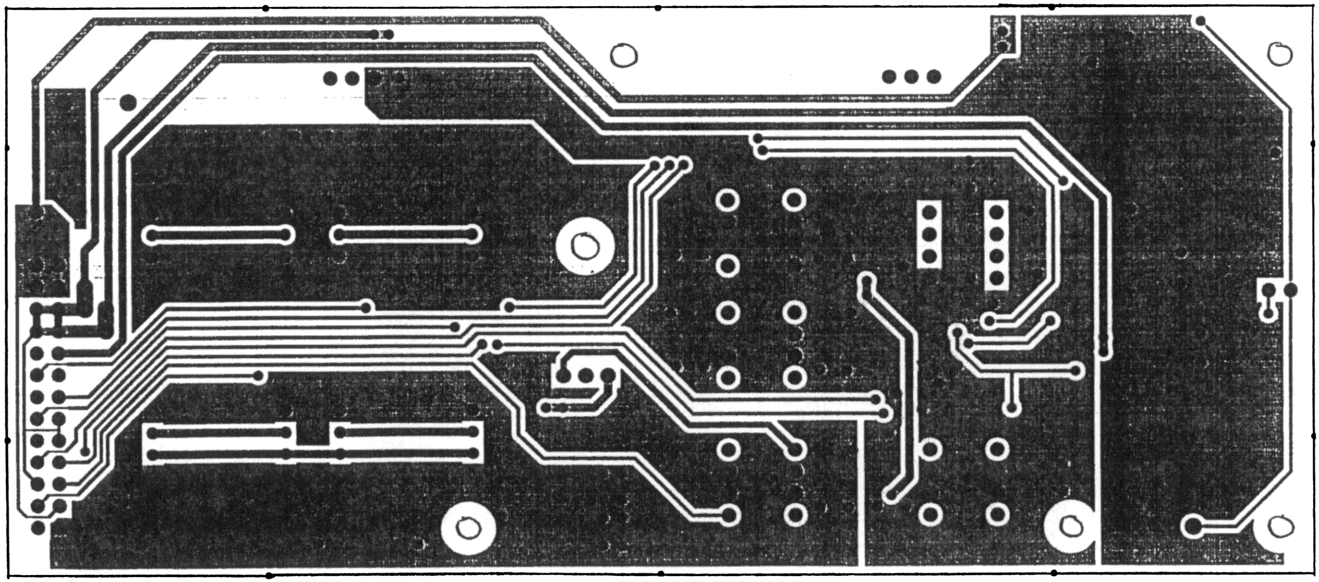
POW2000 Power Supply Board



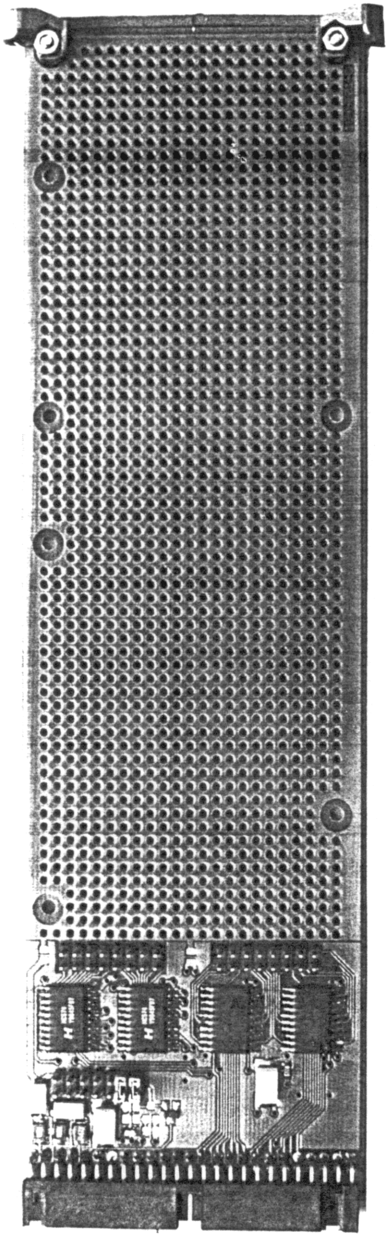
POW2000 Power Supply Board



POW2000 Power Supply Board



DIG2000 Digital Input/Output-Board



DIG2000 16 Bit digital Input/Output Board :

DIG2000 board is connected to 50 pin data-handshake-power supply bus of IL2000 board by flat ribbon wire and X2000 terminal. DIG2000 contains some hardware circuits for digital I/O applications : Two 74HC273 octal D-Flip-Flops with clear function used for 16 Bit digital output wired to output-terminal X2010. Clear is activated during power on and by HP-41 command CLRDEV. Two 74HC574 octal D-Flip Flops with tristate outputs used for 16 Bit digital input on input-terminal X2020.

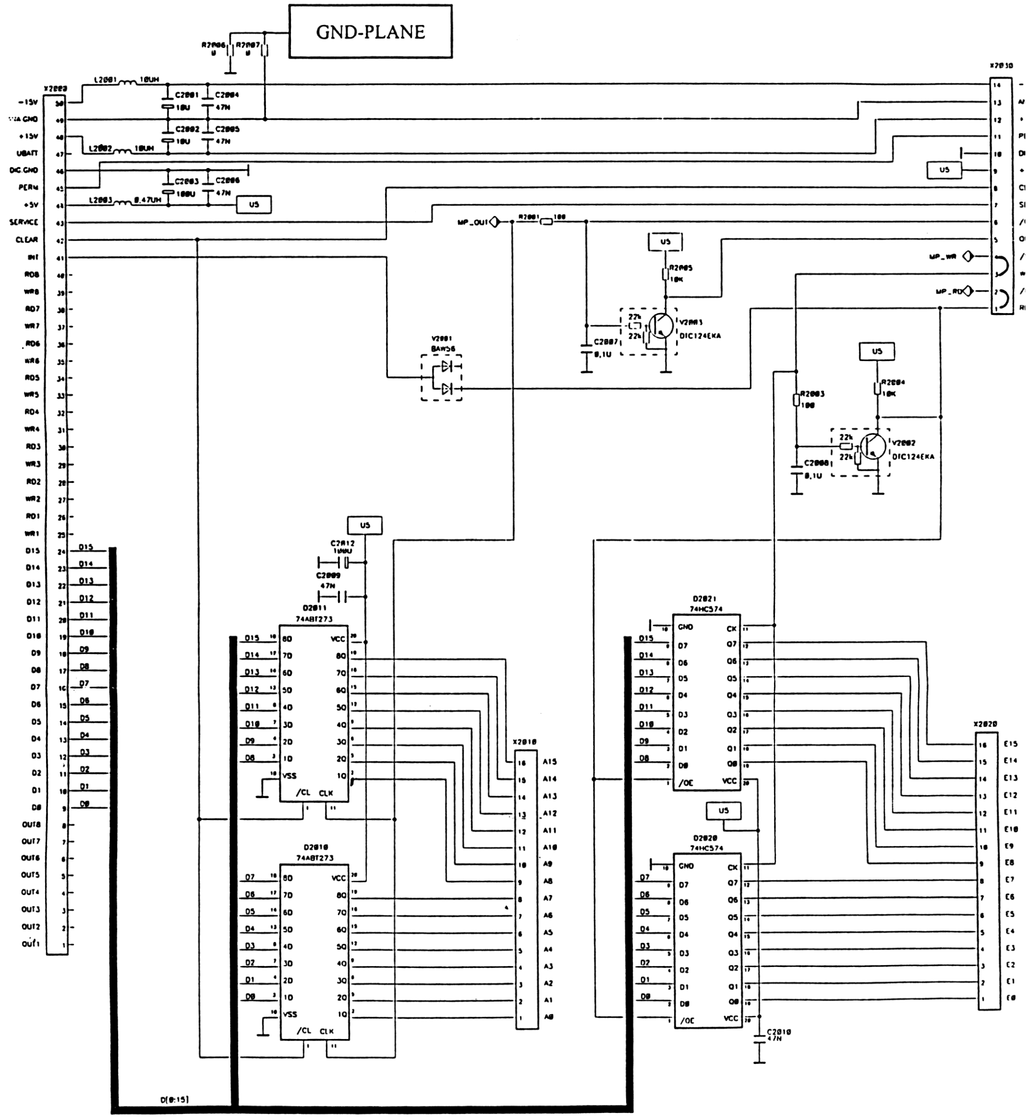
Terminal X2030 exist for wiring some 50 pin bus lines like CLEAR, SERVICE (MSRQ) and power supply lines permanent 5V, digital +5V and analog ±15V. For setting output-address of DIG2000 board, wire one output-handshakeline from OUT1...OUT8 terminals of X2000 to MP_OUT. For setting input-address wire two handshakelines from RD1...RD8 and WR1...WR8 terminals of X2000 to MP_RD and MP_WR. Handshakelines than availlable on X2030 terminal.

For standard output applications set R2001 to 0Ω and work without C2007. Some optional circuits exist for expanding output-handshake : R2001 and C2007 delays OUT signal. Use optional transistor V2003 for inverting OUT singnal.

For standart input applications you do not need R2003, C2008, R2004 and V2002. Insert two jumpers for connecting pin 1+2 and pin 3+4 of terminal X2030. Following circuits expand input-handshake : /WR signal is wired to X2030 for sending data input-trigger puls to extern hardware extensions. This sends 16 bit data to input-terminal X2020 and responses by sending WR pules to X2030. Data stored in D2020 and D2021. R2003 and C2008 delays WR pulse and transistor V2002 generates an inverted RD signal for activating tristate outputlines of D2020 and D2021. Furthermore RD signal pulls down INT line (wired or of IL2000 board) by diode V2001.

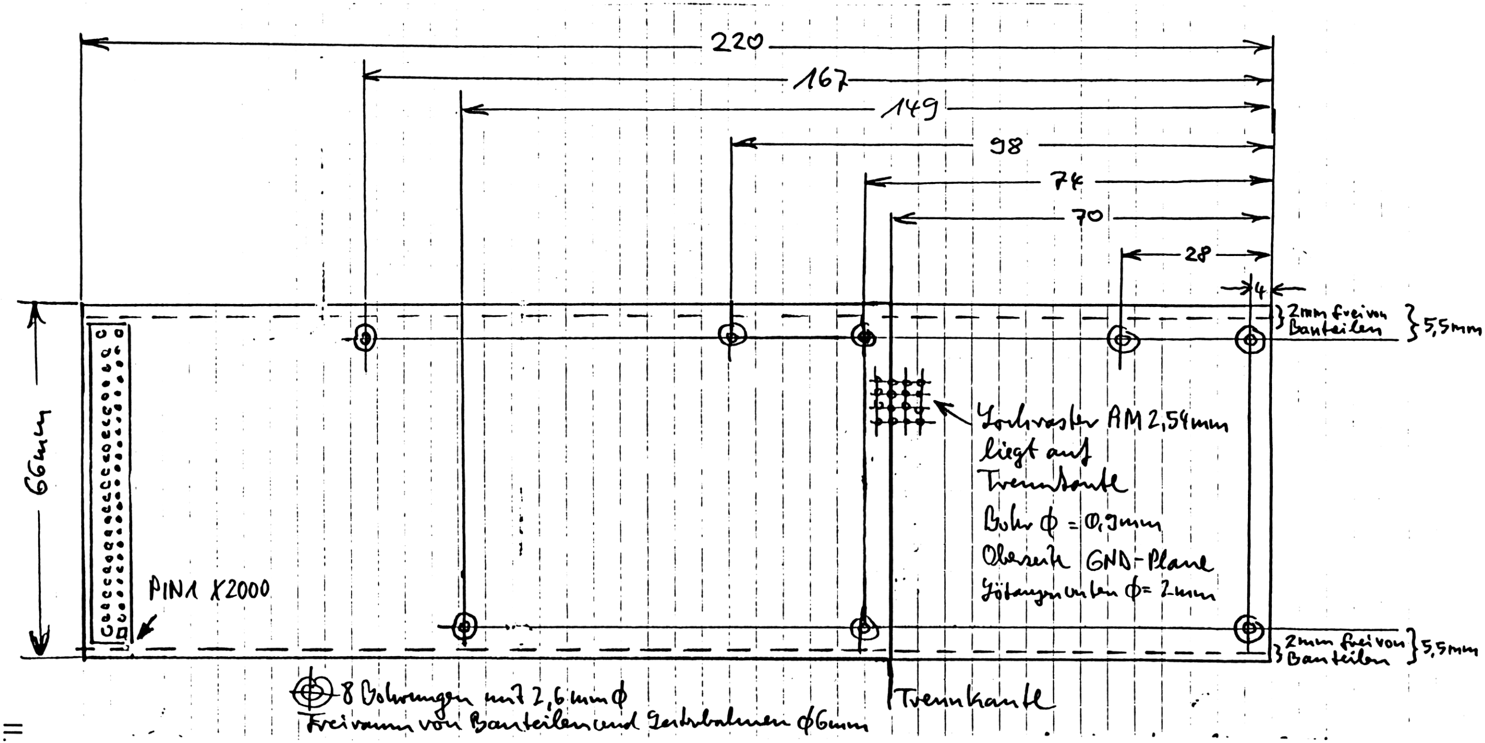
DIG2000 board make available an evaluation area including ground-plane for placing hardware extensions : Use this for placing opto-couplers for signal isolation, open collector transistor circuits for driving different voltage levels, relais for switching high currents, or analog hardware applications. Connect ground-plane to Digital GND by inserting R2006 = 0Ω or to Analog GND by inserting R2007 = 0Ω. Some mounting holes make possible stacking add on boards, or some DIG2000 boards or IL2000 board. Size of DIG2000 board is expanded to 220mm x 66mm for placing larger hardware extensions. By cutting board you reache standard size of IL2000 board = 150mm x 60mm.

DIG2000 16 Bit digital Input/Output Board :



IL 2000

DIG2000 16Bit Digital Input/Output Board :



50 Pin Data & Handshake Bus X2000 :

pinning shown from component side
2 x 25 Pin   2,54mm

-15V	50	49	Analog GND
+15V	48	47	UBATT
Digital GND	46	45	PERM 5V
+5V	44	43	SERVICE
CLEAR	42	41	INT
RD8	40	39	WR8
RD7	38	37	WR7
RD6	36	35	WR6
RD5	34	33	WR5
RD4	32	31	WR4
RD3	30	29	WR3
RD2	28	27	WR2
RD1	26	25	WR1
D15	24	23	D14
D13	22	21	D12
D11	20	19	D10
D9	18	17	D8
D7	16	15	D6
D5	14	13	D4
D3	12	11	D2
D1	10	9	D0
OUT8	8	7	OUT7
OUT6	6	5	OUT5
OUT4	4	3	OUT3
OUT2	2	1	OUT1

16 Pin Digital Output Bus Connector X2010 :

pinning shown from component side
2 x 8 Pin   2,54mm

A15	16	O O	15	A14
A13	14	O O	13	A12
A11	12	O O	11	A10
A9	10	O O	9	A8
A7	8	O O	7	A6
A5	6	O O	5	A4
A3	4	O O	3	A2
A1	2	O □	1	A0

16 Pin Digital Input Bus Connector X2020 :

pinning shown from component side
2 x 8 Pin   2,54mm

E15	16	O O	15	E14
E13	14	O O	13	E12
E11	12	O O	11	E10
E9	10	O O	9	E8
E7	8	O O	7	E6
E5	6	O O	5	E4
E3	4	O O	3	E2
E1	2	O □	1	E0

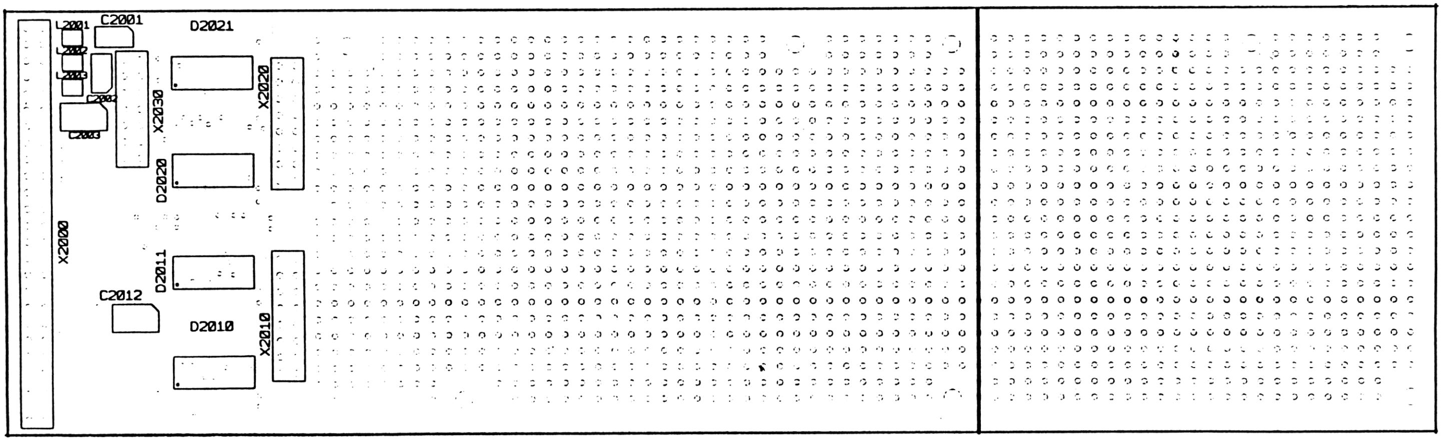
14 Pin Handshake Bus Connector X2030 :

pinning shown from component side
2 x 7 Pin   2,54mm

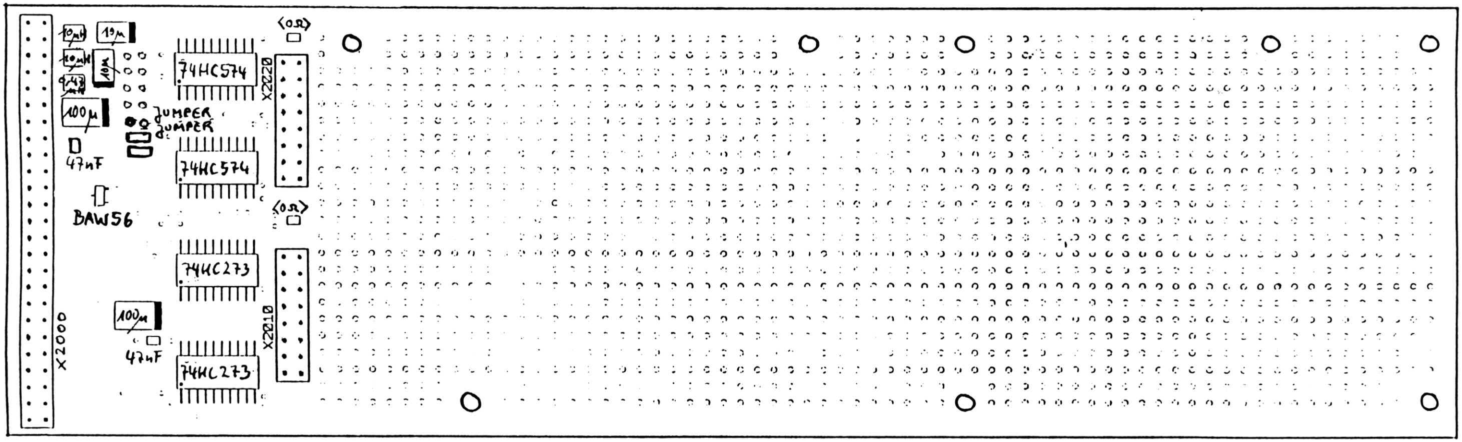
- 15	14	O O	13	Analog GND
+ 15	12	O O	11	PERM 5V
Digital GND	10	O O	9	+ 5V
CLEAR	8	O O	7	SERVICE
/OUT	6	O O	5	OUT
/WR	4	O O	3	WR
/RD	2	O □	1	RD

Bauteil	Wert	Gehäuse	Bemerkung
C2001	10uF/16V		Tantal
C2002	10uF/16V		Tantal
C2003	100uF/16V		Tantal
C2004	47nF	Chip0805	
C2005	47nF	Chip0805	
C2006	47nF	Chip0805	
C2007	100nF	Chip0805	Pulsdelay
C2008	100nF	Chip0805	Pulsdelay
C2009	47nF	Chip0805	
C2010	47nF	Chip0805	
C2012	100uF		Tantal
D2010	74HC273	SO20	Octal Flip Flop with Clear
D2011	74HC273	SO20	Octal Flip Flop with Clear
D2020	74HC574	SO20	Octal Flip Flop
D2021	74HC574	SO20	Octal Flip Flop
L2001	10uH	Chip1210	
L2002	10uH	Chip1210	
L2003	0,47uH	Chip1210	5Volt Siebung
R2001	100Ω	Chip0805	
R2003	100Ω	Chip0805	
R2004	10KΩ	Chip0805	
R2005	10KΩ	Chip0805	
R2006	0Ω	Chip0805	
R2007	0Ω	Chip0805	
V2001	BAW56		Wired-OR für INT
V2002	DTC124EKA		Erzeugt RD aus WR
V2003	DTC124EKA		Invertiert OUT
X2000	IL2000Bus	50Pin	
X2010	16Pin	Stiftleiste	16Bit Output
X2020	16Pin	Stiftleiste	16Bit Input
X2030	14Pin	Stiftleiste	Handshake Leitungen
MP_OUT	Verdrahten mit OUT1...OUT8		
MP_RD	Verdrahten mit RD1......RD8		
MP_WR	Verdrahten mit WR1.....WR8		

DIG2000 16Bit Digital Input/Output Board :

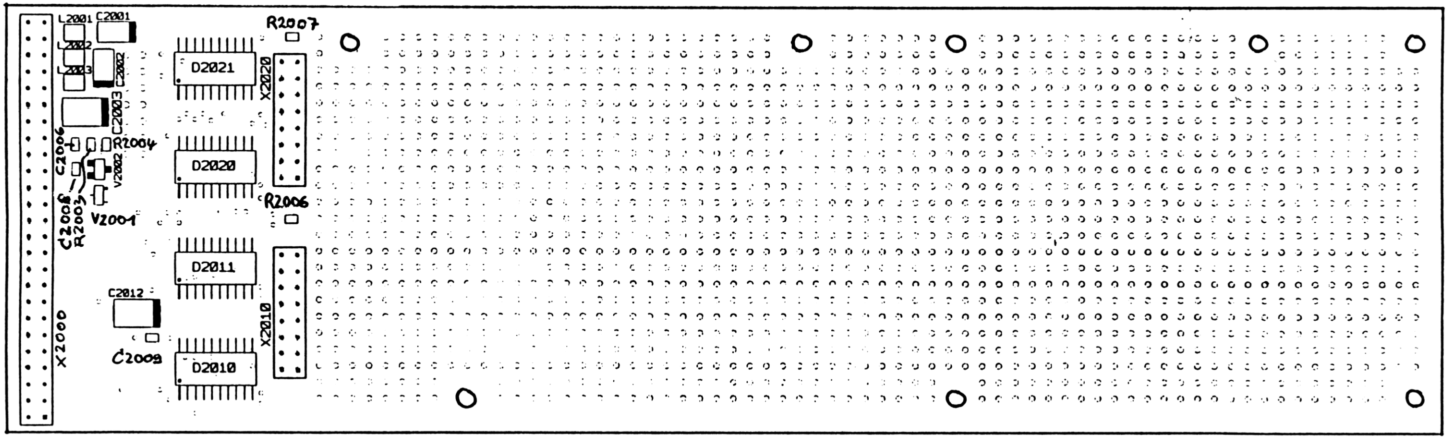


DIG2000 16Bit Digital Input/Output Board :

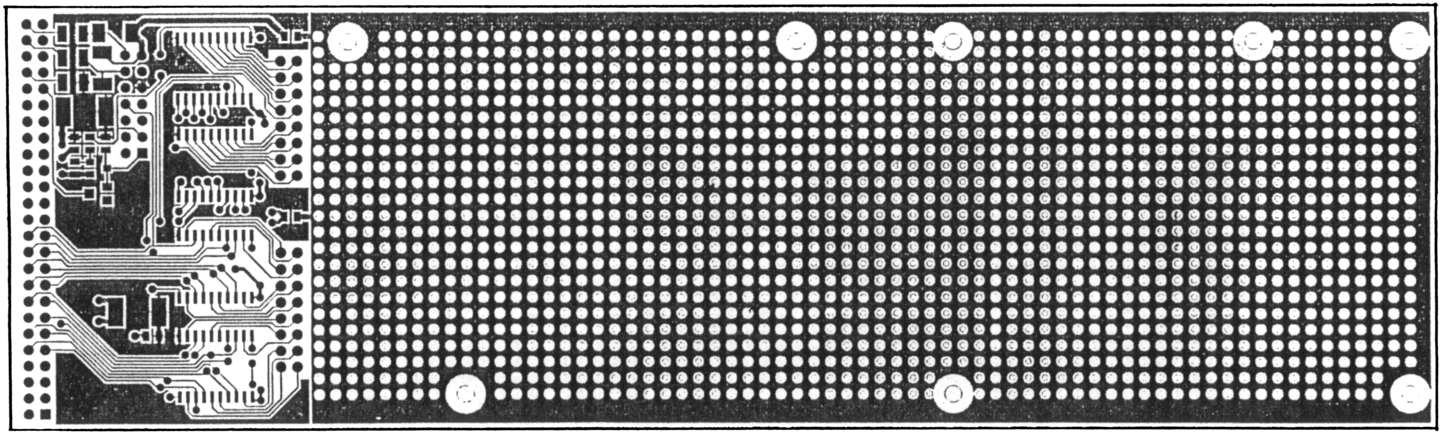


IL 2000

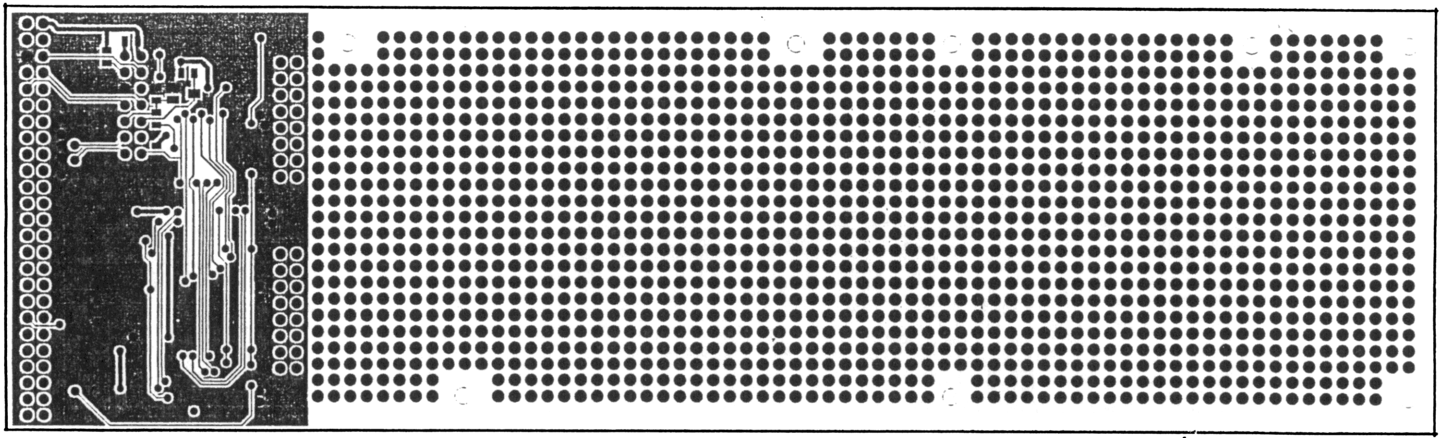
DIG2000 16Bit Digital Input/Output Board :



DIG2000 16Bit Digital Input/Output Board :

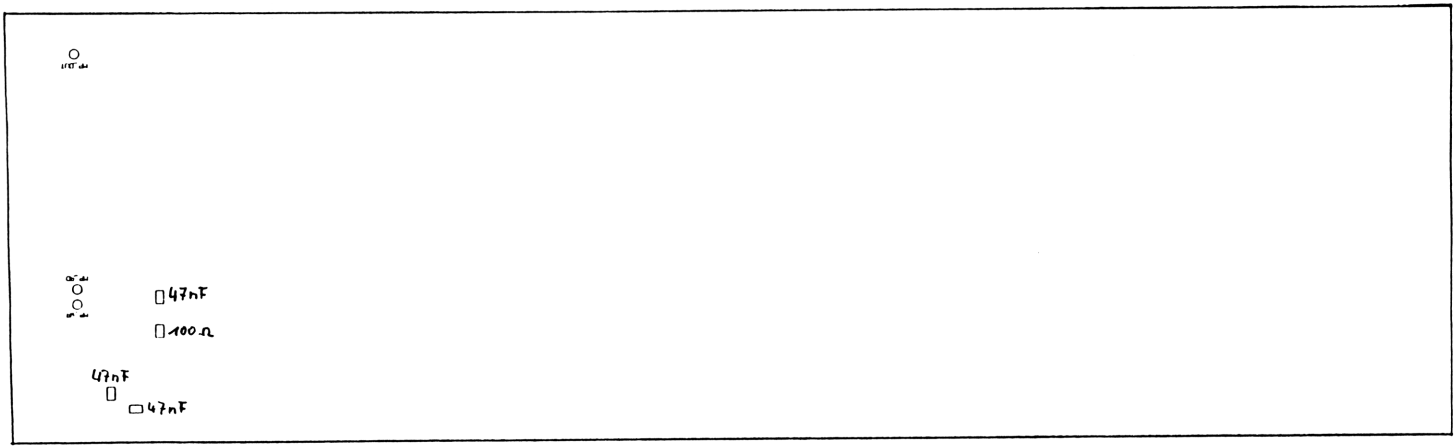


DIG2000 16Bit Digital Input/Output Board :

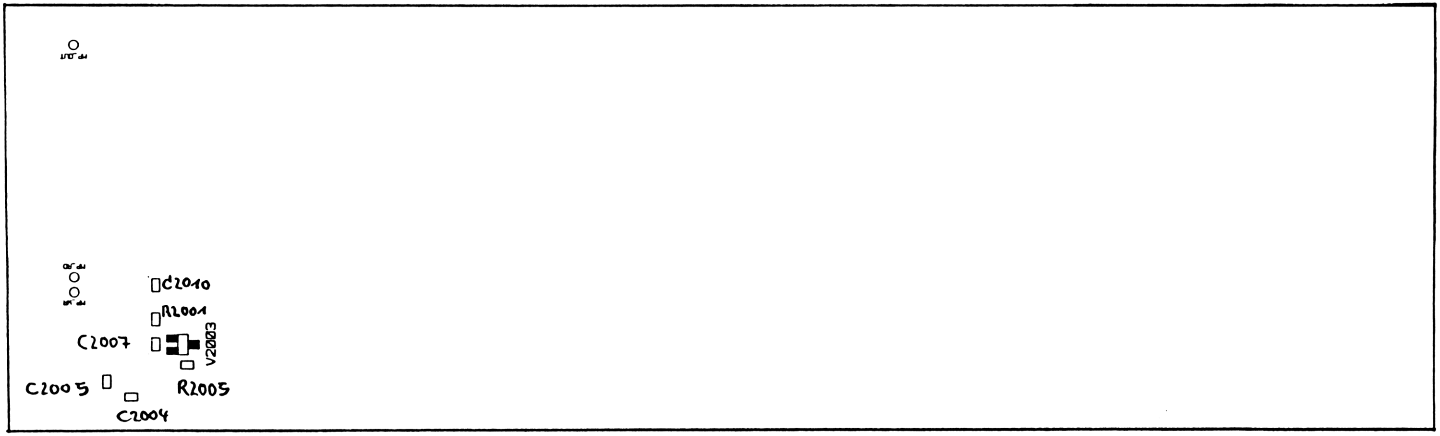


IL 2000

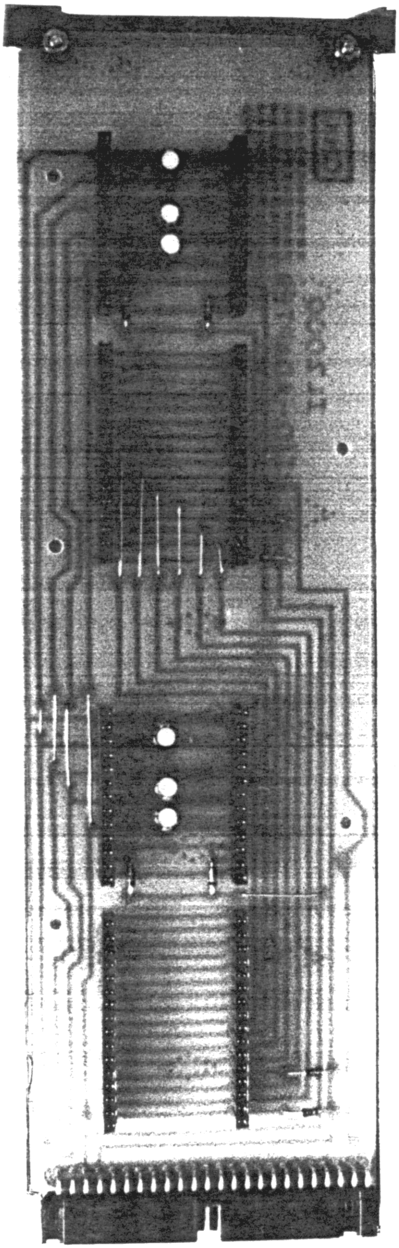
DIG2000 16Bit Digital Input/Output Board :



DIG2000 16Bit Digital Input/Output Board :



I/O2000 Adapter Board

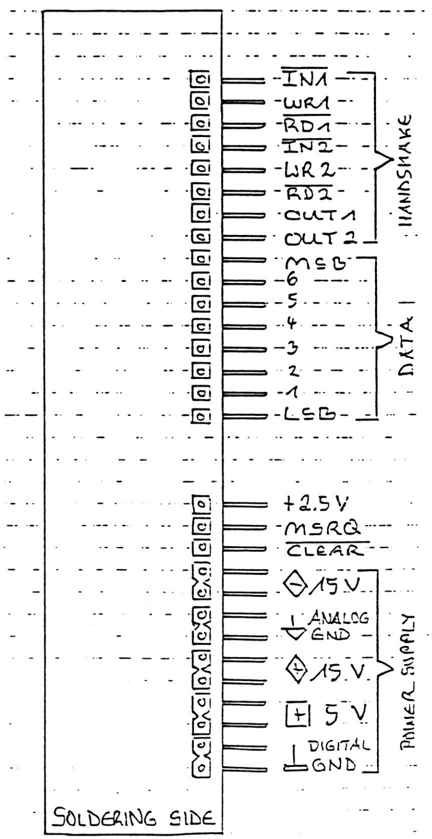


I/O2000 Adapter Board :

I/O2000 board is the adapter solution for employing I/O-Board plug in slot modules. This board routes the 50 pin bus signals of IL2000 system to I/O-Board compatible slot pin design (16 pin data/handshake-lines + 13 pin power-lines). Detailed informations about the pinning of the 8 Bit plug in module you find below. Inserting four 8 Bit, or two 16 Bit plug in modules is possible.

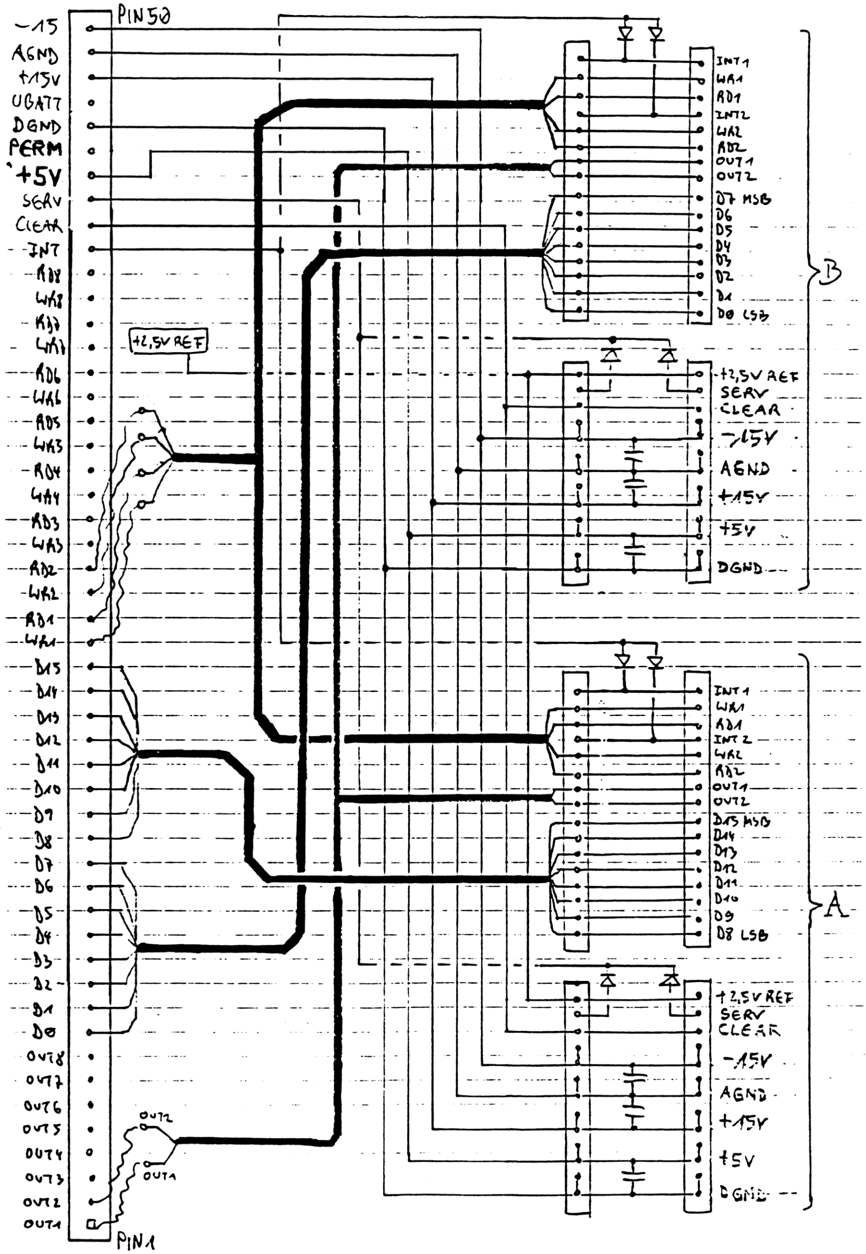
Like I/O-Board also I/O2000 adapter is a simple one side PCB, making not availlable complete lines. Add the missing handshake-lines, 16 bit bus-lines and power-lines manually with thin wire.

INT handshake signal and SERVICE signal (MSRQ) are generated by wired-or circuits. For this insert diodes 1N4148. Place some 10uF/25V electrolyte-capacitors for buffering supply voltages +5V and ±15V.

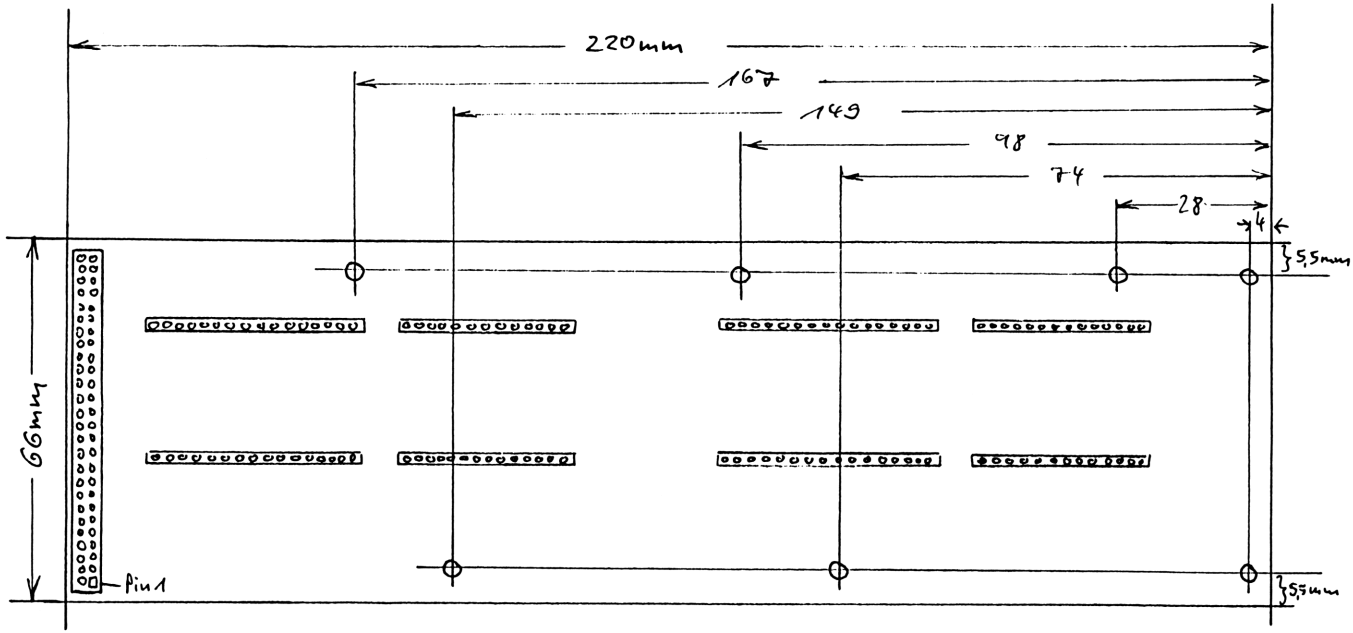


IL 2000

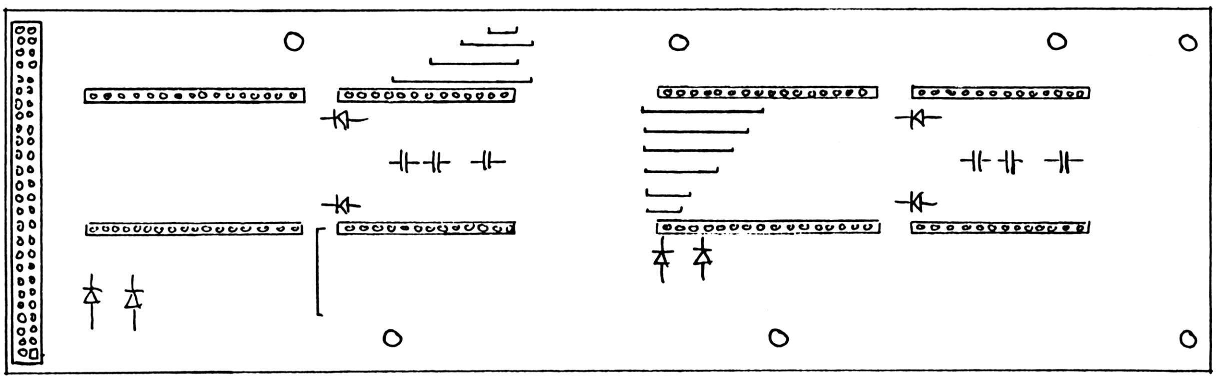
I/O-Board Plug In Module Adapter Board :



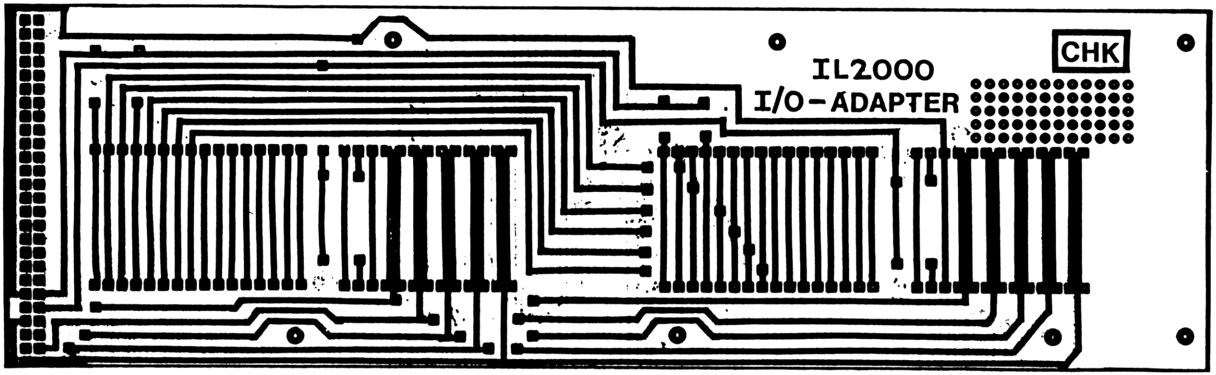
IL2000 – I/O Board Plug In Module Adapter Board :



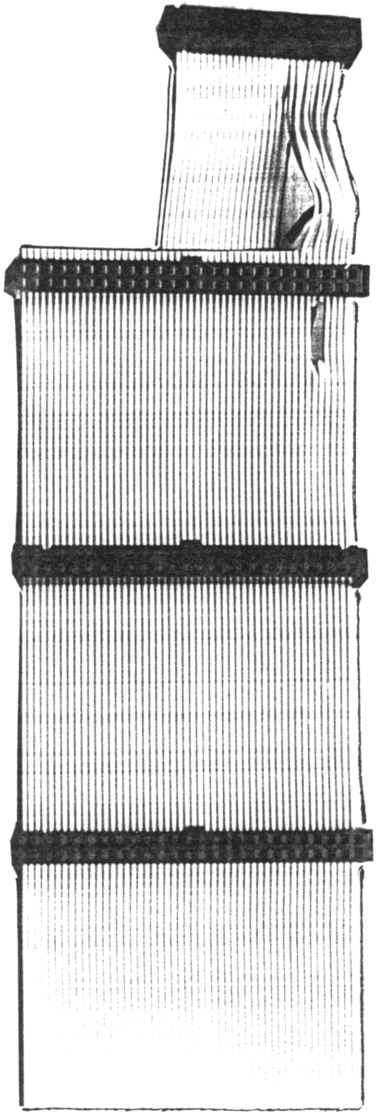
IL2000 – I/O Board Plug In Module Adapter Board :



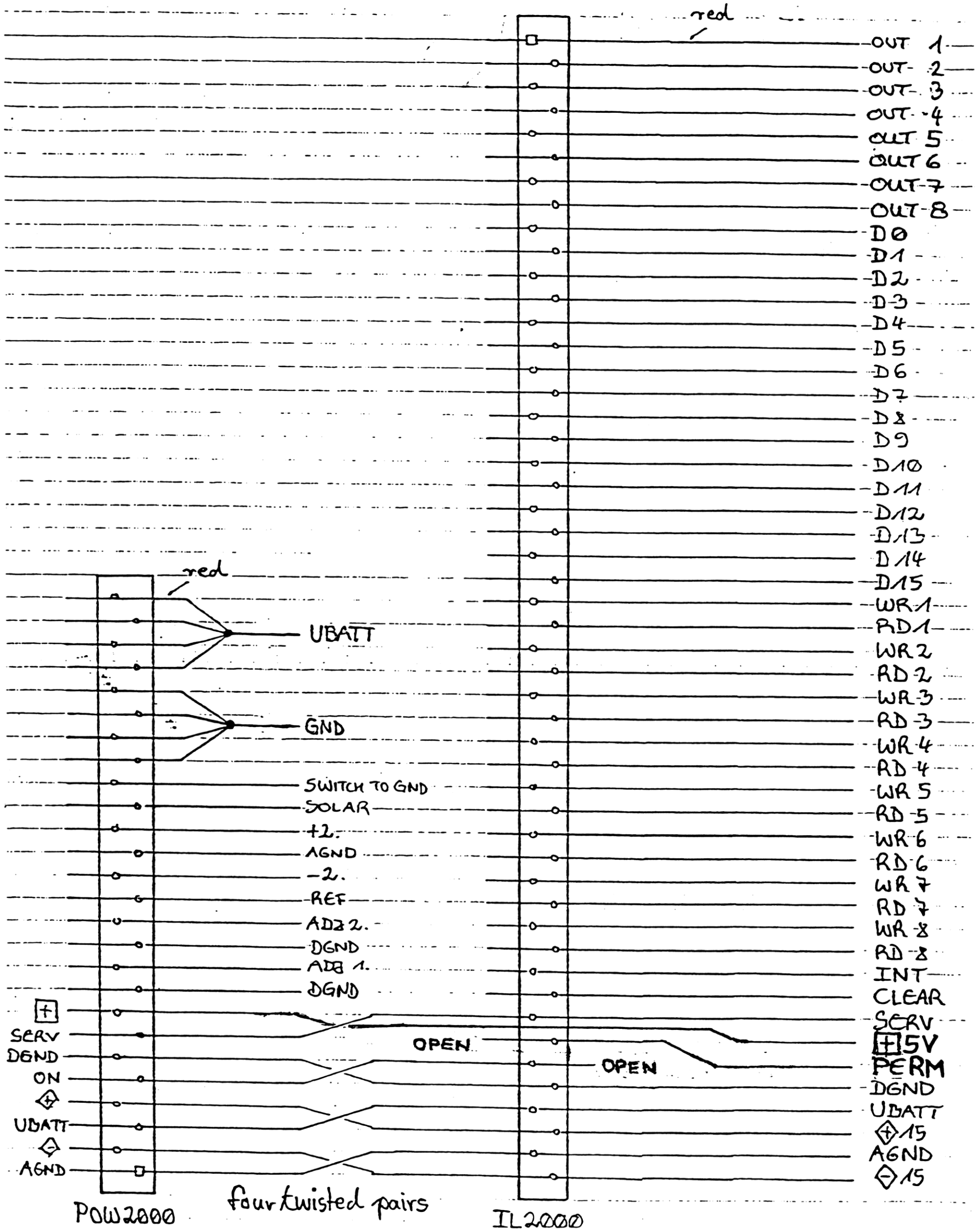
IL2000 – I/O Board Plug In Module Adapter Board :



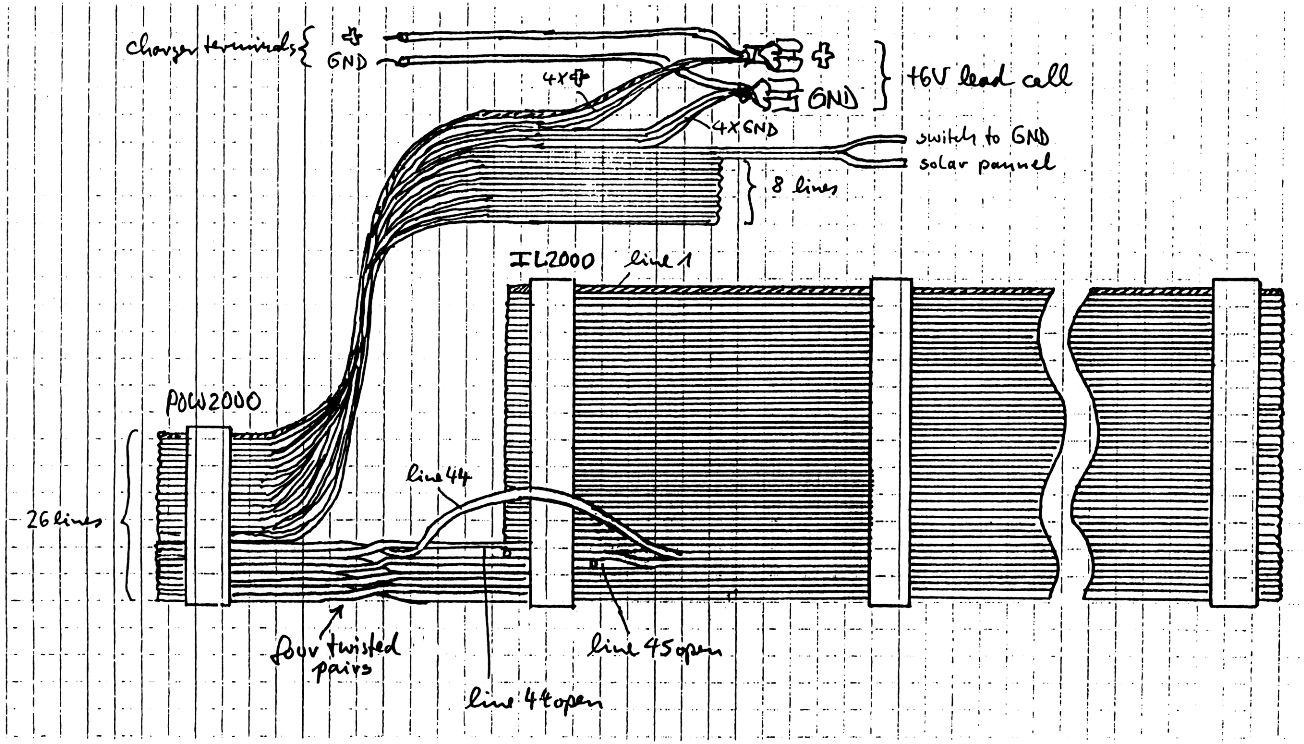
50 Pin Bus Design



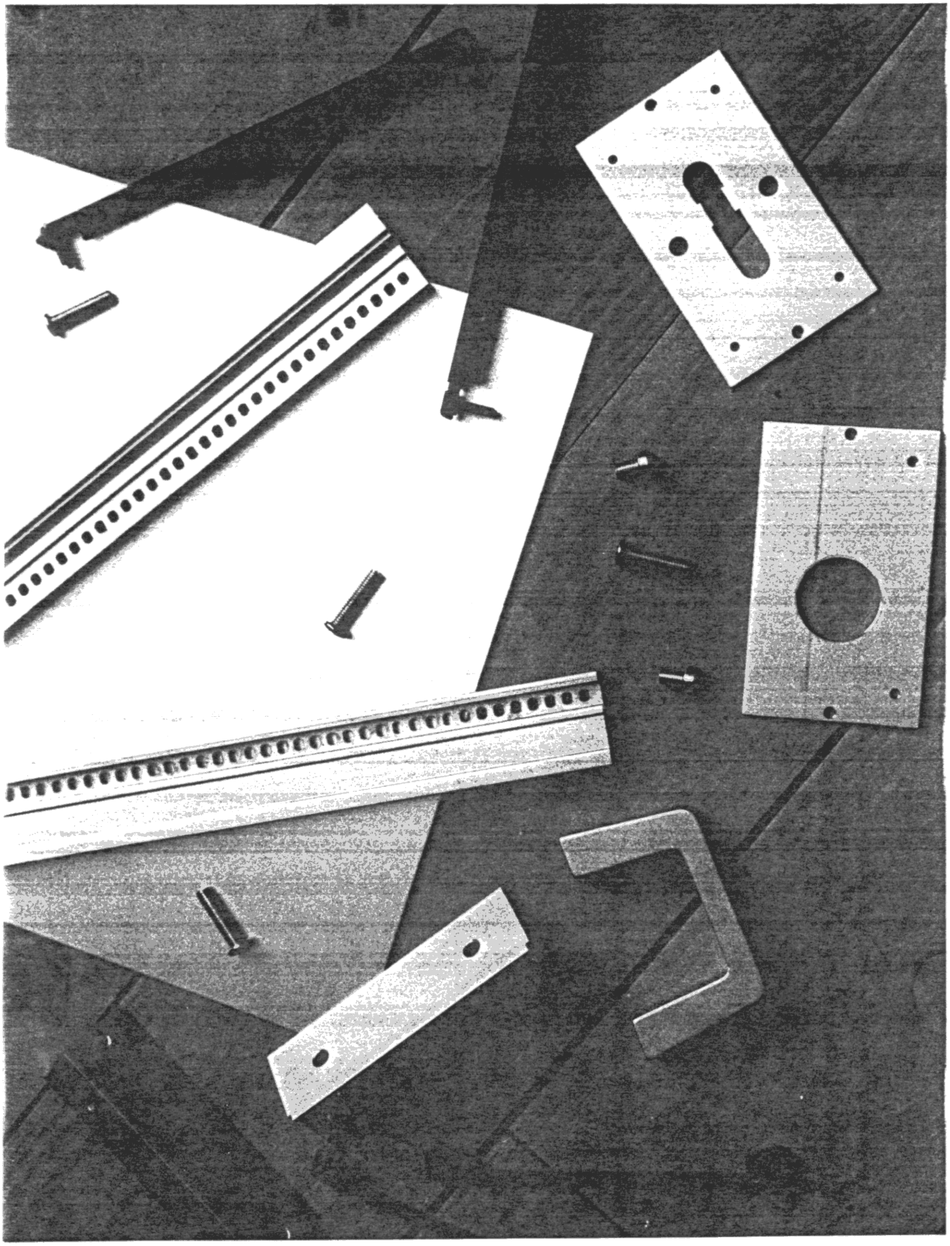
50 Pin Ribbon Wire Bus Design :



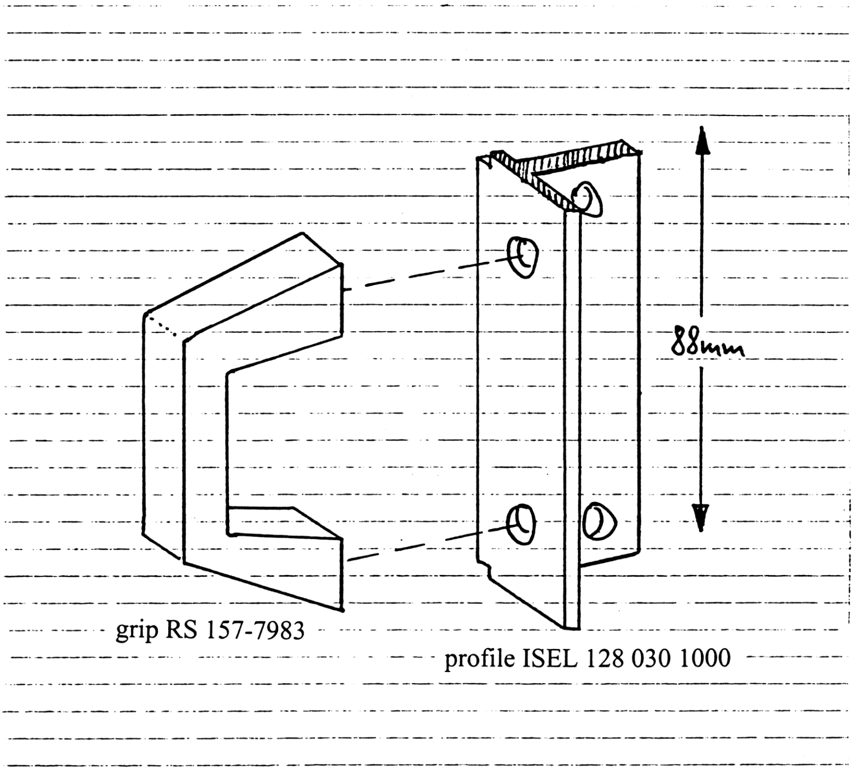
50 Pin Ribbon Wire Bus Design



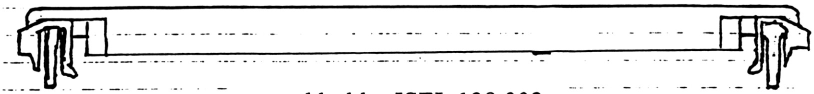
Mechanical Design



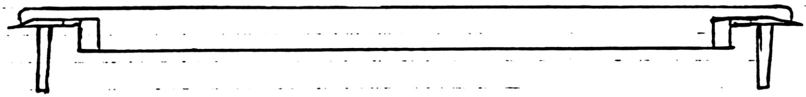
Modifying Brackets :

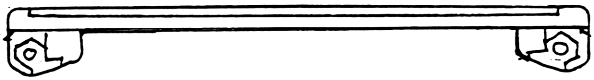


Modifying 19 Inch Rack Parts :

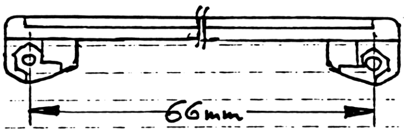


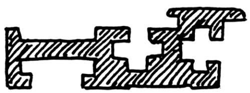
card holder ISEL 138 002





frontpanel holder SCHROFF 60807-011



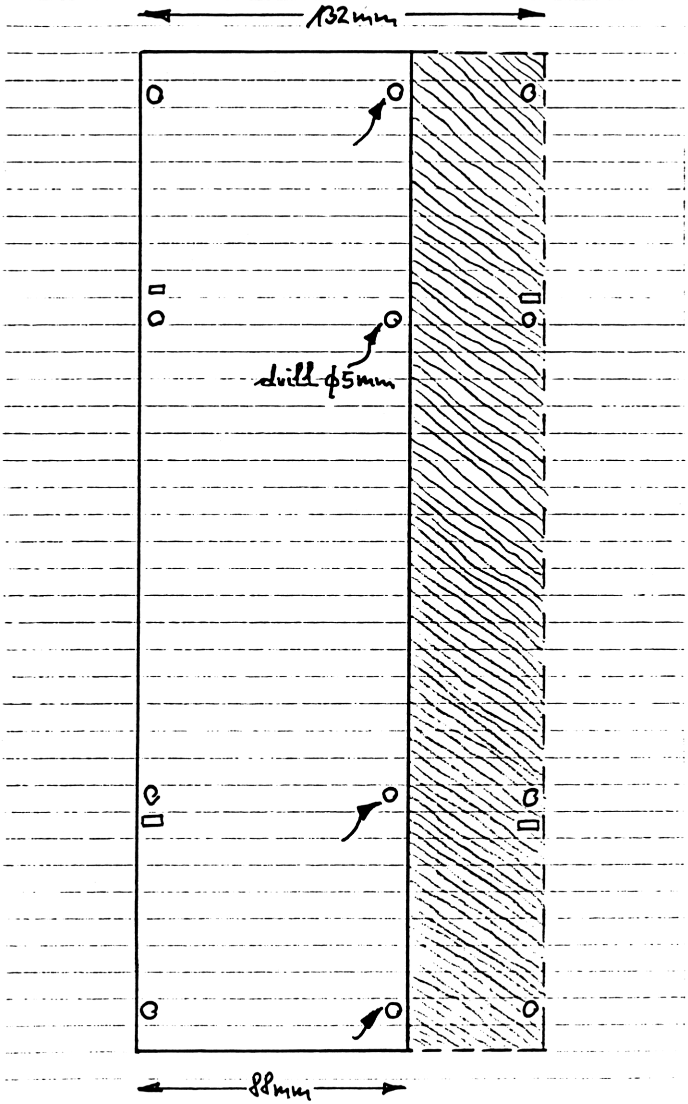


profile-1 / 10 inch = ISEL 125 011 0208
profile-1 / 19 inch = ISEL 125 011 0432

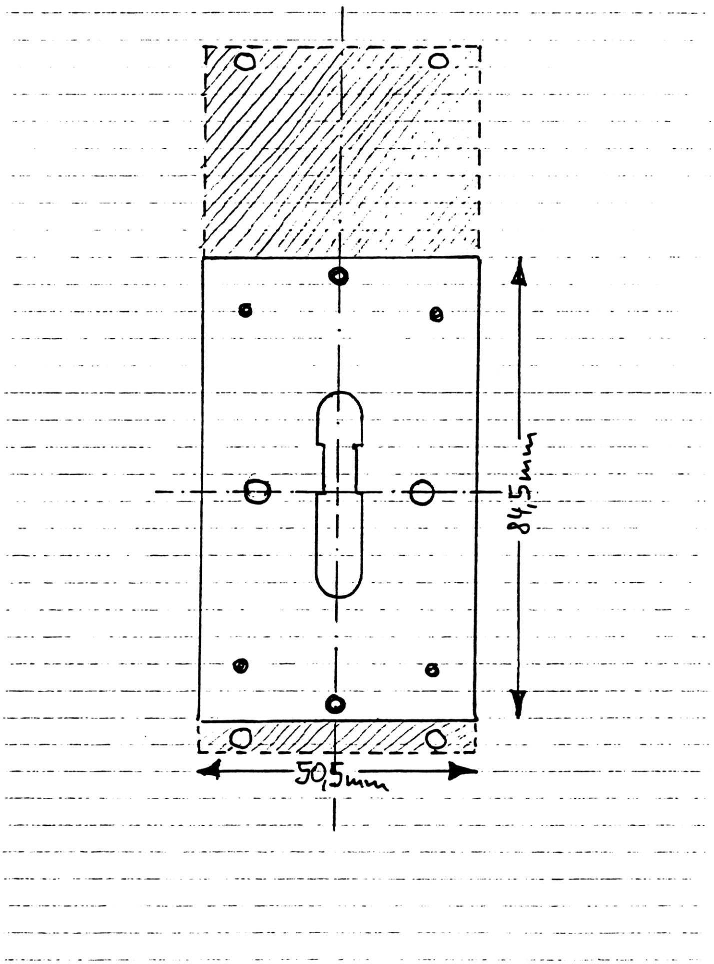
mill for placing
frontpanel holder

Modifying 19 Inch Rack Side-Panels :

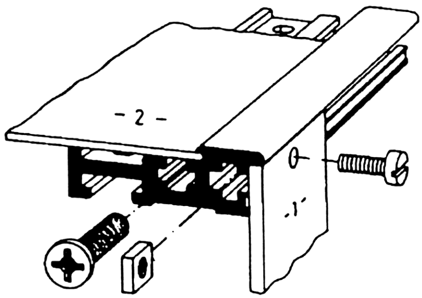
side panel ISEL 138 009

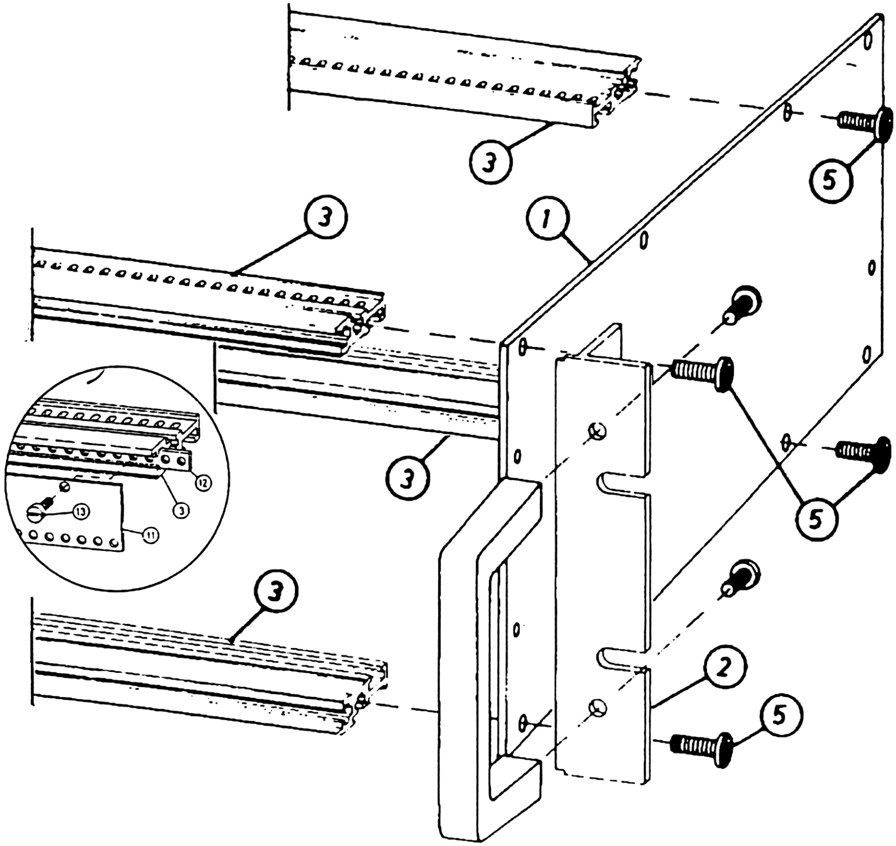


IL2000 & POW2000 Front Panel :

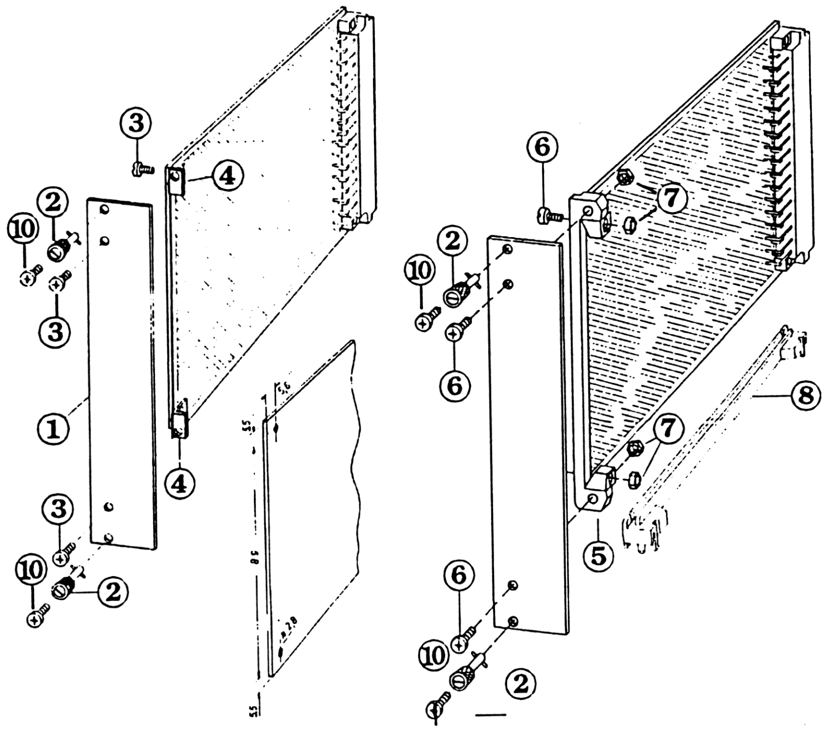


Mounting ISEL-Parts :



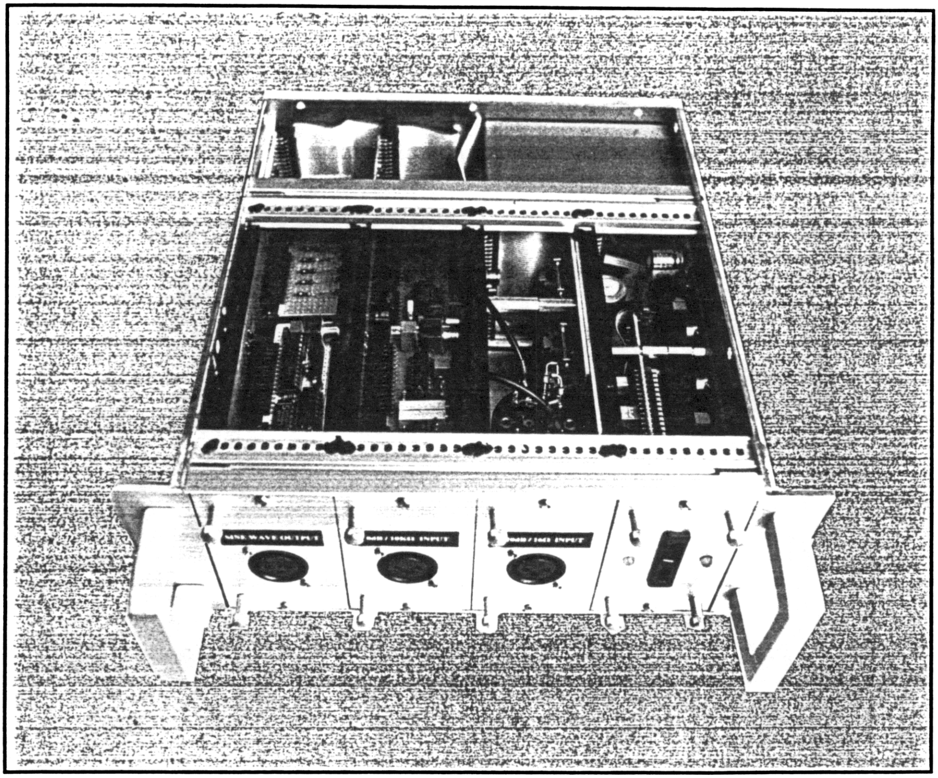


Mounting ISEL-Parts :



PART III :

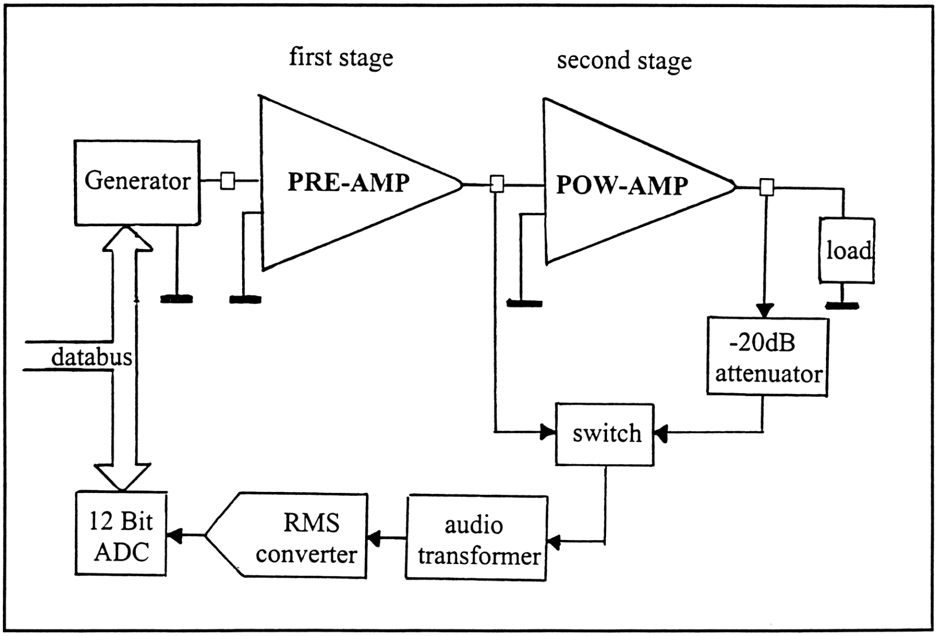
IL2000 Audio Measurement :



IL2000 with plug in hardware modules for Audio Measurement applications. Left module is the basic interface and power supply block (IL2000 Board, IL-Converter and POW2000 Board). Than follows high voltage input module with 16 Ohm load-resistance, attenuator, audio transformer with over-voltage protection and input-multiplexer. Next module with low voltage input contains RMS-Converter and 12 Bit Analog/Digital Converter. Right module contains sine-wave-generator and voltage-controlled-amplifier. Battery (+6V lead cell) is placed behind basic interface and power supply block.

Audio Third Octave Frequency Response Measurement :

Following application continues audio measurement solutions of I/O-Board manual Chapter XVI. This program realize third octave frequency response measurement of two stage amplifiers. Output of first amplifier drives second stage, this is a typicall Pre-Amplifier & Power-Amplifier configuration. For third octave frequency response measurement a sine-wave generator is wired to input of first amplifier. Voltage level measurement occures on output of first and second amplifier stage. By sweeping generator frequency and by level calculation program determines frequency responses of first and second amplifier stage !



I use this solution for researching frequency responses of Hammond Organ Pre-Amplifier and belonging Leslie Cabinet Power-Amplifier. Some Hammond Organs tested on different places, the portable and compact design of IL2000 system allows easy handling. Measurement sessions includes destination of Swell-Pedal loudness characteristic. Using TRANS41 (I/O-Board manual Chapter XV) the complete results transfered to PC for statistical evaluation by EXCEL. This gives a foundated answer to the question of much Organ-Enthusiasts: How sounds a Hammond ? And helps for diagnostic and for sound tuning, like requiered replacement of altered capacitors from electromagnetic tonewheelgenerator.

For Hammond Organ measurement frequencyrange is limited from 30Hz to 10KHz. By expanding frequency range from 20Hz up to 20KHz it is possible to use this program for general audio measurement.

For generating sine wave signals, and for measurement voltage levels, I take the approved hardware modules of I/O-Board manual Chapter XVI. For setting generator output voltage level by handheld computer I add a VCA module behind sine wave generator. The VCA is controlled by 8 Bit DAC. For general audio measurement it is possible to replace VCA module by a simple resistance attenuator. For measuring high voltage levels on speaker outputlines of Leslie Cabinet Power-Tube-Amplifier, I work with additional 16 Ohm load resistance, -20dB attenuator, signal switch and audio-transformer for signal isolation.

Most of the helpfully subroutines of Chapter XVI of I/O-Board manual are used like setting generator frequency, voltage level measurement, generating automatic sweep sequences and level calculation. Therefore programming third-octave frequency response measurement is easy, software generates some specific text lines, defines measurement parameters and controls level calculation and data storage in X-Memory.

For Hammond Organ measurement I feed a 50mVpp sine wave signal into Pre-Amplifier input terminal. Output of Pre-Amplifier is wired to RMS voltage converter and 12 Bit ADC for voltage level measurement. Routine HPRE starts third octave frequency response measurement and stores data in X-Memory (first stage). Now I connect Speaker-Output of Leslie Cabinet Power-Amplifier to 16 Ohm load resistance, -20dB attenuator, audio-transformer, RMS converter and 12 Bit ADC. Routine HPOW starts third octave frequency response measurement of Pre+Power-Amplifier. Than program generates invers Pre-Amp frequency response data. From this, and from sum-frequency response data, program calculates Power-Amplifier frequency response (second stage) and stores data in X-Memory.

Detailled informations about used subroutines FGEN, FM, FMOVE, FSTOM, FINV and FADD are presented in I/O-Board manual Chapter XVI "Audio Measurement".

```
01 LBL "HTERZ"          Third octave frequency response measurement
02 XROM "$I/O"
03 -35                  set VCA to -35 dB = 50mVpp output
04 XROM "FVCA"
05 1000                 set generator frequency to 1000 Hz
06 XROM "FGEN"
07 RTN

08 LBL "HPRE"           Pre-Amplifier measurement (first stage)
09 XROM "F0dB"          activates 0dB/10kΩ Input
10 "ORGEL_TYP_?"        input header text, like A100, B3, C3,
11 AON
```

```
PROMPT
AOFF
ASTO X
"PRE_AMPLI"
"⊦ FIER_"
XEQ "Ha"
CF 00                  LOG increment
31,5                   start frequency = 31,5Hz
STO 23
10160,00337            stop frequency = 10 KHz
STO 24
1,25992105             delta frequency = third octave
STO 25
RCL 23
STO 27
25                     25 terz steps
STO 26
1,001
+
"FDATA"
MDIM
1,001
IJ=A
XROM "FM"              subroutine executes measurement sequence
1000
XROM "FGEN"            when finished set generator to 1000Hz
0
XROM "FMOVE"           set max level to 0dB
"FILE_NAME_?"
AON
PROMPT                 store measurement data in X-Memory
AOFF
XROM "FSTOM"
XROM "FINV"            calculate inverse frequency response and
"INV"                  store it in X-Memory file INV
XROM "FSTOM"
RTN

LBL "HPOW"             Power-Amplifier measurement (second stage)
XROM "F20dB"           activates 20dB/16Ω Input
"LESLIE_TYP-?"         input headertext like 122, 147, 251, RV122...
AON
PROMPT
```

```
54 AOFF
55 ASTOX
56 "AMPLIFIER_LESLIE_"
57 XEQ "Ha"
58 RCL 23
59 STO 27
60 25
61 STO 26
62 1,001
63 +
64 "FDATA"
65 MDIM
66 1,001
67 IJ=A
68 XROM "FM"          subroutine executes measurement sequence
69 1000               when finished set generator to 1000 Hz
70 XROM "FGEN"
71 10                 consider -20 dB attenuator = x 10
72 ST* 20
73 "INV"              take sum frequency response and inverse
74 XROM "FADD"        frequency response and calculate
75 0                  Power-Amplifier frequency response
76 XROM "FMOVE"       set max level to 0dB
77 "FILE_NAME_?"
78 AON
79 PROMPT             store measurement data in X-Memory
80 AOFF
81 XROM "FSTOM"
82 "INV"              clear X-Memory file INV
83 PURFL
84 "├ +"              clear X-Memory File INV+
85 PURFL
86 FIX 4
87 CLA
88 CLX
89 RTN

90 LBL "Ha"
91 ARCL X             complete header text line
92 ASTO 12            store header text in Register 12...15
93 ASHF
94 ASTO 13
95 ASHF
```

```
96  ASTO 14
97  ASHF
98  ASTO 15
99  "NAME=?"          input command text like name....
100 AON
101 PROMPT
102 AOFF
103 ASTO 16           store command text in Register 16...19
104 ASHF
105 ASTO 17
106 ASHF
107 ASTO 18
108 ASHF
109 ASTO 19
110 1                 reference voltage 0dB = 1V
111 STO 20
112 TIME              measurement Time
113 STO 21
114 DATE              measurement Date
115 STO 22
116 END
```

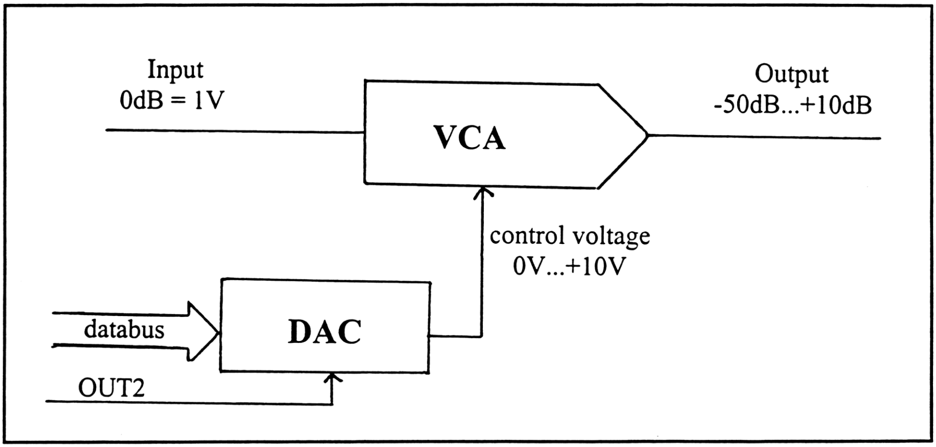
For special Hammond Organ measurement frequency response range runs from 30Hz up to 10KHz. For general audio measurement applications it is ingenious expanding frequency response range from 20Hz up to 20KHz. For this alter following program lines :

```
19  20                start frequency = 20 Hz
20  STO 23
21  20480,003         stop frequency = 20 KHz
22  STO 24
23  1,25992105        delta frequency = third octave
24  STO 25
25  RCL 23
26  STO 27
27  30                30 terz steps
28  STO 26
```

Furthermore change program line 71 and line 72 for adapting factor of voltage attenuator (-20 dB = x 10) to your individual application.

VCA-Module :

The Voltage Controlled Amplifier Module make possible setting output voltage level of sine wave generator by software. For generating needed 0V...+10V control voltage for VCA I use the 8 Bit DAC, described in I/O-Board manual on pages V.12 / V.14 and V.15 . For VCA I take the dBX146732 VCA circuit. Input level is 0dB = 1V. Output level ranges from–50dB to +10dB. Maximal output level error is 0,5dB. Frequency response is linear from 20Hz to 20KHz.



Because dBX chip is not availlable on consumer market, IL2000 manual contains no wiring diagram ! For building your own VCA hardware, take the modern dual VCA SSM2122 from Analog Devices. For this exist an Application Note 131 including complete circuit diagramms. Output level ranges from –85dB to +10dB.

Following HP-41 program controls VCA module. Software works with curve fitting for transforming dB level value in X-Register to 8 Bit control value 0...255 for DAC. For curve fitting I used the HP-41 AEC-Module. For analyzing VCA circuit I work with Rhode&Schwarz UPA 3.

Y 8 Bit control value	output level (dB)	X (out lev+50,1) x 10	typical error (dB)
0	-50,1	0	+0,5
40	-40,4	97	+0,4
80	-31,0	191	+0,3
120	-21,5	286	+0,2
160	-12,0	381	+0,3
210	- 0,3	498	+0,2
255	+10,4	605	0

LIN HYP :

$$\boxed{Y = a + b X + c / X}$$

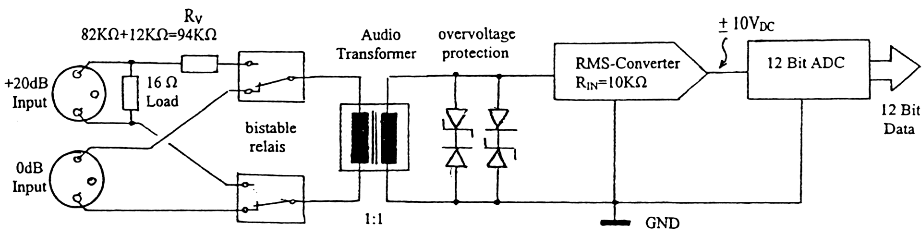
a = -0,82285738
b = 4,22712902 / 10
c = 8,2285732 E-10

For 8 Bit data output in program line 22 software executes the $OUT2A command (I/O-Board manual II.05 and II.08). VCA module is addressed to port OUT2A.

```
01  LBL "FVCA"          Set output level of VCA module
02  50,1
03  +
04  10
05  *
06  ENTER
07  ENTER
08  1/X
09  2285732 E-10
10  *
11  X< >Y
12  4,227129302
13  *
14  10
15  /
16  +
17  0,82285738
18  -
19  FIX 0
20  RND
21  FIX 4
22  XEQ $OUT2A
23  END
```

Input Multiplexer :

Because Pre-Amplifier and Power-Amplifier output signals have different voltage levels, I work with two input sections : The 0dB/10KΩ analog-input is used for Pre-Amplifier measurement. The +20dB/16Ω analog-input includes a 16Ω load resistance, and is used for higher voltage Power-Amplifier measurement. Two bistable relais switching signal- and ground lines to an 1:1 audio-transformer for signal isolation (avoiding ground loops). Output of audio-transformer is wired to overvoltage protection diodes (1N4148+ZPD12) and RMS-Converter (input resistance = 10KΩ). DC output of RMS-Converter (±10V) feeds 12 Bit ADC, both modules described in I/O-Board manual Chapter XVI and Chapter V.



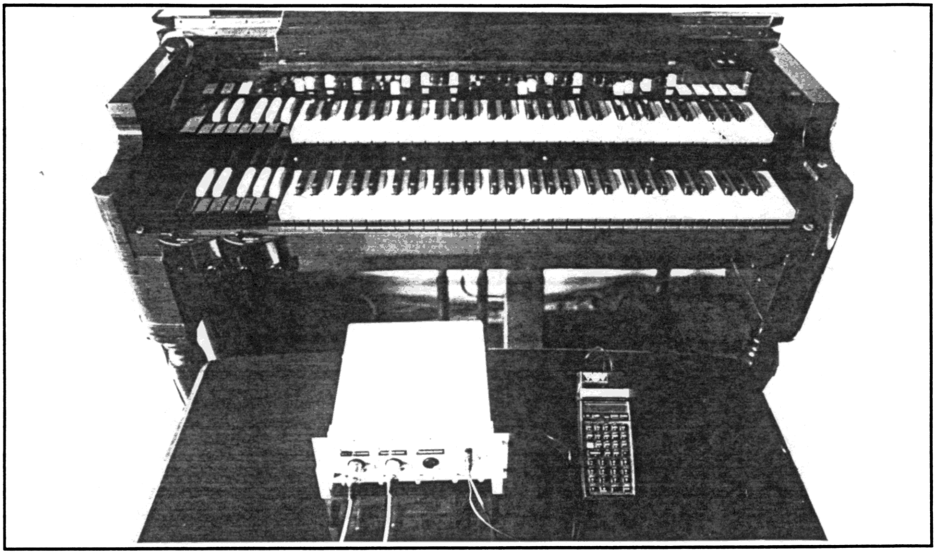
Bistable relais (SIEMENS V23040-C0051-B201) controlled by an 74HC273 octal flip flop with power on reset. This multiplexer solution is described in I/O-Board manual Chapter V. Switching bistable relais by short voltage pulses is ideally for battery powered systems. Following software routine toggels between both measurement inputs. Multiplexer is addressed to port OUT2B. Used $OUT2A command is explained in I/O-Board manual pages II.05 and II.08.

```
01 LBL "F0dB"       activates 0dB/10KΩ Input
02 5                bit combination 0000 0101
03 XEQ $OUT2B
04 0                bit combination 0000 0000
05 XEQ $OUT2B
06 RTN

07 LBL "F20dB"      activates +20dB/16Ω Input
08 10               bit combination 0000 1010
09 XEQ $OUT2B
10 0                bit combination 0000 0000
11 XEQ $OUT2B
12 END
```

IL 2000

Hammond Organ Measurement :



Picture shows Hammond Organ B3 and IL2000 System (with audio frequency response measurement hardware modules) and HP-41 Handheld Computer acting as HP-IL Interface Loop controller.

Up to now it is not possible reproducing the original and typical sound of electromagnetic Hammond Organ and belonging Leslie rotating speaker cabinet with analog- or digital signal proccessing, used by modern keyboard instruments.

IL2000 audio measurement system will help today Hammond Organ enthusiasts finding out the mysteries of Hammond Organ sound production by third-octave frequency response measurement of Hammond-Pre-Amplifier and Leslie-Power-Amplifier. Furthermore it is possible to determine the half-tone frequency characteristic of the whole instrument including tone-wheel generator and keyboard assembly.

Visiting Hammond Organ fans and their instruments, I collect frequency data of some Hammond Organs. Later follows data upload to PC and import to EXCEL for calculating reference values. This values are helpfull for technical service and repair and for sound tuning and modification.

Example Hammond Organ C3 :

Next two pages gives an example for third-octave frequency response measurement :

On first page you find the frequency response plot of the internal Pre-Amplifier from a Hammond Organ C3. Swell-Pedal is set to max volume. The response plot is nearly linear up to 10 KHz, this is not typicall for high frequency limiting Hammond Pre-Amplifiers. The reason of equalizing is a small hardware modification of Swell-Pedal circuit. From this results a clearly Hammond Organ sound, including detailled reproduction of noisy sound components and key-click, most today Hammond Organ enthusiast want to hear.

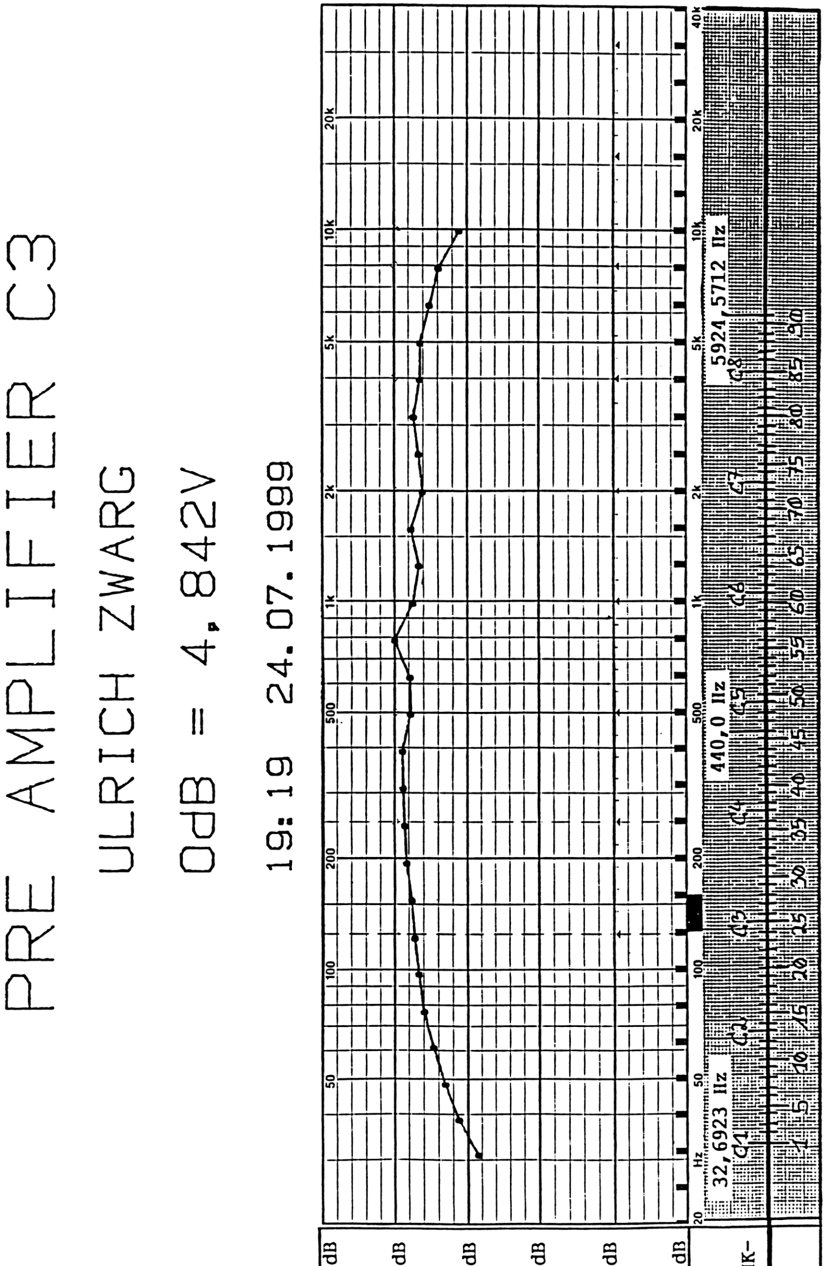
Second page shows the frequency response plot of belonging Leslie Cabinet Power-Amplifier. Both plots generated by own plott routine FPLOT (I/O-Board manual Chapter XVI) controlling HP 7470A IL-Plotter. Generally frequency data stored commonly with some additional data like organ type, owner name, 0dB reference value, time and date.

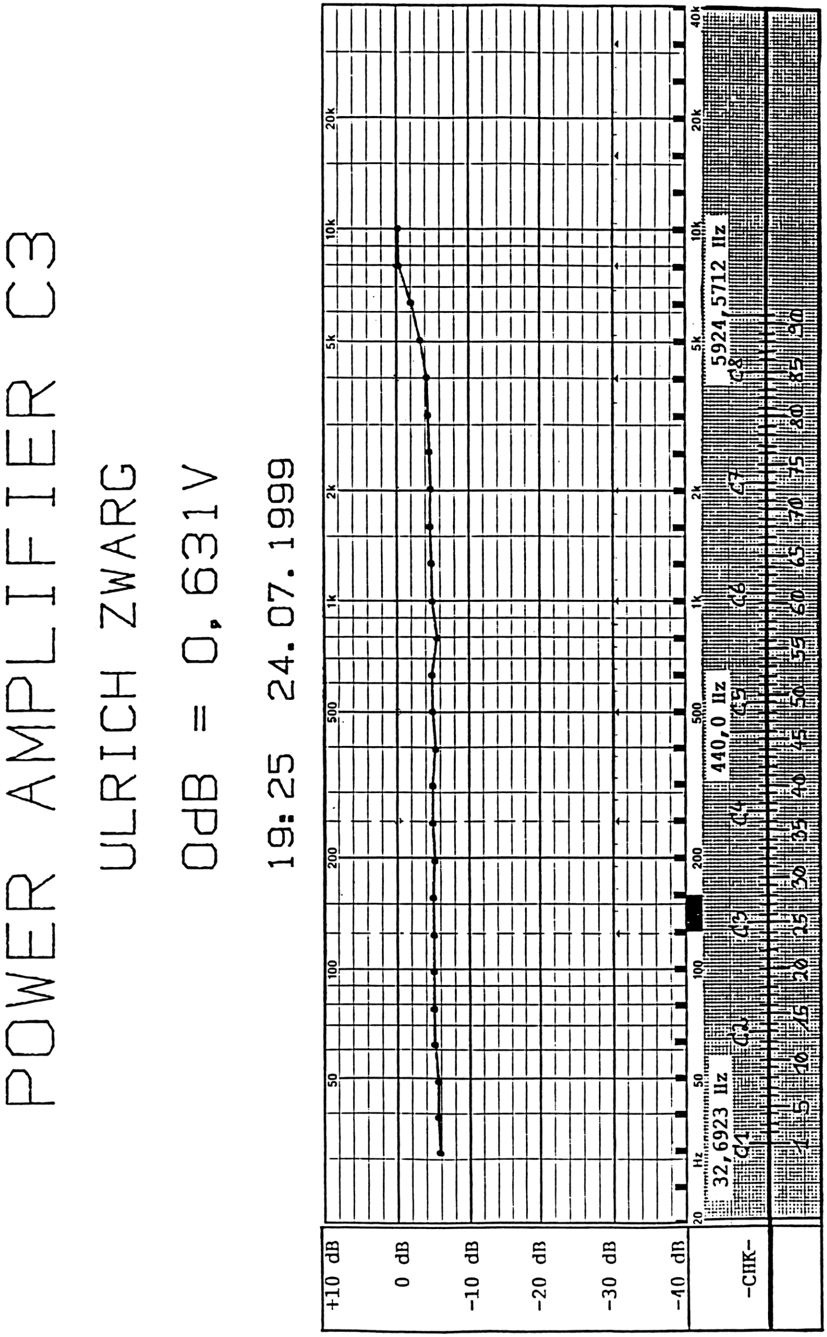
Example Hammond Organ C2 :

Third page gives an example for half-tone frequency response measurement. Belonging HP-41 software is not presented in this manual, because this is only usable for specific Hammond Organ measurement.

During half-tone frequency response measurement IL2000 system acts as AC millivoltmeter, recording voltage levels of every played key of a register stop. In this example 61 tones of the 2 2/3 busbar register stop. Voltage probes are taken on Pre-Amplifier output terminal. Resulting response plot shows frequency characteristic of the whole instrument, including tone wheel generator, keyboard assembly, matching transformer and Pre-Amplifier.

Measuring frequency characteristic of only one register stop gives technicans detailed informations about organ sound and about electronic components (like altered capacitors) who need a replacement for sound tuning. This Hammond Organ C2 example shows half-tone frequency response plot before - and after restaurating tone wheel generator by replacing drifted capacitors and alignment of generator output levels. From this results a much better organ sound. The typically level scaling (high frequency slope) is determined by analyzing frequency response data of some Hammond Organs, more informations about this you find in I/O-Board manual pages XVI.49 and XVI.50 .


PRE AMPLIFIER C3
ULRICH ZWARG
0dB = 4,842V
19:19 24.07.1999
+10 dB
0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-CHK-
32,6923 Hz
440,0 Hz
5924,5712 Hz

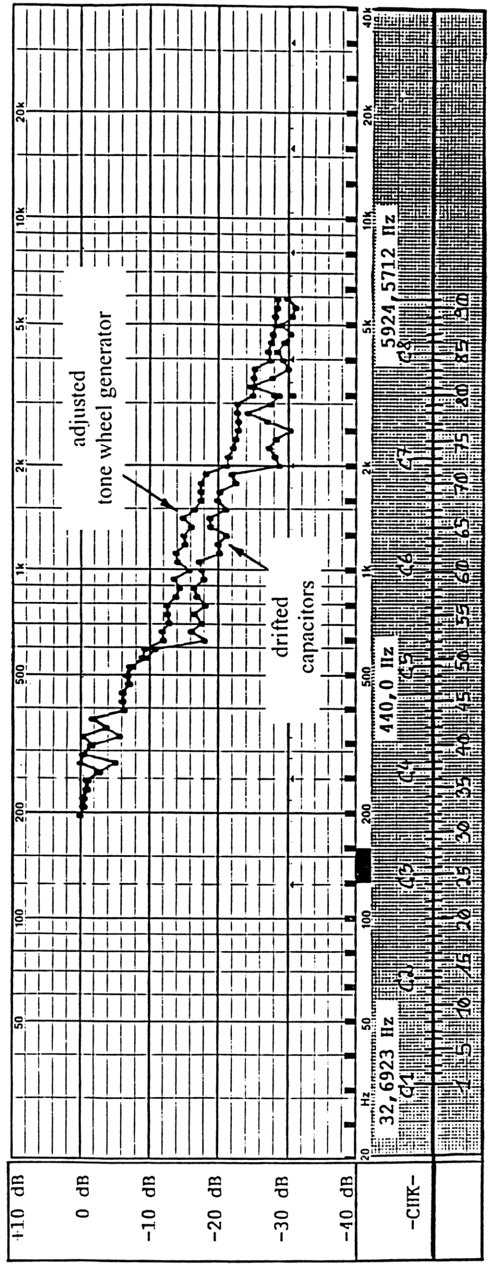

POWER AMPLIFIER C3
ULRICH ZWARG
OdB = 0,631V
19:25 24.07.1999
+10 dB
0 dB
-10 dB
-20 dB
-30 dB
-40 dB
-CHK-
20
50
100
200
500
1k
2k
5k
10k
20k
40k
32,6923 Hz
440,0 Hz
5924,5712 Hz

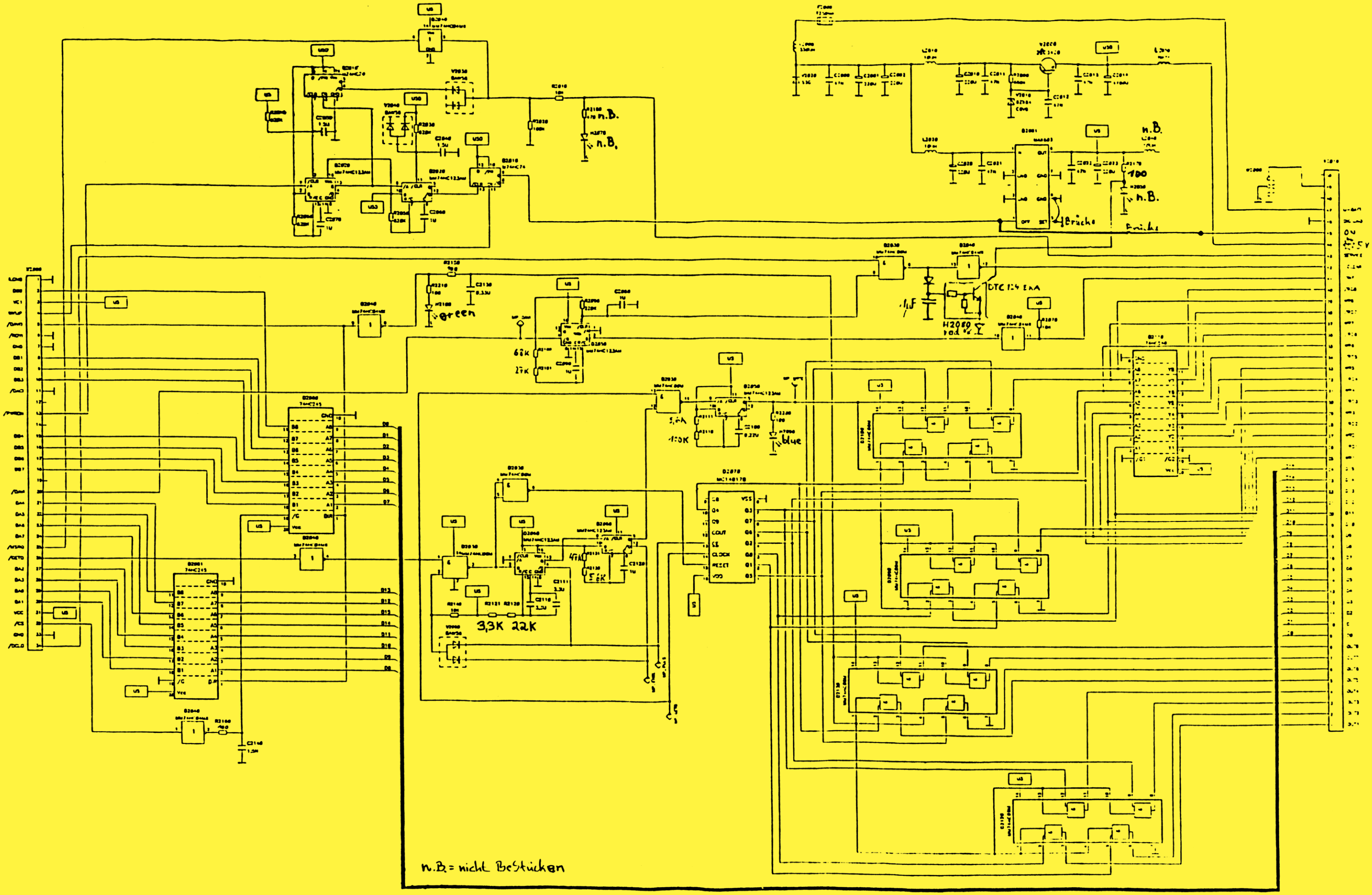
HAMMOND ORGEL C2

JÜRGEN MAGIERA

ZUGRIEGEL 2 2/3 FUSS

04.10.1999




n.B. = nicht Bestücken
3,3K
22K
green
blue
Brücke
n.B.