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Switch Interface for Monochromator and Radiometer

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MRL-TN-598

Abstract

This note describes a digital switch interface designed and constructed at MRL. The unit enables an IBM compatible personal computer to control and collect data from an Optronic Laboratories monochromator and two radiometers but could also be used for control of other instruments with digital input and/or output. Modifications to achieve a master/slave synchronisation with the clocks of the analogue to digital converters in the radiometers are also described.

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Switch Interface for Monochromator and Radiometer

1. *Introduction*

This report provides a detailed description of a digital interface unit which, when used in conjunction with a Data Translation 32 bit input/output (I/O) board [1], enables an IBM compatible personal computer to control an optical monochromator [2] and two optical radiometers [3]. It could also be used to control other equipment containing digital input and output (I/O).

The optical monochromator and the radiometers were used to obtain optical reflectance and absorbance information about materials and/or equipment. Both the monochromator and the radiometers were manufactured by Optronics Laboratories Incorporated [2]. Figure 1 shows a common configuration of the monochromator and radiometers. In this configuration a white light source illuminates the entrance slit to the monochromator. The monochromator splits the incident light into a colour spectrum. A narrow wavelength band (~10 mm depending on slit width) of light exits the monochromator and is directed at normal incidence onto a specular optical surface or device. Before this however, 50% of the light is split off, by means of a beam splitter, onto the detector of radiometer number 1. This radiometer reading is proportional to the power of the incident light upon the sample. The light reflected off the sample is directed by the beam splitter into the detector of radiometer number 2 whose reading is proportional to the power of the reflected light from the sample. Therefore, the ratio of the signal from radiometer No. 2 over the signal from radiometer No. 1 is directly proportional to the reflectivity of the sample. Using a calibrated mirror at position "AA" (Fig. 1) or a calibrated beam splitter, an exact measure of the reflectivity can be obtained.

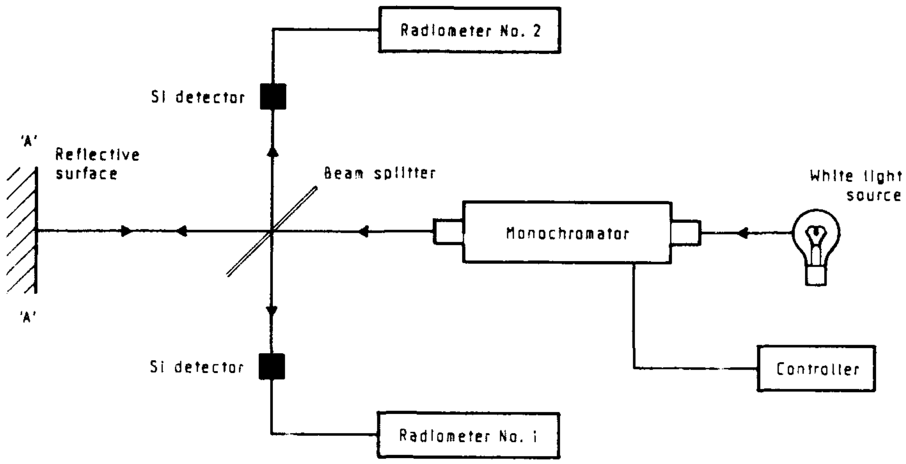


Figure 1: *Common configuration of the monochromator and radiometer.*

Previously, the configuration in Figure 1 minus one radiometer was attached to a Hewlett-Packard 86B computer [4] which used binary coded decimal (BCD) input cards [5] to control the monochromator and also to collect data from the one radiometer and the monochromator. A comprehensive program in HP Basic written by Kennett [7] enabled a scan of a selected wavelength range to be obtained and the data to be stored and graphically displayed. Since only one radiometer and the monochromator were able to be connected to the computer at a time, multiple runs were required in order to measure the incident and the reflected light. Furthermore, the HP86B computer system was no longer fully supported by HP, thereby limiting future growth and future faults may be very difficult to repair. Accordingly, it was decided to rewrite the software in Turbo Pascal (Version 4) and implement control from an IBM compatible PC to improve and safe-guard the automated data acquisition procedure [6].

Both the radiometers and the monochromator use a BCD interface. However, it was decided that the use of the Data Translation 32 bit I/O board already installed in some existing computers within the Materials Division was the most cost effective and practical way to proceed. In order for three machines to be controlled, a digital switch interface was required that would multiplex commands and data to and from the computer. Multiplexing was required because there were insufficient lines of communication (32) to directly address the three devices. Figure 2 shows the final configuration achieved.

The following Sections describe the design of the digital switch interface and small modifications that were subsequently required on the two radiometers. Appendices 1 and 2 detail the mechanical design and the electrical circuit design respectively.

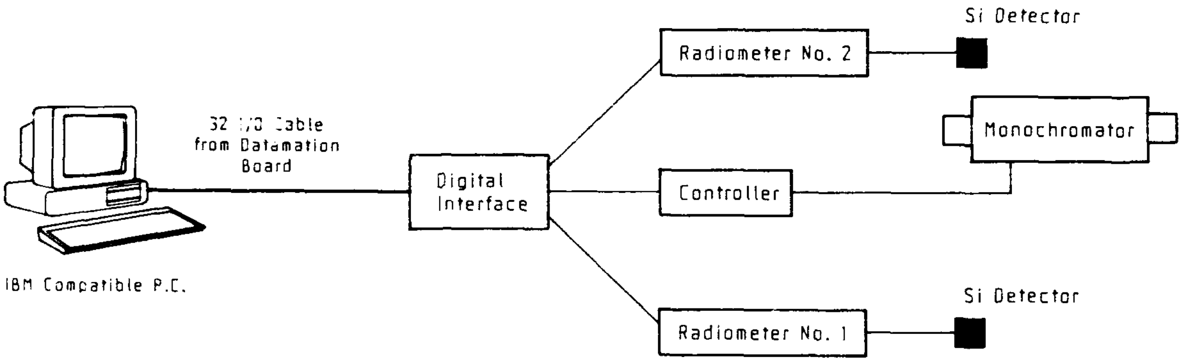


Figure 2: Monochromator and radiometers controlled by an IBM personal computer using the digital switch interface

2. *Digital Switch Interface*

A picture of the digital switch interface is shown in Figure 3. The unit is mounted in a standard instrumentation case 260 mm × 380 mm × 73 mm (*d* × *w* × *h*) (Appendix 1). Weight of the unit is 1 kg. It is connected to the data translation board, which is mounted in a PC, from the rear panel by a 50 way ribbon cable. Connection to the radiometers and monochromator is also made from the rear panel by 25 way ribbon cables (Appendix 1).

2.1 *Electronic Design*

The digital switch interface was designed to enable a data translation 32 bit I/O board (DT2817) to communicate with up to three instruments. This was achieved by using three of the 32 lines to control solid state switches which in turn control the flow of data to and from the instruments. In essence the data to and from each instrument are multiplexed onto the 32 bit I/O port installed in the IBM compatible PC (Fig. 2).

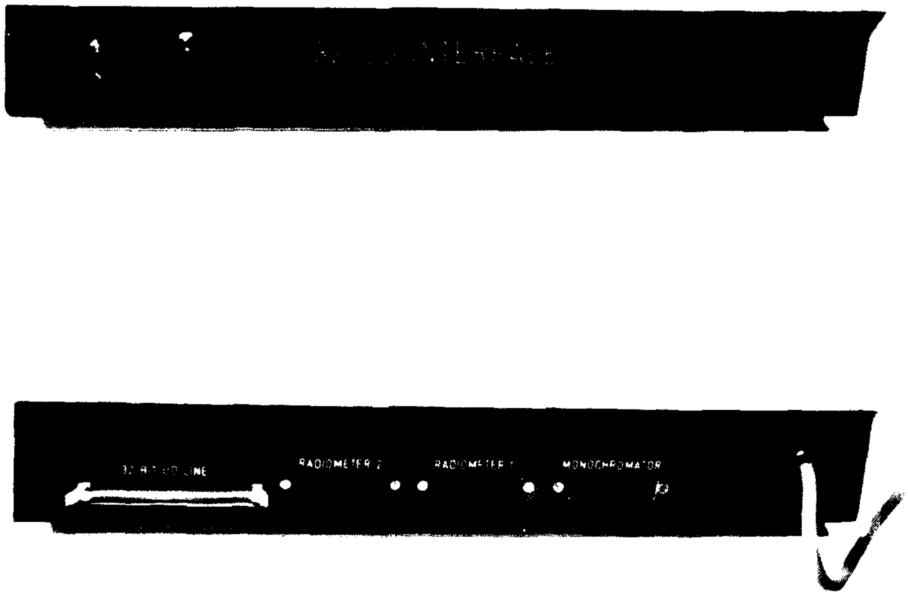


Figure 3: Picture of the digital switch interface (front and rear panels).

The communication requirements of the monochromator and each radiometer were:

(i) the monochromator required 18 data output lines, four control input lines and ground.

(ii) each radiometer required 20 data output lines, four control input lines and ground.

It is evident that if all three instruments were connected on separate I/O lines into the computer, 70 input output (I/O) lines plus three ground lines would be required. The logic levels were TTL for all the instruments.

The I/O of the data translation board is configured as four I/O ports, plus 14 ground lines. Each port is composed of eight digital I/O lines. Any complete port (of eight I/O lines) could be switched by software to an input or output mode. All eight I/O lines in any given port are either all in the input mode or all in the output mode as mixed modes within any given port is not possible. In order to change the state of one output line, all eight lines in any given port are addressed even if logic level changes are not required for the other seven lines in that port.

For this project the I/O lines are arranged in the following way; three ports (total 24 I/O lines) were used for 20 data input lines to the PC, and the remaining port was used for output from the PC. Of these eight output lines, four lines issue commands for instrument control, e.g. slow or fast wavelength scan on the monochromator. Three of the remaining four lines control the switching (multiplexing) of data to/from each instrument. Five I/O lines were not used.

Figure 4 shows the circuit of the digital switch interface. Quad tri-state buffers (74 LS 125) were used for the three banks of digital switches. Each bank of digital switches (24 switches in each bank) controls the flow of data between the PC and an instrument, e.g. radiometer 1. Furthermore, each bank of switches has a single control line input; control line M for the monochromator and R1 and R2 for the respective radiometers (Fig. 4). The logic levels on the control line inputs are determined by the outputs: M′, R1′ and R2′ (Fig. 4) from the PC. If M′ is low, R1′ and R2′ high, then collection of data from and control of the monochromator can occur as the outputs on the other instruments are switched off. In a similar manner, inputs R1′ and R2′ relate to radiometers 1 and 2 respectively. However, to avoid a condition where two or more control inputs go low, thereby causing a conflict (shorting of outputs), some switch control logic was employed (integrated circuits D19 and D20, Fig. 4). This control logic ensures that all the correct switching commands described above are acted upon. All other switching command combinations received from the PC will switch M, R1 and R2 high thereby causing the radiometers and the monochromator to be electronically isolated from the PC. The occurrence of any illegal command will be indicated by the PC being unable to collect any data from or control the instrument(s) addressed.

The four instrument control lines (Fig. 4) allow control of either radiometer or the monochromator. The reader is referred to references 2 and 3 for detailed information on the control commands.

Appendix 2 contains the printed circuit board design detailing the circuit components and their layout.

3. *Modifications to the Radiometers*

3.1 *Description of the Problem*

In the design stage of the Turbo Pascal control software [6], it was decided to change the data collection procedure implemented in the original HP Basic program [7]. The original software produced a continuous scan of the monochromator and at regular intervals the wavelength would be read from the monochromator followed by the radiometer reading. This procedure introduced an error that was dependent on the rate of the wavelength scanning (slow or fast) and the resolution (slit width used) of the monochromator because there was a finite time delay between reading the wavelength and then requesting and receiving a reading from the radiometer. This delay meant that the monochromator had moved on from the wavelength recorded when the radiometer was requested to hold and transmit a reading. With the further introduction of another radiometer this error could only increase if the procedure was not changed to remove the delay.

The simple remedy was to have the monochromator scan performed in a multitude of small steps. For example, at the start of the computer program the wavelength would be read and both radiometers would also be read. The monochromator would then be directed by the software to increment a small amount and then stop. All three instrument readings would again be obtained by the PC. This procedure was repeated over the full range of the scan required thereby removing the reading delay error between the monochromator reading and the radiometers.

However in overcoming measurement errors by modifying the computer program controlling the mechanical method of measurement, another source of potential instrument error (not including detector accuracy) became evident. In each radiometer, the analogue to digital (A/D) convertor would sample and hold its respective detector signal and then convert it to a digital format suitable for transmission to the PC. This sample, hold and conversion process within the A/D is controlled by an internal clock cycle. If the A/D convertors are not sampling data at the same time, the readings obtained could lead to large errors especially where input signals to the monochromator are changing rapidly. In order to ensure this could not happen, each radiometer was modified slightly so that they could be linked together in a master/slave configuration in which the data sampling became synchronous. The modification involved introducing a small circuit into each radiometer. This modification is described in Section 3.2.

Synchronisation of the radiometers with the monochromator was not a problem because the wavelength reading was obtained directly from a shaft encoder on the drive mechanism after it had stopped.

3.2 *Radiometer Circuit Modification*

The modification of the radiometers was slightly complicated due to the fact that although the two radiometers were the same models, the manufacturer had modified the circuitry between the purchase dates of the radiometers. The analogue to digital (A/D) convertors in each radiometer were different. The main difference of concern was the timing of A/D conversion initiation pulse. The radiometer (S/N 850202) used an ICL 710 A/D which generated an internal A/D conversion initiation pulse, whereas the second radiometer, S/N 88200289, used an ICL 7135 A/D which required an externally generated pulse to initiate an A/D conversion.

The modification implemented involved using the rising edge of the busy output pulse of the ICL 7135 to generate a 1 ms pulse to the ICL 7101 to synchronise the radiometers. Figure 5 shows the circuit used. The rising edge of the busy pulse from the ICL 7135 is transformed into a 1 ms pulse using a 74221 dual monostable. This pulse is transmitted to the second radiometer by coaxial cable from the rear of the first radiometer. Isolated BNC sockets and an opto-isolator receiver were used to avoid any potential problems from ground loops. A simple toggle switch on the rear of the second radiometer (S/N 850202) enabled the user to synchronise the A/Ds producing a master/slave situation. A light emitting diode mounted on the front panel of the radiometer indicated the "slave" mode.

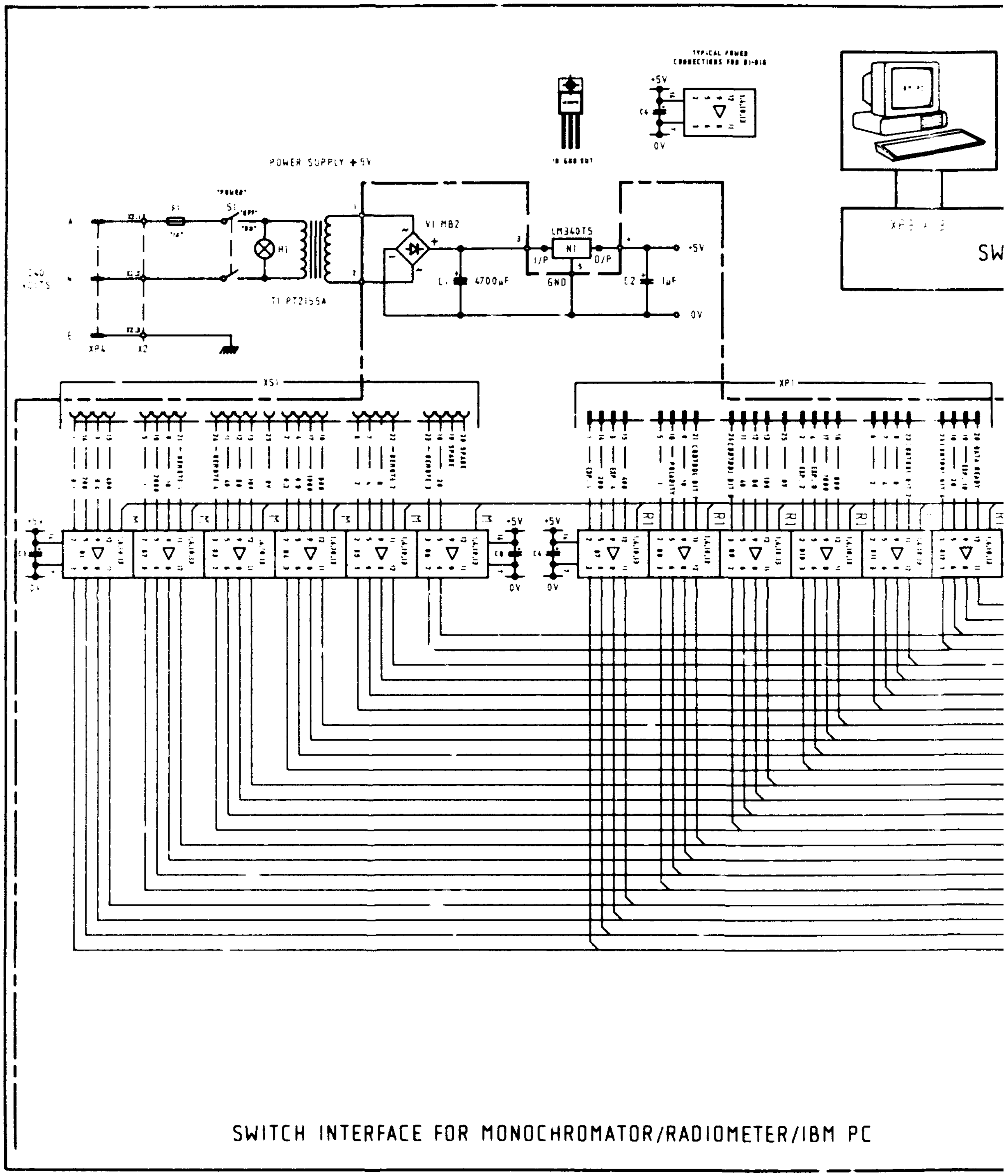
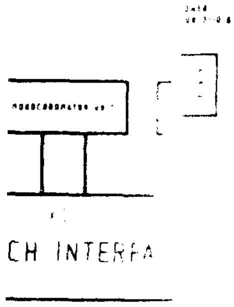
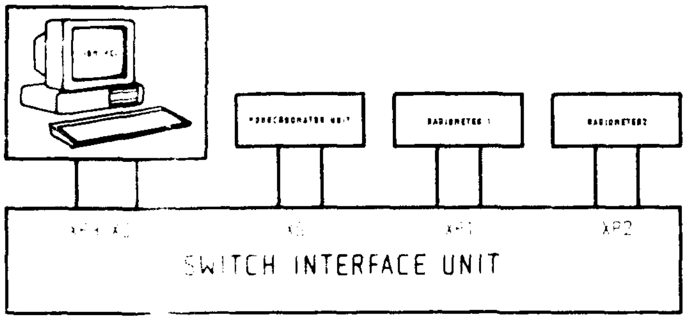
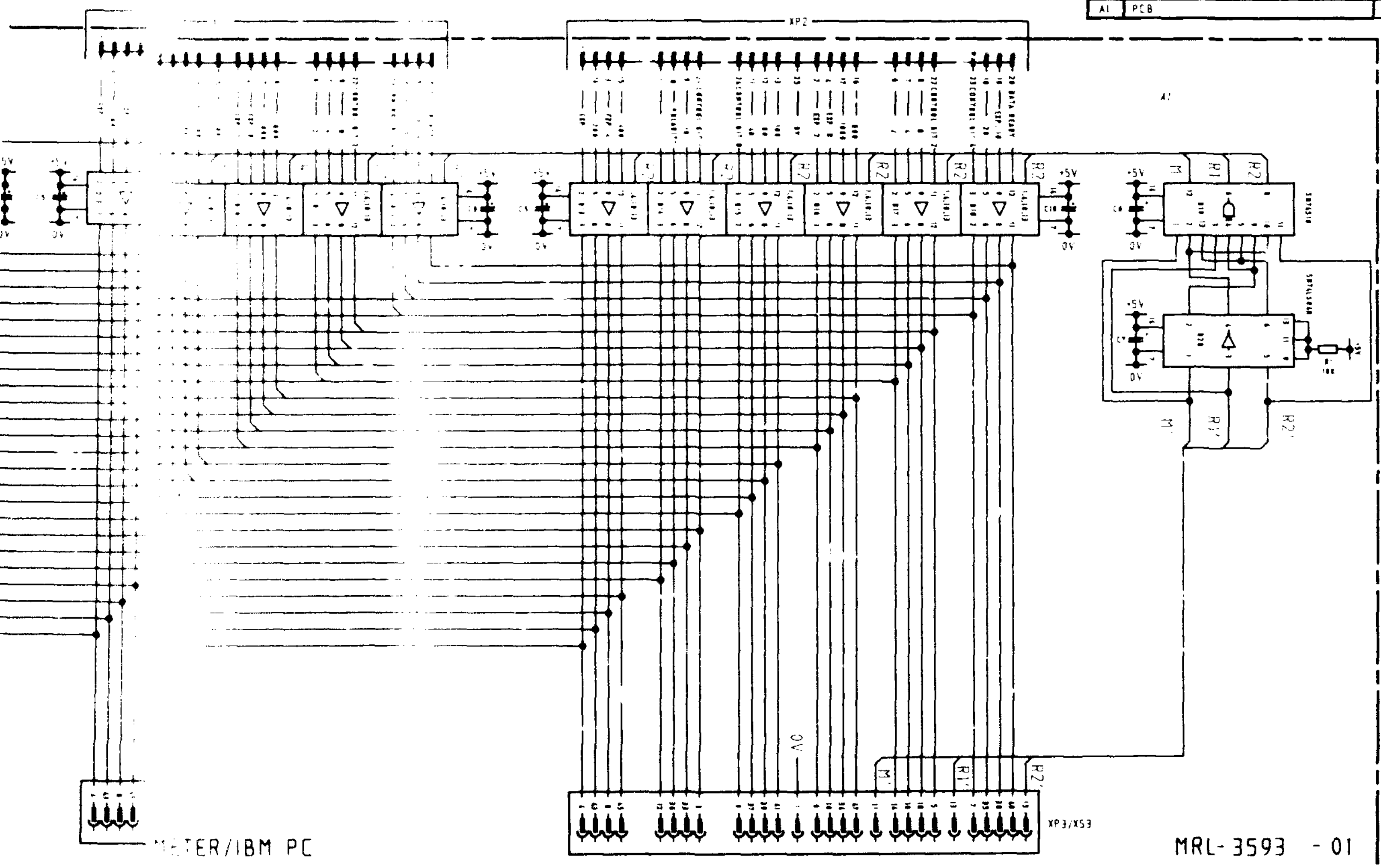


Figure 4: [illegible] of the digital switch interface





COMP No.	DESCRIPTION	RAT.
C.1	CAPACITOR ALUM. ELECTROLYTIC 4700μF	35 V
C.2	" TANT ELECTROLYTIC 1.0 μF	35 V
C3-10	" TANT ELECTROLYTIC 0.1μF	35 V
V1	BRIDGE RECTIFIER MB2	1.5
H1	RED NEON LAMP FP7/CL/NR	0.2
N1	VOLTAGE REGULATOR LM340T-5	1.5
T1	TRANSFORMER PT2155A	1A
D1-18	TRISTATE BUFFER SN74LS125AN	
D19	TRIPLE 3-INPUT NAND GATE SN74S10	
D20	HEX INVERTER SN74LS04N	
S1	DPDT SWITCH C&K TYPE	2A
XP1-2	25 PIN D-TYPE CONNECTOR PCB MOUNT	
XP3	50 WAY KEYED IDC CONNECTOR PCB MOUNT	
XS3	" " " " "	
XS1	25 PIN D-TYPE CONNECTOR PCB MOUNT	
X2	TERMINAL BOARD WILCO COS1512	15
XP4	3 PIN CLIPSAL ELECTRICAL PLUG	10
F1	BELLING LEE PANEL MOUNT FUSE HOLDER	2.5
	FUSE SIZE 00	1A
R1	RESISTOR METAL FILM 10K	1/4
A1	PCB	



50 WAY KEYED IDC CONNECTOR TO IBM PC

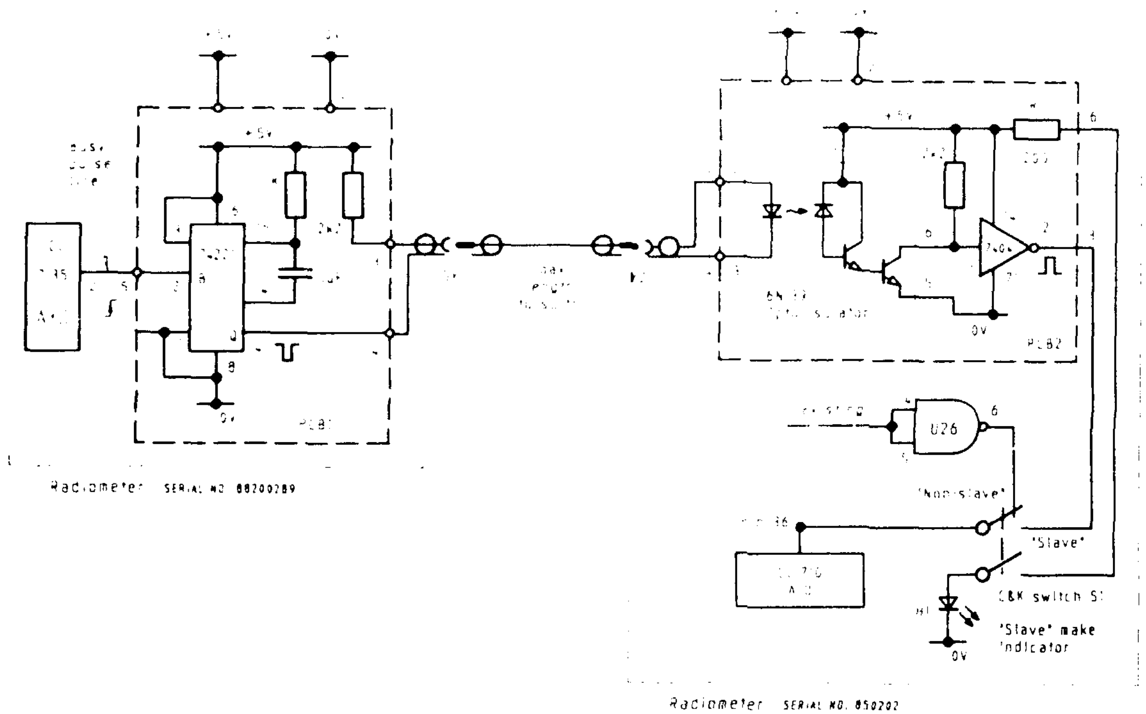


Figure 5: Circuitry of the radiometer modification

4. Summary

A digital switch interface has been constructed enabling an IBM compatible PC to multiplex control to, and the data acquisition from, two radiometers and a monochromator. In addition, the general design of the switch interface enables it to be used by a PC to control any other three instruments where a digital interface (TTL level) is used.

5. Acknowledgements

The author wishes to thank Mr George Servanis in the MRL drafting office for his work on the PCB design and packaging of the digital switch interface. Mr Cameron Stewart must also be acknowledged for the final design of the master/slave modifications and for co-ordinating the task through the drawing office and the MRL instrument workshop. Last but not least Mr Max Butler must be thanked for his skills in producing the figures for this report.

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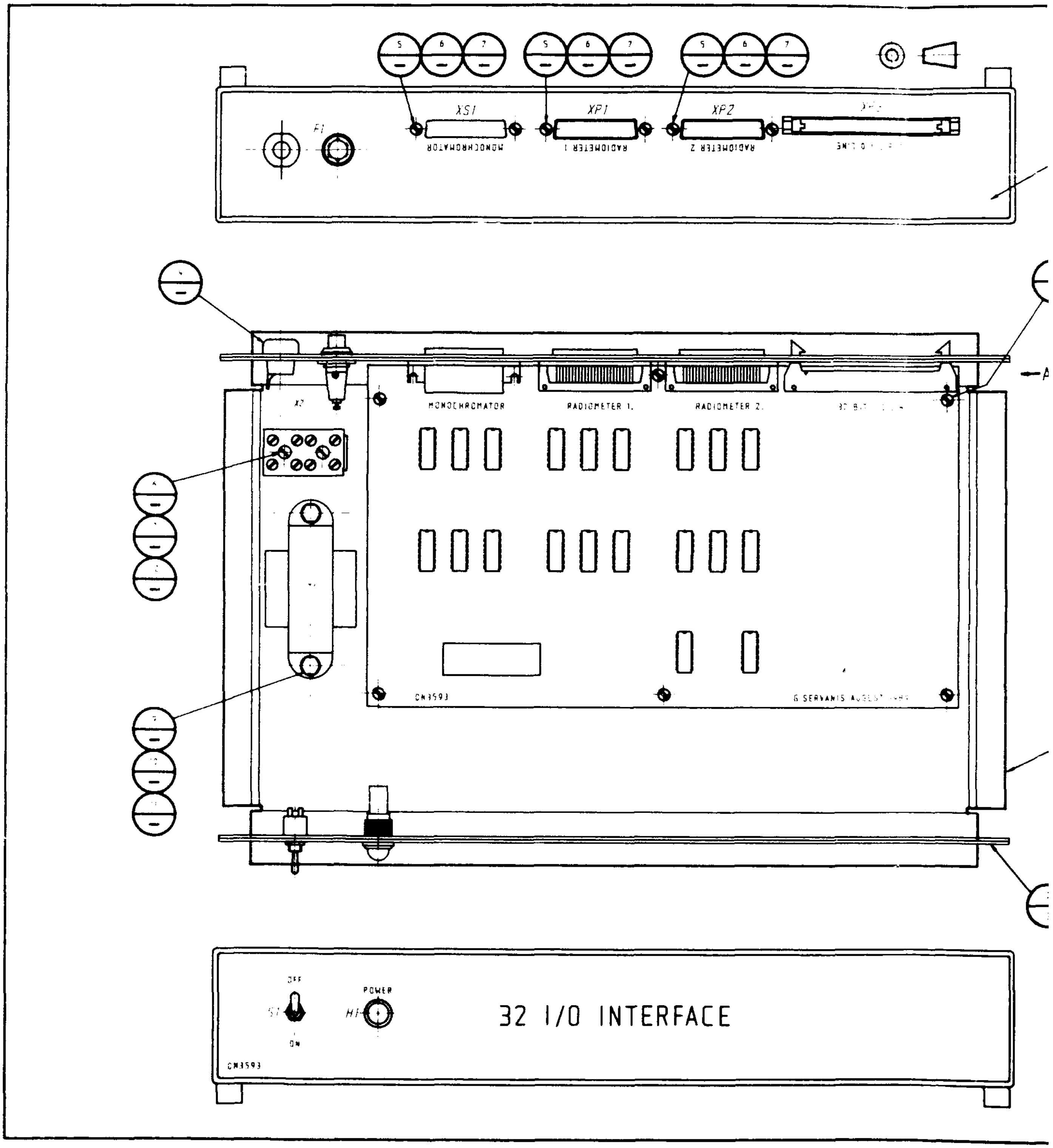
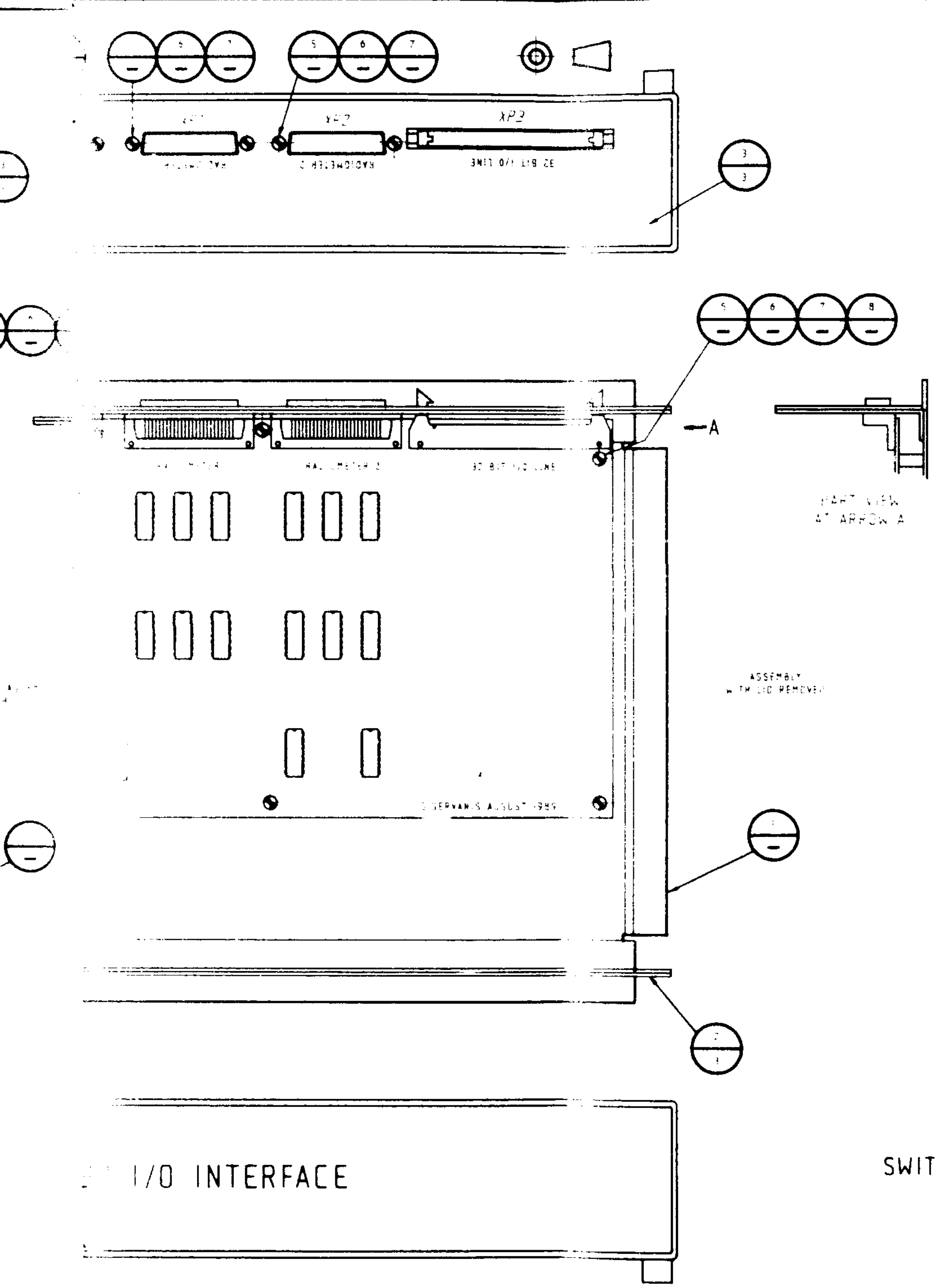
Appendix 1

Mechanical Layout





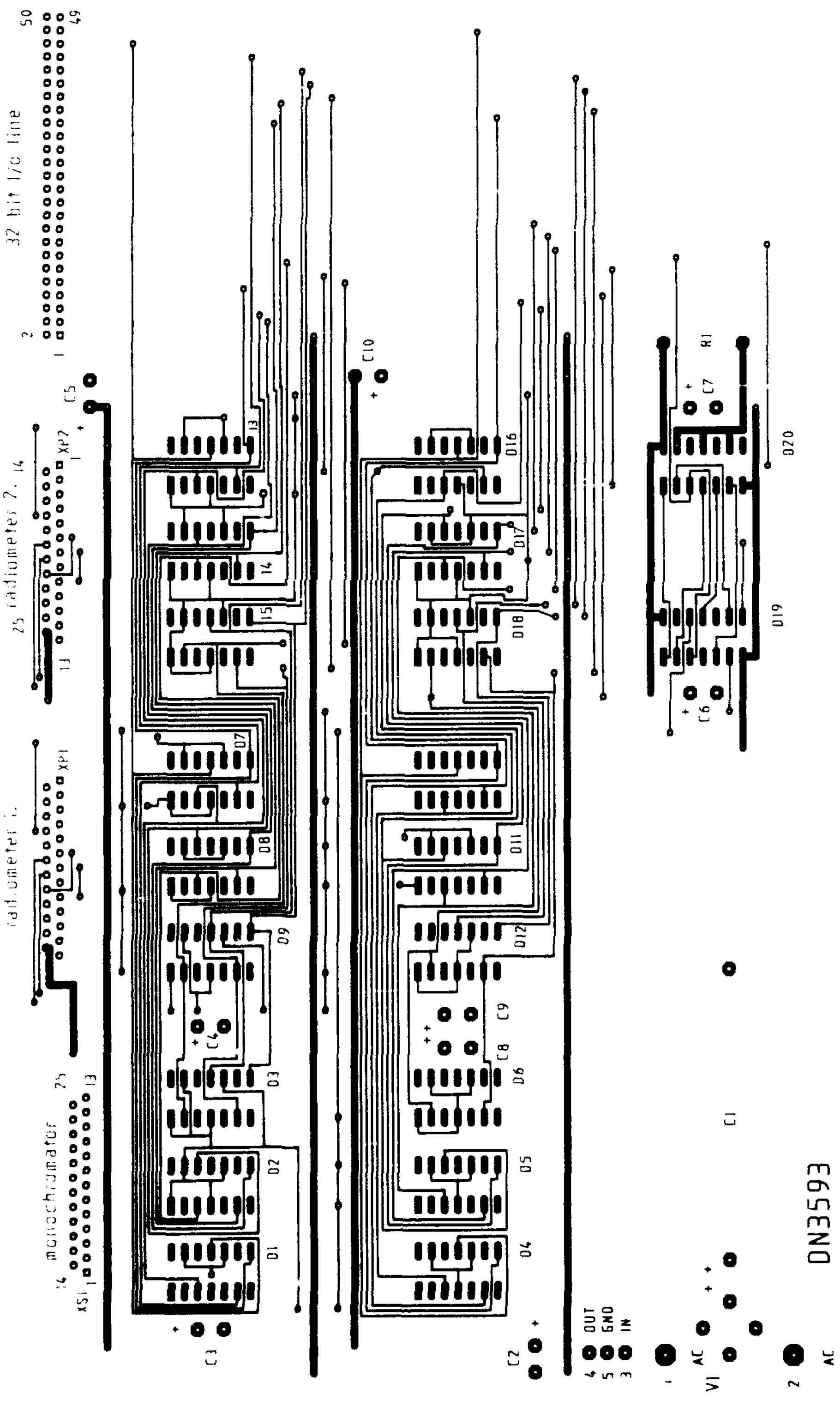
PART No	DESCRIPTION	SHEET No.	MATL	NO OFF
1	STYLE 2 ENCLOSURE RS 501-430	1		1
2	FRONT PANEL SCOTT - PLY	3		
3	BACK PANEL SCOTT - PLY	3		
4	CORD GRIP RS 607-774	1		
5	SCREW M3 X 10LG PAN HD. ZINC PLT	5305-997-7796		12
6	WASHER M3 ZINC PLT	5310-990-1564		14
7	HEX NUT M3 ZINC PLT	5310-990-1541		14
8	TAPPED HEX SPACER M3 LENGTH TO SUIT.	1		6
9	SCREW M5 X 16LG PAN HD. ZINC PLT	5305-990-1525		2
10	WASHER M5 ZINC PLT	5310-990-1566		2
11	HEX NUT M5 ZINC PLT	5310-990-1543		2
12	SREW M3 X 20LG PAN HD. ZINC PLT	1		2

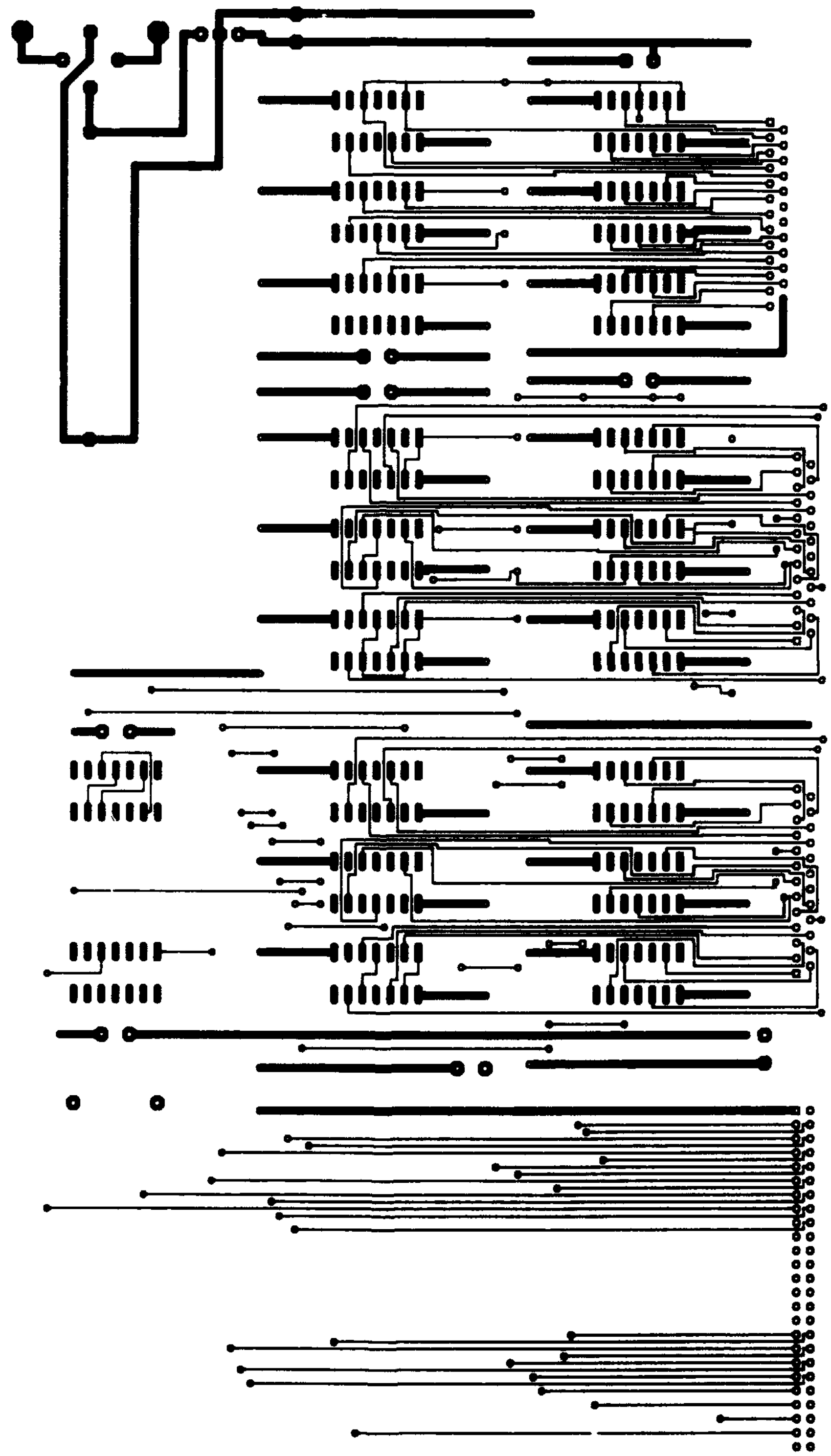
SWITCH INTERFACE FOR MONOCHROMATOR/
RADIOMETER/IBM PC

MRL - 3593 - 01

Appendix 2

Printed Circuit Board Design





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