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DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

ELECTRONICS RESEARCH LABORATORY

TECHNICAL REPORT

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A MICROPROCESSOR BASED 16 CHANNEL DATALOGGER

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S U M M A R Y

This report describes a 16 channel voltage recording instrument designed for use in optical radiometry, but with applications in other fields. The 16 channel datalogger provides a means of connecting a radiometer, consisting of 16 silicon diodes with appropriate filters, to a Hewlett-Packard 97S printing, programmable calculator. On command, the datalogger simultaneously samples and stores the 16 input voltages, and supplies the values and corresponding channel numbers to the calculator, to allow recording using the inbuilt printer. The calculator can be programmed to control how often samples are taken, and it can also perform numerical manipulation of values for calibration or scaling, before printing. The datalogger can display the stored voltages on an inbuilt LED display, and can also display input voltages in real time, while samples are not being taken.

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1. INTRODUCTION

A reflecting surface can often be characterised by a plot of reflectance versus wavelength, known as its spectral signature. To make practical comparative measurements of this signature, the reflected radiance values in a number of discrete wavebands is a good approximation.

The 16 channel datalogger was designed to be used with a 16 channel radiometer and a Hewlett-Packard 97S calculator, to form a measuring and recording instrument for the collection of spectral signatures of vegetation. This involved the continual logging of sets of 16 values in an airborne environment, an environment characterised by vibration and temperature problems.

The interconnection of the equipment used in this task is shown in figure 1, and is typical of an experimental setup using the datalogger. The three blocks represent

(i) Radiometer - a sixteen channel instrument, with each channel having an independant voltage output in the range 0 to +999 mV.

(ii) Datalogger - input buffer amplifiers, with an input voltage range of -99 mV to +999 mV, sample and hold circuitry, logical control and visual readout.

(iii) Calculator - the HP-97S calculator, programmed to accept data from the datalogger in digital form and print it, and to provide some limited control of the datalogger.

This technical report describes the 16 channel datalogger, including details of the electronic circuitry, and also describes the basic features required in an HP-97S program when used with the datalogger. Figure 2 shows the datalogger connected to the HP-97S. This combination could provide datalogging facilities to any experimental setup with 16 or less voltages to be recorded, at intervals greater than 30 s.

2. PRINCIPLES OF OPERATION

2.1 General description

The datalogger is designed to simultaneously read and store 16 input voltages, and write them out, along with identifying channel numbers, to the HP-97S calculator. The calculator's prime function is to record the values using its inbuilt printer, however it may be used to apply calibration corrections and scaling factors to data before printing.

A facility has been included, additional to design requirements, to allow the datalogger to be of limited use without the calculator attached, by the inclusion of a digital readout which displays a channel number and its corresponding voltage.

The datalogger operates in two modes - "voltmeter" mode and "storage" mode.

(i) "Voltmeter" mode is the idling mode selected when power is first applied or a RESET invoked. The actual (varying) input voltages can be viewed, one channel at a time, on the datalogger's digital readout. Hence in this mode the datalogger behaves as a 16 channel voltmeter. The calculator cannot acquire data from the datalogger in this mode.

(ii) "Storage" mode is entered when the SAMPLE control is activated.

On entering this mode, all 16 input voltage values are stored simultaneously. If the calculator has been programmed to accept data, then the 16 stored voltage values are transferred via the interface, and when this is complete, the datalogger reverts to the "voltmeter" mode, ready for the next sample.

If the datalogger receives no indication that the calculator is ready to accept data (in particular, if no calculator is connected), the stored voltages may be reviewed on the digital readout. In this case the "voltmeter" mode can only be re-entered by activating the RESET control (or power off/on).

Figure 3 is a state diagram to clarify the transactions between the two modes.

2.2 Datalogger display

The datalogger can display voltage values and their corresponding channel numbers, one at a time. The voltage values are displayed in the form +.ddd (where d is a decimal digit) or -.0dd for values in the range of the datalogger, and overload is indicated by blanking the display and showing a sign only. To scan the channels, the display is associated with a CHANNEL ADVANCE control, which causes the channels to be displayed in channel number sequence. Channel one is selected if the maximum channel count is exceeded, and also if the mode is changed.

2.3 Calculator control of the datalogger

The HP-97S calculator has 3 usable flags (control lines) which can be set or cleared under program control. Two of these flags have been assigned functions which may control the datalogger. Flag F0 has been assigned the RESET function and Flag F1 has been assigned the SAMPLE function, and both these flags are in parallel with manually operable controls on the datalogger. By appropriately programming the HP-97S calculator to reset and clear these flags, it is possible to automatically collect samples at regular intervals of time.

2.4 Monitoring fewer than 16 channels

A wire link on the datalogger's printed circuit board can be used to set the datalogger to monitor and record less than 16 channels of input.The wire link sets the number of channels and all functions take account of this.

3. ELECTRICAL OPERATION

3.1 Overview

The datalogger is a solid state electronic device, based on large-scale-integration (LSI) integrated circuits. The circuitry can be broken down into four functional areas, shown in the block diagram, figure 4.

Each of the sixteen analogue inputs is independantly buffered and amplified. A sample and hold circuit is provided for each channel so that, on command, the sixteen inputs can be stored simultaneously. A digitally controlled analogue switch selects one of the 16 voltages for analogue to digital (A/D) conversion. An A/D converter produces a 3 decimal digit representation of the selected voltage, which is fed to the logic controller. The controller controls all functions of the datalogger, including the mode, data displayed and information exchanged with the programmable calculator.

The full electronic circuit diagram is given in figure 5 and details of the LSI integrated circuits used can be obtained from references 1, 2 and 3.

3.2 Input stage

The input stage provides input buffering and analogue voltage storage for sixteen input channels. Each input channel consists of a sample and hold circuit, based on an LF398 (as described in reference 1) which provides input buffering to give an input impedance of the order of $10^{10}\Omega$, and because of such a high value, some precautions are necessary against stray electromagnetic pick up and noise. Thus, either the input loads should be short and screened, in which case the high impedance is usable, or the loads should be driven by a low impedance source, such as a preamplifier, and terminated in low value resistive leads near the sample and hold circuits.

The storage function of the sample and hold circuits is utilized in the "storage" mode of the datalogger, and the controls of all LF398's are ganged together to ensure simultaneous sampling of each channel. The circuit design of the sample and hold circuit represents a compromise involving stability of stored voltage, speed of sampling, and temperature dependance. Here component values were chosen to give a sampling error of 2 mV for an input slew rate of 100 mV s^{-1}, and a stored voltage droop rate of between 0.2 mV s^{-1} at 25 C and 10 mV s^{-1} at 85 C (a temperature range of 25 to 48 C is typical).

A further source of error is the input offset voltage associated with the LF398 integrated circuit. This is a constant systematic error for a given integrated circuit, but varies between individual integrated circuits due to manufacturing tolerances. Each channel of the datalogger is provided with an offset null control to cancel differences between channels, and in association with the zeroing control in the A/D converter stage, all channels can be adjusted to read zero for zero voltage input.

3.3 Switching

The gating of one of the 16 channels to the input of the A/D converter is performed by a mosfet analogue switch (Fairchild 3708). The switch is digitally controlled by the microprocessor using a 4 bit channel number.

3.4 Analogue-to-digital conversion

A/D conversion is performed by a single chip integrated circuit, Analogue Devices AD2023/B (described fully in reference 2). The analogue input range of the device is -99 mV to +999 mV, and for voltages in this range, a positive voltage is represented by 3 binary coded decimal (BCD) digits, and negative voltage is represented A_{16}, (1010 in binary), plus two BCD digits. Overloads are signified by 3 hexadecimal digit output, positive overload represented by BBB_{16} and negative overload by AAA_{16}. This is summarised in Table 2.

The output of the A/D convertor is multiplexed onto seven lines, and these are connected to the logic controller. The hexadecimal digits representing various conditions are recognised by the logic controller, and appropriate action is taken.

3.5 The logic controller

The logic controller controls all functions of the datalogger as well as the data transfer to the external calculator. It is based on the Intel 8748 microprocessor (reference 3) and uses a combination of CMOS and TTL logic integrated circuits.

3.5.1 The microprocessor

The 8748 microprocessor comprises a central processing unit and an ultraviolet light erasable, programmable read only memory (EPROM) on a single integrated circuit, and as such is more correctly referred to as a single chip microcomputer. The EPROM is intended to store fixed data and an internal program prepared by the designer.

The 8748 is usually programmed in assembly language which is assembled with the aid of a development system, or by hand (tedious). The assembled machine code is transferred to the 8748 by raising a specially assigned programming pin to an unusually high voltage while data and address are applied to other pins. Reprogramming is possible but is intended to be an infrequent operation to correct errors. Before reprogramming the integrated circuit chip must be exposed to ultraviolet radiation for approximately 30 min to erase the previous program.

In use, the microprocessor continually executes its internal program (in the EPROM), and interacts with the outside world via 3 testable input pins, and 24 pins which are defined as input or output by the internal program. In the datalogger, an additional integrated circuit is used as an "expander" to increase the available number of input/output pins to 36. The "expander" and the microprocessor communicate with each other in a way which is transparent to the user and the combination appears in all respects to be a single entity.

Once programmed, the 8748 appears similar to any other special purpose integrated circuit, and it is not important that it is a microprocessor.

3.5.2 Functions of the 8748 as a special purpose integrated circuit

The functional assignments of the 8748 pins are shown in Table 1. The sequence of functions executed and controlled by the 8748 is dependant on the mode of operation. When power is first turned on this will be the "voltmeter" mode. After the SAMPLE control has been activated the mode will change to "storage" mode.

(i) Voltmeter mode

In this mode the SAMPLE control is continuously monitored, and the input value from a selected channel is displayed on the readout. The CHANNEL ADVANCE control will cycle the channels displayed, and the RESET control resets the channel number to one. The A/D converter's output values indicating overload are trapped and the display shows + or - sign only. The calculator interface is ignored.

(ii) Storage mode

When this mode is entered, the input stages sample and hold their input voltages (simultaneously) and the 8748 scans and stores a digital representation of the values captured by the input stages.

If a calculator is connected, and it indicates its readiness to accept data, the 8748 will read out the values from its store to the calculator asynchronously at a rate of approximately one per second, a rate determined by the calculator. A/D overload conditions are converted to +9E9 or -9E9 which represents $+9X10^9$ or $9X10^{-9}$ to the calculator. After all channels have been read out the datalogger reverts to "voltmeter" mode.

If no active calculator is connected to the datalogger, the stored values are retained in memory until RESET is pressed. The display will show stored values while still in storage mode one at a time, with overloads displayed as + or - sign only.

Electrically, the programmed microprocessor/expander combination is a logic element compatible with TTL logic, with 5 V=high and 0 V=low. The expander outputs are used to drive the front panel display in parallel with some of the data lines through the interface to the calculator. The eight input/output (I/O) lines grouped as port 1 are used as outputs from the 8748 and are used individually as control lines for various functions within the datalogger. Port 2 is half used by the expander with the remaining 4 bits giving the channel number in binary. Port 3 (except bit 7) is used to transfer the A/D output to the 8748, and bit 7 is used to program the 8748 to use less than 16 channels (using a wire link). These uses of I/O are set out in Table 1 more explicitly and explained with respect to the internal program in Section 3.5.3.

3.5.3 The microprocessor's internal program

The microprocessor is internally programmed to have the characteristics described in Section 3.5.2. The program is summarised in flowchart form in figures 6 and 7. It has four identifiable sections - initialisation, sample and hold processing, display and debug. The latter section is meant for maintenance purposes only; it is an entirely independant section of program and it is discussed in Section 3.5.4.

(i) Initialisation

Whenever the microprocessor is reset, ie reset pin is taken low, either by turning power off momentarily or by pressing RESET, the internal program begins execution from the first instruction in memory. The first few instructions reset the channel number to 1 and set the mode to "voltmeter" mode. Referring to figure 5, immediately after the reset pin is taken to low state, the microprocessor sets Port 2 bits 4 to 7 to zero and outputs BCD 1 to the channel number display. It also resets the hold bit (Port 1 bit 0) and also the negative and overload bits. Control passes to the display section of the program, and channel one's current input voltage will be displayed before any controls will be needed.

(ii) Sample and hold

The sample and hold section of the program is invoked whenever "storage" mode is entered. (Storage mode is entered when SAMPLE control is activated; which causes the INT input of the 8748 to go low). The program first sets the mode bit (PORT 1 bit 0) to "storage", then resets the channel number to one. The binary value of the channel number operates the digitally controlled analogue switch, and hence selects the input channel for A/D conversion. After waiting for at least 2 A/D conversions per channel, to allow settling time, each channel's voltage value is stored in the microprocessor's internal "scratchpad" memory. Control passes back to the display Section of the program when values for all channels have been stored.

(iii) Display

The display section of the program forms the main part of the program, and executes some alternative instructions depending on mode.

Firstly, the channel number is outputted in binary and BCD, and then if in "storage" mode recalls that channel's voltage value from its scratchpad, or if in "voltmeter" mode gets a voltage value from the A/D. The value is processed so that only the correct representations of negative and positive overloads will reach the display or calculator, and then the value is displayed on the inbuilt readout. If in "voltmeter" mode the program checks that no controls are currently pressed, then begins processing the next A/D conversion for the current channel. If in "storage" mode the program idles by checking the command controls and calculator interface, with no further recall necessary for the current channel.

When activation of the CHANNEL ADVANCE control is detected, the channel number is increased by one, except in the case that all channels have already been displayed, when the number becomes one. The program then begins the display Section again.

A RESET causes initialisation as explained above.

A SAMPLE command in "voltmeter" mode causes the sample and hold section of the program to be executed. In "storage" mode SAMPLE is, of course, ignored.

The calculator interface is only monitored in "storage" mode. If it indicates the calculator is ready to receive data, all control inputs are ignored, and the program writes the channel numbers and corresponding voltages in sequence, to the calculator, handshaking via T1 and Port 1 bit 2. After all channels have been transferred, the program jumps to location zero, effectively performing RESET.

During execution of the program, the maximum number of channels is limited to 16, however at places where the channel number is increased, a check is always made to see if a wire link is currently causing port 3, bit 7 to be low. If it is, this indicates that the maximum channel count has been exceeded and appropriate action is taken.

3.5.4 Debugging aid

The microprocessor has an independant program recorded in its memory, which can be used for debugging hardware faults. It will execute if the SAMPLE control is activated during a RESET and is designed to transfer the raw output of the A/D converter directly to the display. A flowchart is given in figure 7.

When this function is selected, it is immediately acknowledged by the display of < D ACC > until the SAMPLE control is released. The program then outputs a channel number in binary to the display and the voltage to the display. This gives a hexidecimal value for the channel number in the range 0 to 15, and shows the raw output of the A/D converter, A/D on the as described in Table 2, on the voltage display. The CHANNEL ADVANCE control can be used to cycle through the input channels, and the HOLD control is inactive. The calculator controls are inactive, the interface being inhibited by setting port 1 bit 7 high.

RESET will cause the initialisation program to be executed, and debug will be cancelled unless SAMPLE is again activated simultaneously.

3.6 Power requirements

This unit is designed for portable use in an environment with either +15,-15 and +5 V, that is usually available in a laboratory, or with +12, -12 and 6 V from lead acid accumulators, for portable use. In the former case R17 is shorted by a strap and D3 removed from the circuit. In latter case the R17, D3 combination is necessary to supply +5 V for logic circuits.

Power supply voltages are, in general, non-critical if stable, however some alteration in gain and zero correction preset controls is necessary when changing from one set of supply voltages to another.

4. USING THE DATALOGGER WITH THE HP-97S CALCULATOR

4.1 Overview

Operating the datalogger in conjunction with the HP-97S requires a knowledge of the calculator's operation and architecture, and a knowledge of the format of data presented to the interface by the datalogger. The former is described briefly in Section 4.2 and in detail in references 3 and 4. The latter is a function of the 8748 programming and the calculator interface requirements. These will be described in detail, and some examples of typical programs will be given.

4.2 Operation of the calculator

The HP-97S is a programmable, stack oriented calculator with a stack of four operational registers, x, y, z and t. Numbers entered using the keyboard are placed in the x register. Pressing an "enter" key copies the contents of z, denoted (z), into register t, copies (y) into z, and copies (x) into y. The contents of register t is lost.

The calculator performs operations on numbers in its registers according to the Lukasiewicz (reverse polish) convention (reference 5). Monadic (single argument) functions are performed on register x, and dyadic (two argument) functions are performed on registers x and y. When the result of a dyadic function is a single value, it is placed in register x, with (z) copied into y,(t) copied into z.

Besides the 4 working registers, the calculator also has 10 addressable memories, which are usually recalled into the working registers for use.

The HP-97S is programmable and can store subroutines in the form of a series of key strokes. Programs are labelled A to F, a to f, and are invoked by pressing keys which execute a "go to subroutine N" intruction.

A number of functions are included specifically as programming aids. These include compare x with y and skip intructions, and set and test flag intructions (four flags are provided).

A facility to store and later reload programs is provided using magnetic cards. This is detailed in reference 4.

4.3 The calculator interface

The calculator interface of the HP-97S consists of 40 data lines, 4 flags and a number of control lines (see figure 8). The 40 data lines are divided into 10, 4 bit nibbles, (labelled A to J) which can input the numbers or instructions shown in Table 3, using binary code.

The four flags, F0 - F3, can be controlled by the calculator program, and are available to communicate with the external device. Flags F0 to F2 are usable in a general way, however Flag F3 has a meaning pre-assigned by the calculator manufacturer - setting it inhibits data transfer from the interface - and it is always set by the interface after a data transfer.

The control lines are used in this application to perform handshaking during transfer of data from the external device (the datalogger) to the calculator. The "load enable" (LE) is an output from the calculator and is effectively a ready flag. The "load" line is used as an input to the calculator and a low to high logic level transition on this line transfers the 10 4-bit nibbles to the calculator in sequence, just as though the calculator keys had been pressed.

4.4 Data transfer between the datalogger and the calculator

The interface between the datalogger and the calculator is configured so that information is always transferred in the format

<channel number><ENTER><+.DDD><Go to subroutine A>

The <ENTER> and <GSBA> are permanently wired onto the plug, and the other information comes from the logic controller. (Table 4 sets out this format in specific detail).

The calculator is ready for data transfer when flag F3 is cleared and the calculator's program has halted. It signifies this with the LE line. The datalogger's logic controller then supplies the required information for one channel to the interface and pulses the load line. The calculator must be programmed to accept the information for the single channel, process and print it if required, and subsequently clear flag F3 and halt ready to accept a new channel's information. When all data from each used datalogger channel has been transferred, the datalogger resets itself to voltmeter mode, and the calculator's program must take account of this.

The calculator can communicate with the microprocessor via flags F0 and F1. F0 has the same effect as activating the RESET control, and F1 has the same effect as activating the SAMPLE control.

Flag 3 can be used to end the logging sequence with fewer than all available channels, by causing a RESET which sets the datalogger to voltmeter mode.

4.5 Programming the calculator

The essentials of a program to provide a printed log when used with the datalogger, are summarised in figures 8 and 9. The following discussion assumes a knowledge of the HP-97S architecture. (See reference 2).

Figure 9 shows the simplest form of program which assumes that the number of channels is limited to 16 or set by a wire link on the PC board, and that the SAMPLE control will be activated when a reading is required.

Subroutine B is used to initialise the calculator. Flags F0 and F1, which parallel the RESET and HOLD controls in the datalogger, are cleared giving the calculator no control over those functions. The two conditions necessary for data transfer are then set up namely, flag F3 is cleared, and the calculator is halted.

At this point data is loaded into the calculator, including a "go to subroutine A" which causes execution to recommence at label A. At this time the calculator's stack contains the channel number in position y and the voltage reading in position x (which is displayed).

Subroutine A should perform any processing required, include calibration corrections of the form ax+b, and could perform different corrections to different channels. After such processing, any data required to be recorded should be printed and then flag F3 cleared and execution halted to allow the next data transfer.

Figure 10 shows a more complicated calculator program. Here the datalogger controls the sampling rate, (option C) which can be as fast as can be logged by the printer (assuming negligable time for mathematical processing). This program also makes provision for use of less channels, as determined by the calculator program.

5. CONCLUSIONS

The device described in this technical report is an application of large-scale-integration integrated circuits to multichannel measurement. While the 16 channel datalogger described is used in conjunction with an HP-97S calculator there is no reason why the microprocessor controller cannot be reprogrammed to handle any other sort of calculator with similar facilities, or to exchange information with another computer type device, or to just control a (dumb) printing device. By using a programmable logic device, not only is the information exchange protocol simple and easily alterable but also the effort in producing the electronics hardware is considerably reduced.

The general principles of this datalogger are applicable to any similar combination of A/D and programmable microprocessor where multichannel measurement is required, and this particular class of device should find application in many related areas.

REFERENCES

No.	Author	Title
1	National Semiconductors	"Linear Data Book".
2	Analogue Devices	"Data Collection Devices". 1979
3	Hewlett Packard Co.	"Installation and Operation Guide for the HP-97S".
4	Hewlett Packard Co.	"HP-97: Owners Handbook and Programming Guide".
5	Dijkstra, E.W.	"Making a Translator for ALGOL 60". APIC Bulletin, 1961, 7, 3-11

TABLE 1. FUNCTIONAL ASSIGNMENTS OF MICROPROCESSOR CONNECTIONS

8748 function	Active	Programmed Function	Use
TO	L	MANUAL CHANNEL ADVANCE control	FP,CF
T1	L	Monitor LOAD ENABLE from calculator	CI
INT	L	SAMPLE control	FP,CF
RESET	L	RESET control	FP,CF
PORT1,bit 0	H	Mode: H = "Storage"	D,I/P
P1,1	H	Negative Voltage	D,CD
P1,2	H	Control calculator LOAD	CI
P1,3	L	Overload	D,CD
P1,4	H	Channel number, most significant BCD digit	DCD
P1,5	H	Latch display (not used)	
P1,6	H	Debug flag (not used)	
P1,7	H	Control calculator INHIBIT	CI
PORT2,bits 0-3	na	Expander connection (transparent to user)	
P2,4-7	H	Channel number in binary	CS
P3,bits 0-3	L	BCD digit	AD
P3,bit 4 6	L	MSD/NSD/LSD select	AD
P3 bit 7		Maximum channel count exceeded - ie set No. of channels	Internal
P4(on expander)	H	Channel number in BCD	D,CD
P5(on expander)	H	Most significant digit of voltage	D,CD
P6(on expander)	H	Next significant digit of voltage	D,CD1
P7(on expander)	H	Least significant digit of voltage	D,CD

Use:
- CD = calculator data
- CF = calculator flag
- CI = calculator interface control
- CS = calculator selection switch
- D = front panel display
- FP = front panel control
- I/P = input stage control
- AD = digital data from A/D convertor

TABLE 2. ANALOGUE TO DIGITAL CONVERTER OUTPUTS

Input Voltage	Output Code hex	Output Code binary
0V to +999 mV	ddd	(xxxx,xxxx,xxxx)
-99 mV to 0V	A_{16}	(1010,xxxx,xxxx)
less than -99 mV	AAA_{16}	(1010,1010,1010)
greater than +999 mV	BBB_{16}	(1011,1011,1011)

where d is a BCD digit
and x is a binary 1 or 0

TABLE 3. CALCULATOR INPUT CODES

Input Code		Meaning (calculator function)	
0000	0_{16}	0	(decimal digit)
0001	1_{16}	1	(decimal digit)
0010	2_{16}	2	(decimal digit)
0011	3_{16}	3	(decimal digit)
0100	4_{16}	4	(decimal digit)
0101	5_{16}	5	(decimal digit)
0110	6_{16}	6	(decimal digit)
0111	7_{16}	7	(decimal digit)
1000	8_{16}	8	(decimal digit)
1001	9_{16}	9	(decimal digit)
1010	A_{16}	.	(decimal point)
1011	B_{16}	EEX	(enter exponent)
1100	C_{16}	ENTER	(number terminator)
1101	D_{16}	GSBA	(go to subroutine A)
1110	E_{16}	CHS	(change sign)
1111	F_{16}	NO-OP	(no operation)

TABLE 4. DATA TRANSFER FORMAT OF THE DATALOGGER

Nibble	Possible Value	Function
A	1 or NOOP	MSD of channel number
B	0...9	LSD of channel number
C	(ENTER)	Causes number to be pushed up in calculator's stack.
D	(decimal pt)	$\left.\begin{array}{l} \\ \text{MSD} \\ \text{NSD} \\ \text{LSD} \\ \pm \end{array}\right\}$ ±.DDD voltage reading
E	0...9	
F	0...9	
G	0...9	
H	(CHS) or NOOP	
I	GSBA	Causes calculator to start executing subroutine A
J	Not Used	

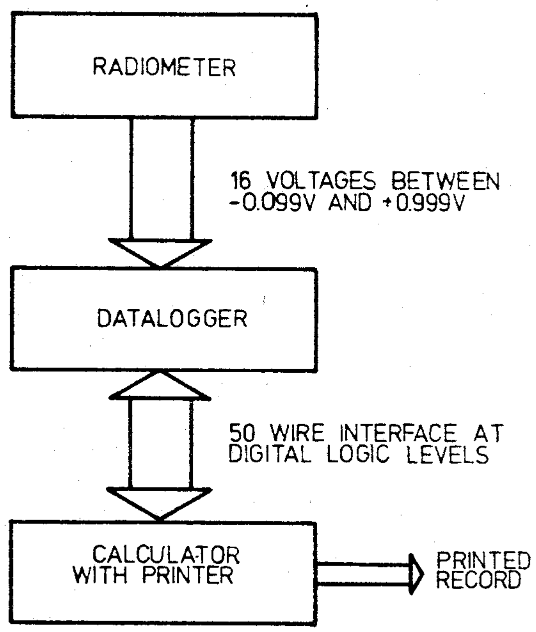

Figure 1. The interconnection of the datalogger used with a radiometer

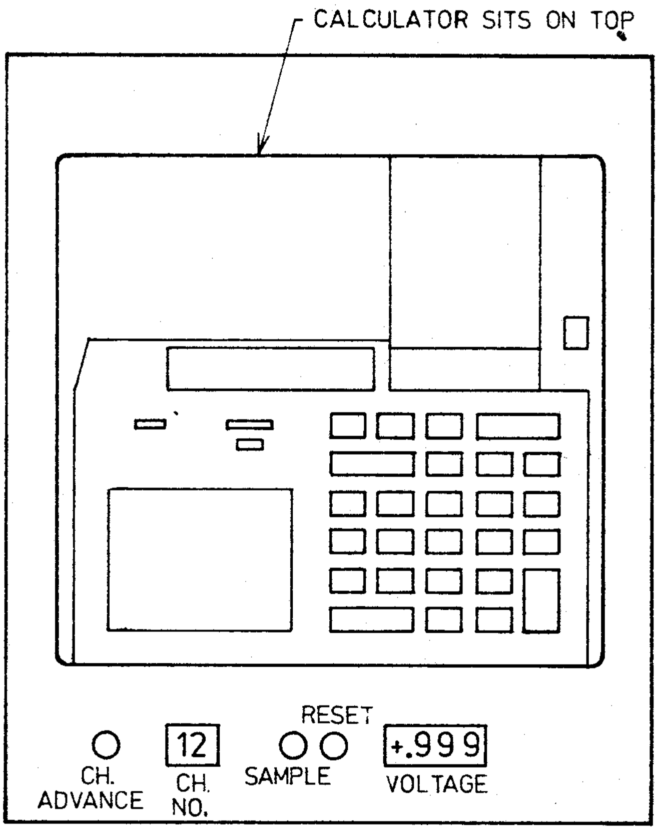

Figure 2. The datalogger connected to the HP-97S calculator

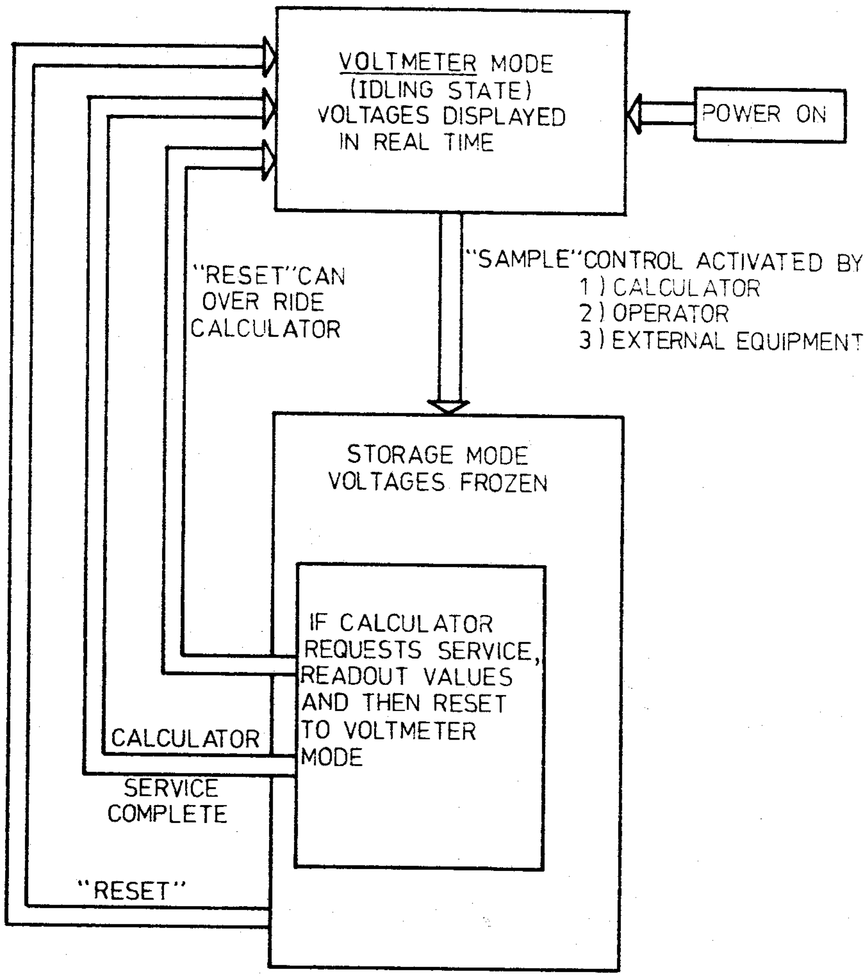

Figure 3. State diagram showing the two modes of operation

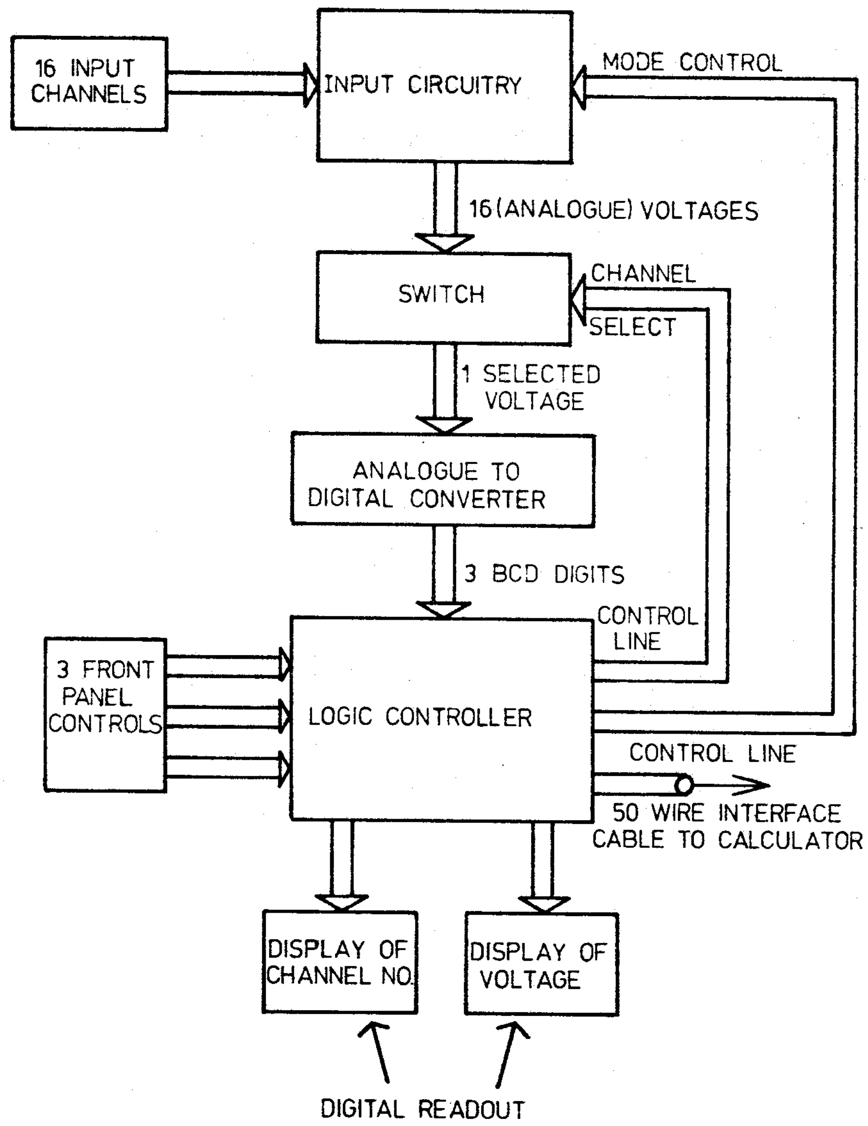

Figure 4. Block diagram showing a functional schematic of the electronic circuitry

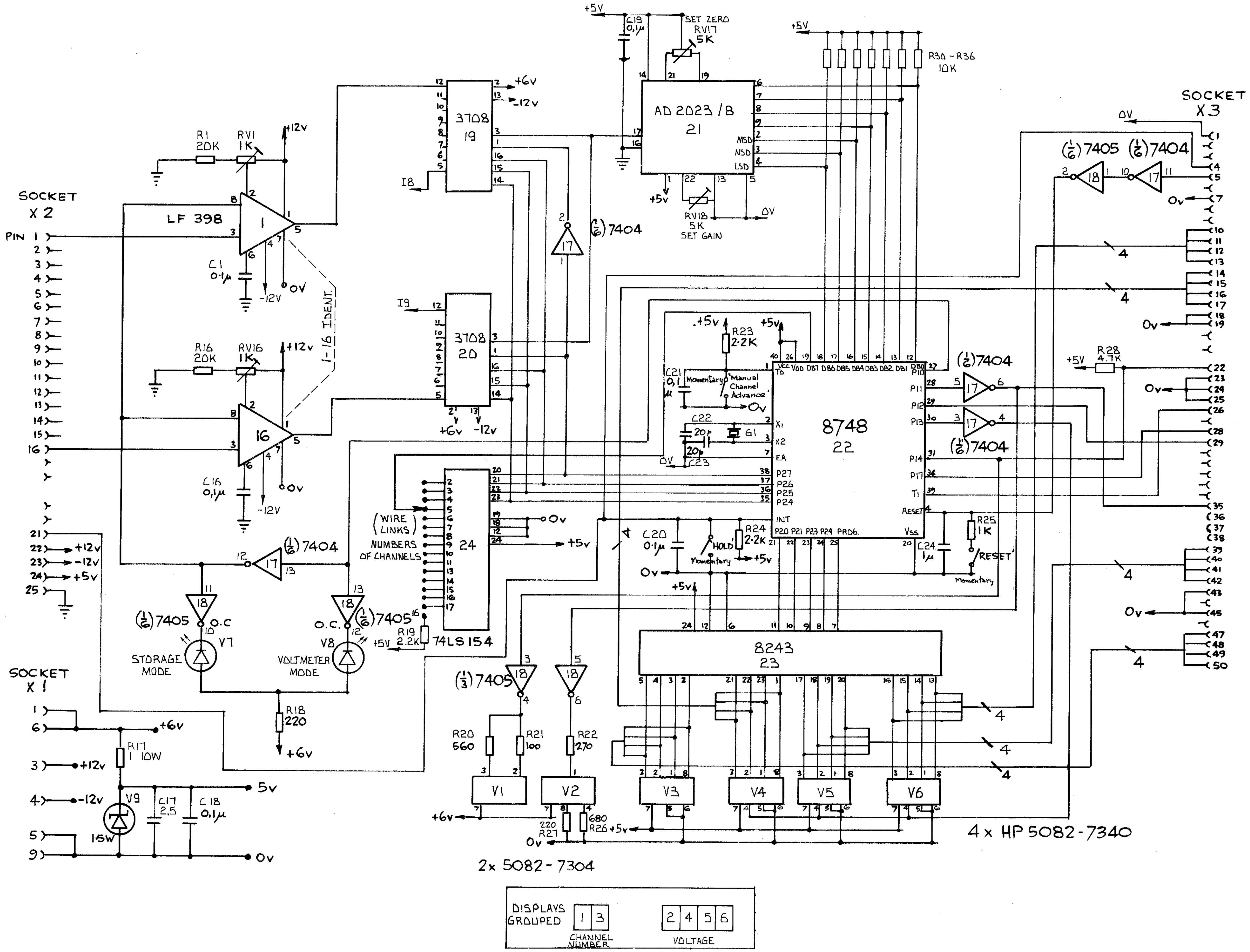

Figure 5. Electronic circuit showing component values

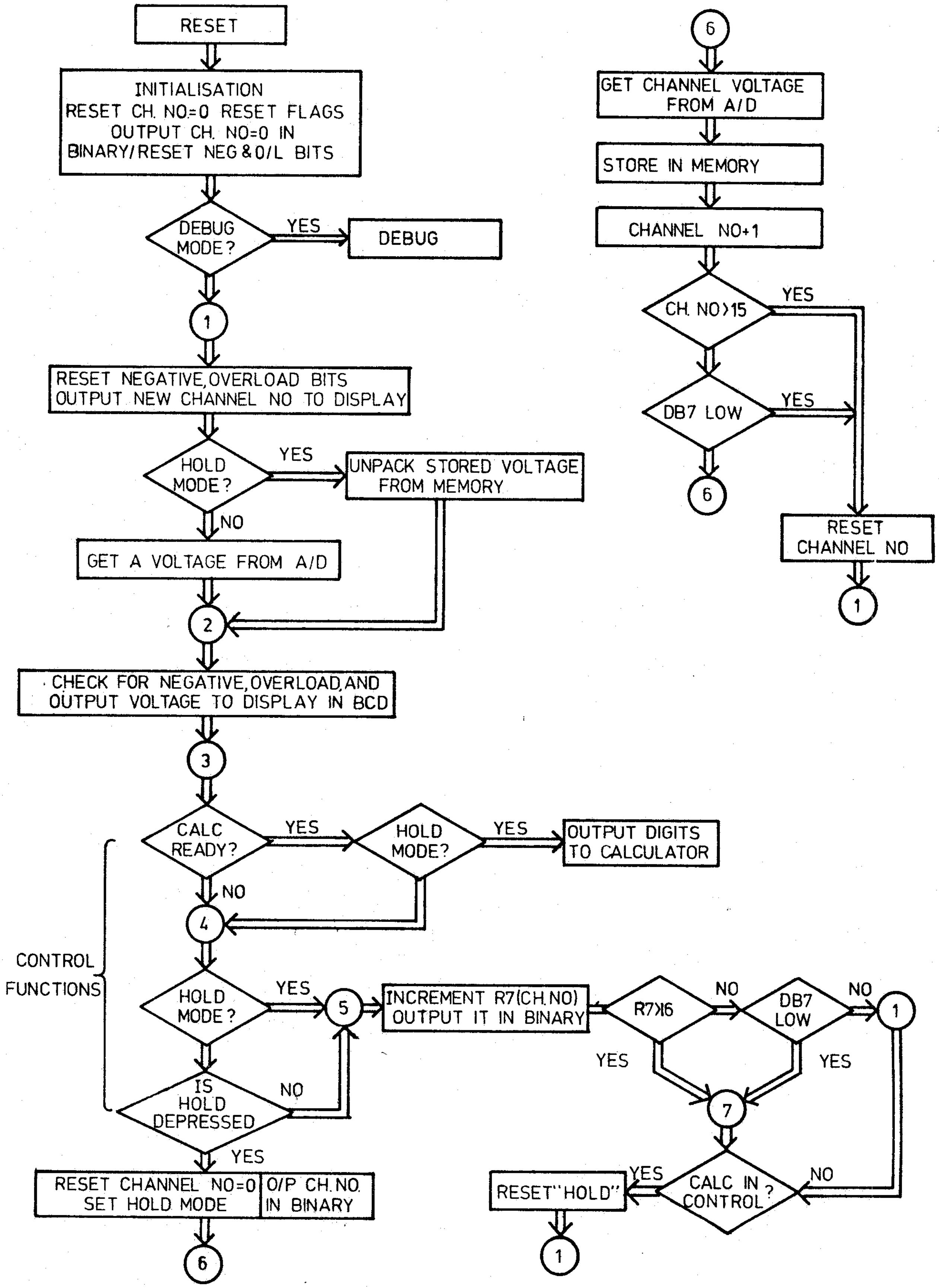

Figure 6. Flow chart of 8748 program - main section

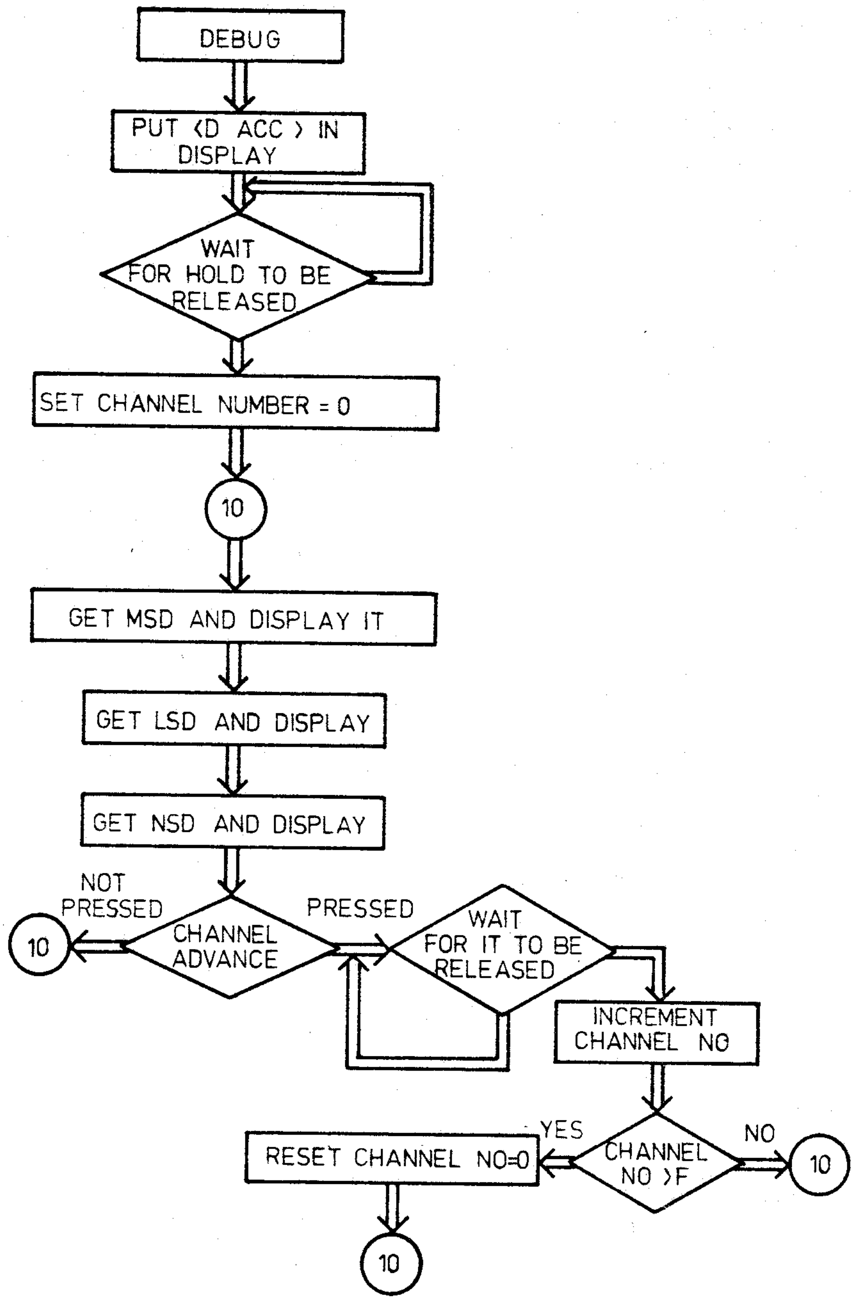

Figure 7. Flow chart of 8748 program - debug section

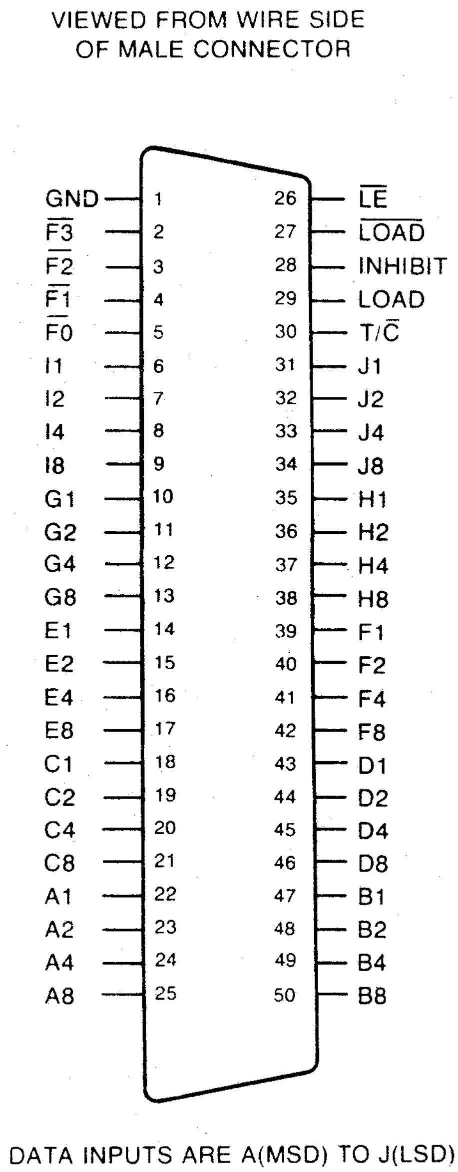

Figure 8. The HP-97S interface connector plug

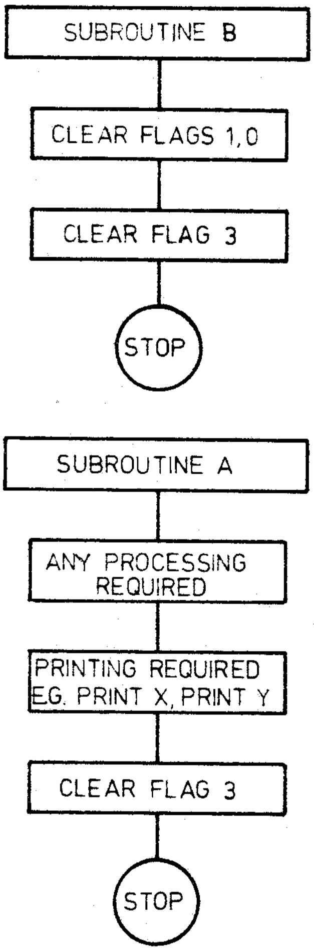

Figure 9. Flow chart of a typical calculator program

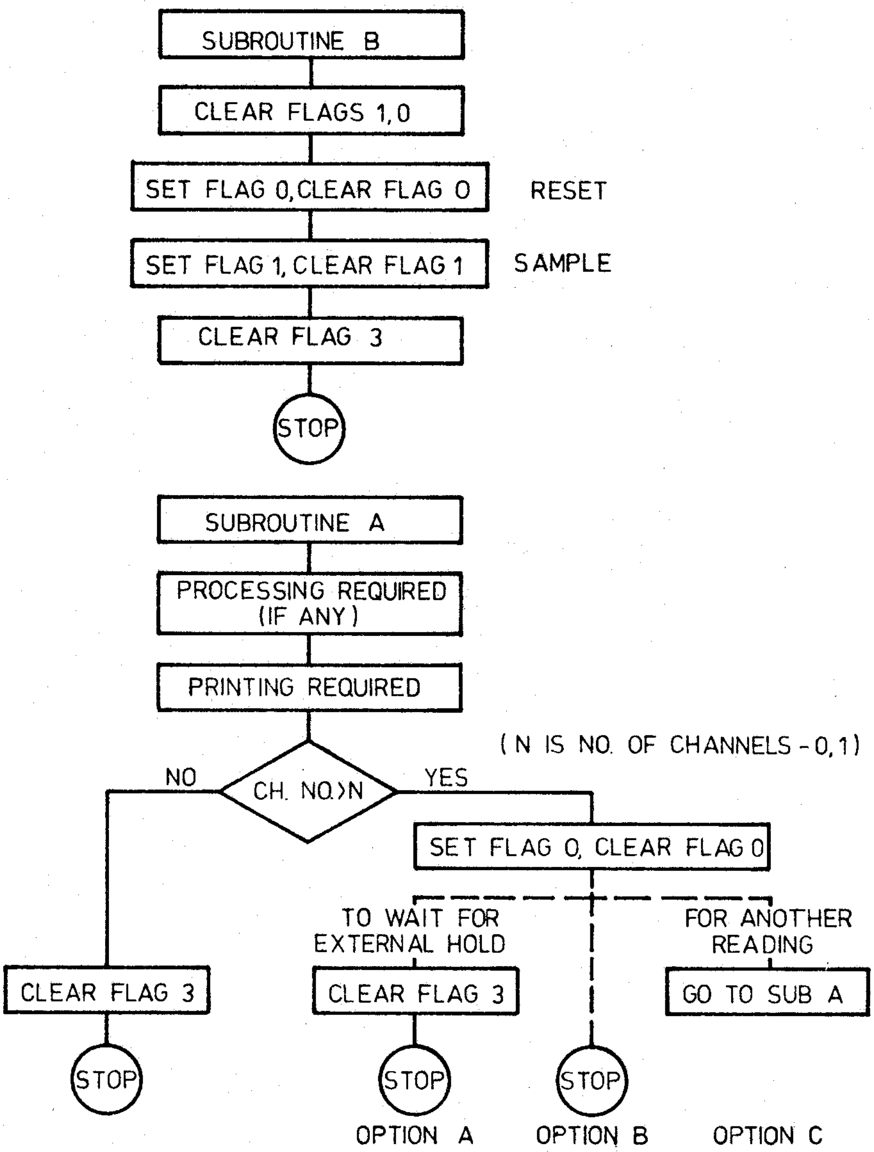

Figure 10. Flow chart of a more complicated calculator program

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16 SUMMARY OR ABSTRACT:
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This report describes a 16 channel voltage recording instrument designed for use in optical radiometry, but with applications in other fields. The 16 channel datalogger provides a means of connecting a radiometer, consisting of 16 silicon diodes with appropriate filters, to a Hewlett-Packard 97S printing, programmable calculator. On command, the datalogger simultaneously samples and stores the 16 input voltages, and supplies the values and corresponding channel numbers to the calculator, to allow recording using the inbuilt printer. The calculator can be programmed to control how often samples are taken, and it can also perform numerical manipulation of values for calibration or scaling, before printing. The datalogger can display the stored voltages on an inbuilt LED display, and can also display input voltages in real time, while samples are not being taken.

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