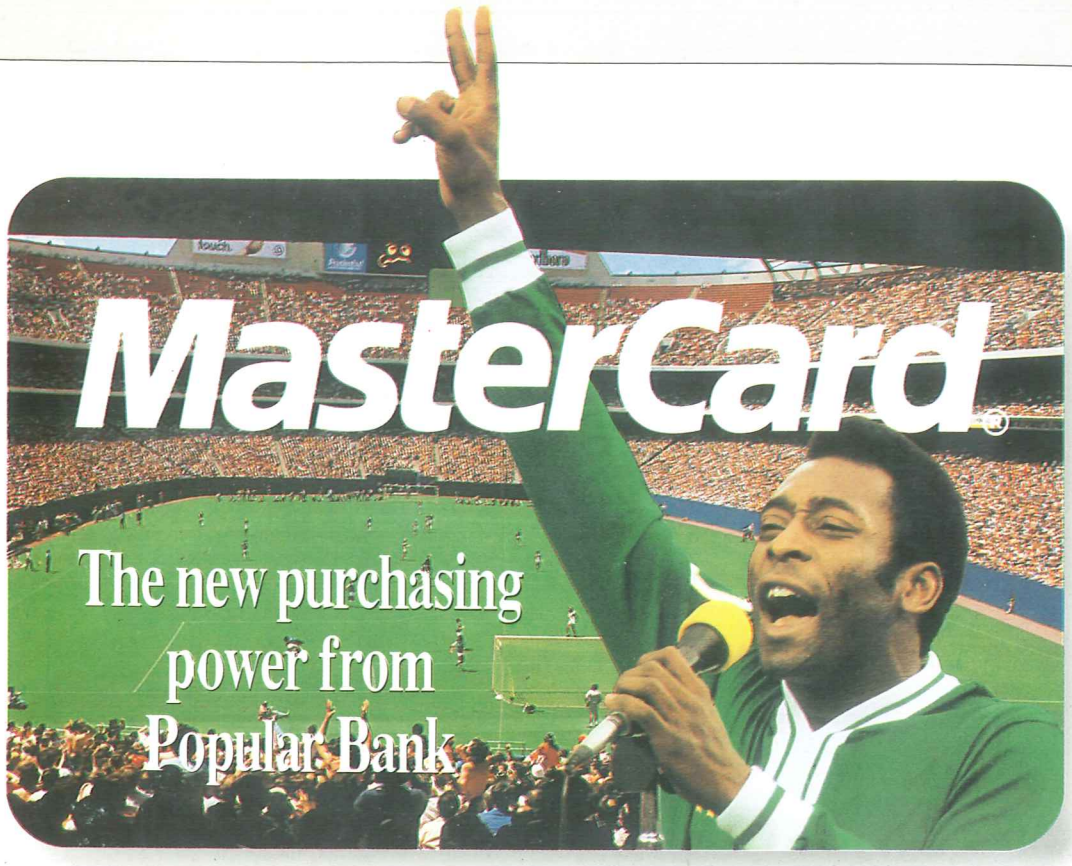
No. 22 September 1993 Nicosia Cyprus

Review

THE HIGHER TECHNICAL INSTITUTE



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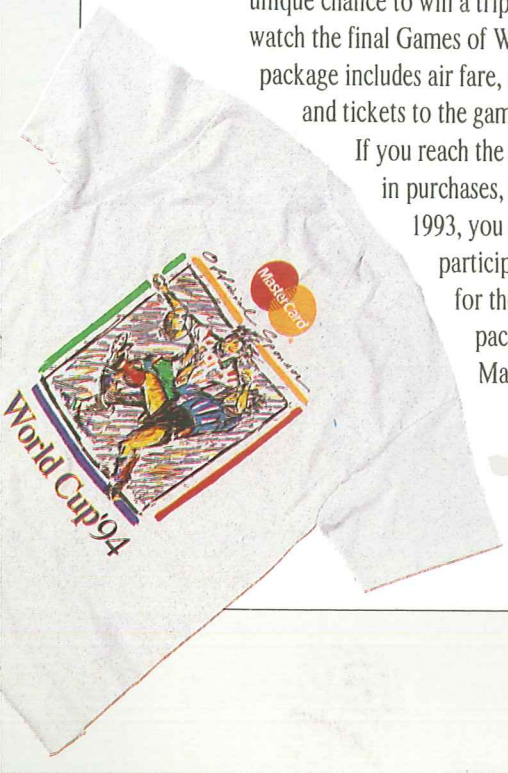

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The Higher Technical Institute (HTI) was established in 1968 as a Government of Cyprus project with assistance by the United Nations Special Fund (UNDP), the United Nations-Educational Scientific and Cultural Organisation (UNESCO), the International Labour Office (ILO). Cyprus Government Executing Agency: The Ministry of Labour and Social Insurance.

HTI Review

No. 22 September 1993 Nicosia Cyprus

H.E. The President of the Republic, Mr Glafcos Clerides, bestowing the Presidential Prize to Alexandros Onoufriou, graduate of the Mechanical Engineering Department.

HTI Review is published by the Press and Information Office in cooperation with the Higher Technical Institute, Nicosia. It accepts articles which promote and further new developments and knowledge in technology, especially with reference to Industries of Cyprus. Requests for further copies of the magazine and for information concerning the published articles should be made to Chief Editor HTI Review, Higher Technical Institute, P.O.Box 2423 - Nicosia, Cyprus.
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1993 HTI
Graduation Ceremony

The 22nd Graduation Ceremony of the Higher Technical Institute was held on Friday, 2 July 1993 at the Cyprus International Conference Centre.

The President of the Republic, Mr Glafcos Clerides, attended the Ceremony and presented the Presidential Prize for the Highest

The Minister of Labour and Social Insurance, Mr Andreas Moushouttas, awarding the Diplomas to the graduates

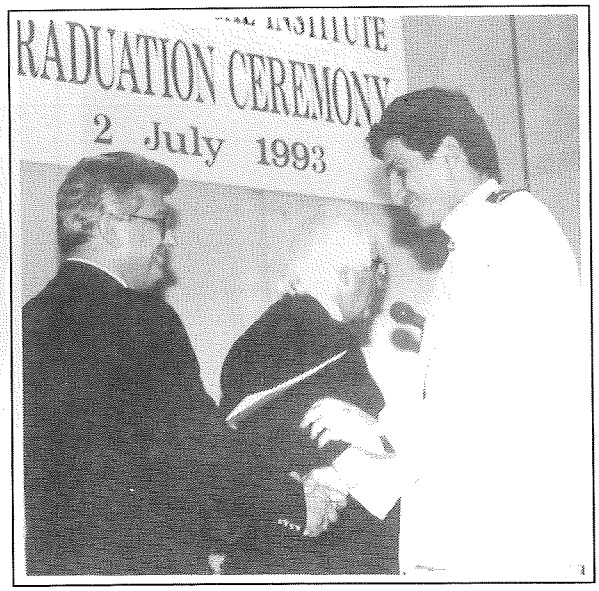
Overall Performance to Alexandros Onoufriou, Mechanical Engineering graduate.

The Minister of Labour and Social Insurance, Mr Andreas Moushouttas, awarded the Diplomas to the graduates of the Civil, Electrical, Mechanical and Computer Studies Specialisations. The Diplomas to the graduates of the Marine Specialisation were awarded by the Minister of Communications and Works, Mr Adamos Adamides. The HTI Director, awarded the prizes which are sponsored by the local industry and other professional bodies to the students who excelled during the Academic Year 1992/93.

Ministers, Members of Parliament, Director Generals, Members of the Diplomatic Corps and other dignitaries honoured the Graduation Ceremony with their presence. There were also representatives from various political parties, the trade unions and the industry sector as well as HTI staff and graduates with their families.

The main speaker was the Director of the HTI Mr Demetrios Lazarides. The gathering was also addressed by Mr N. Nestoros, HTI Students Union President.

Mr Lazarides outlined the achievements of HTI during the current Academic Year adding that the "Higher Technical Institute, with its excellent educational programme, its first class equipment and facilities, and with its well-trained and dedicated staff has equipped today' s graduates with all the necessary knowledge and expertise in order to fulfill their role in the Cyprus Industry".



The Minister of Communications and Works, Mr Adamos Adamides, awarding the Diplomas to the graduates

The Director stated that 163 students graduated in 1993 from the regular three-year programmes. Moreover, HTI in collaboration with various professional organisations and financial assistance from the Industrial Training Authority has organised programmes tailored for engineering and technical personnel working

The HTI Director delivering the Graduation Speech

in the Cyprus Industry and Government Departments.

The HTI Director went on to say that HTI is proud of its graduates who are highly respected in the local professional market and abroad. He pointed out the fact that the demand for HTI graduates far exceeds the supply, which attests to the high quality of education that HTI students receive. This proves that HTI graduates really fulfill the task for which they are trained for.

Mr Lazarides referred to the problems relating to the Professional status of HTI graduates both in the public and private sectors and said that these problems are gradually being resolved.

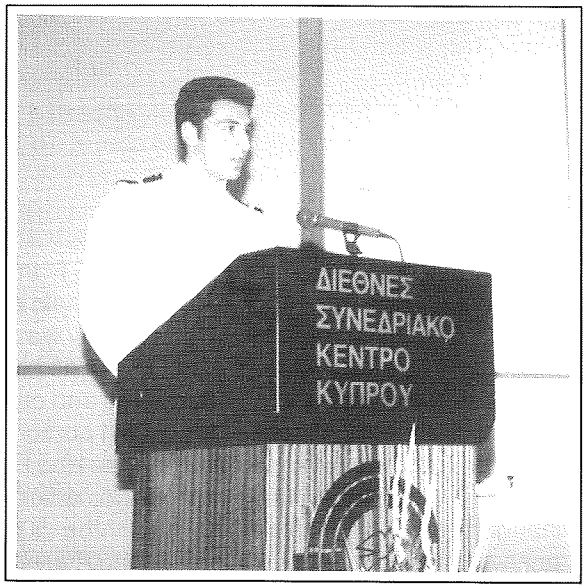
He then outlined the HTI objectives adding that HTI will seek close co-operation with the University of Cyprus at all levels and particularly in research. HTI has already established contacts with European Universities with which HTI will co-operate in research programmes financed by the European Community.

The HTI Director pointed out that the work of HTI is highly appreciated by the local industry. "An indication of the appreciation of our work" he said, "is the number of donations, scholarships and prizes offered each year to HTI by numerous industrial and professional organisations. For this we are most grateful".

The Director also mentioned the recent tragic death of last year Students Union President, Mr Constantinos Konnaris, and went on to add that the HTI Academic Council decided to issue his Diploma as an honour to the deceased. The Diploma of the deceased was received by his father.

Concluding, the Director thanked the members of the HTI Board of Governors and all other individuals and bodies that spend valuable time to serve HTI through various committees to run smoothly. Mr Lazarides ended his speech by wishing the graduates every success in their career and personal life.

Then the President of the Students Union spoke outlining the activities of the HTI Students Union in the current Academic Year. Mr Nestoros in particular underlined the efforts of the Students Union to gain Professional status for HTI graduates in the public and private sectors and expressed his gratitude to the Minister of Labour and Social Insurance, Mr Andreas Moushouttas, the HTI Staff and Administration for their support.



The President of the Students Union addressing the gathering

He also pointed out that HTI students were in the vanguard for the struggle for freedom and justice for Cyprus. "The HTI students guided by the vision of a free, united and peaceful Cyprus", Mr Nestoros said, "played a leading role in the struggle of the youth of Cyprus for freedom".

E Ts, Phone Us

A.Z. Achillides, MSc
Senior Lecturer, HTI

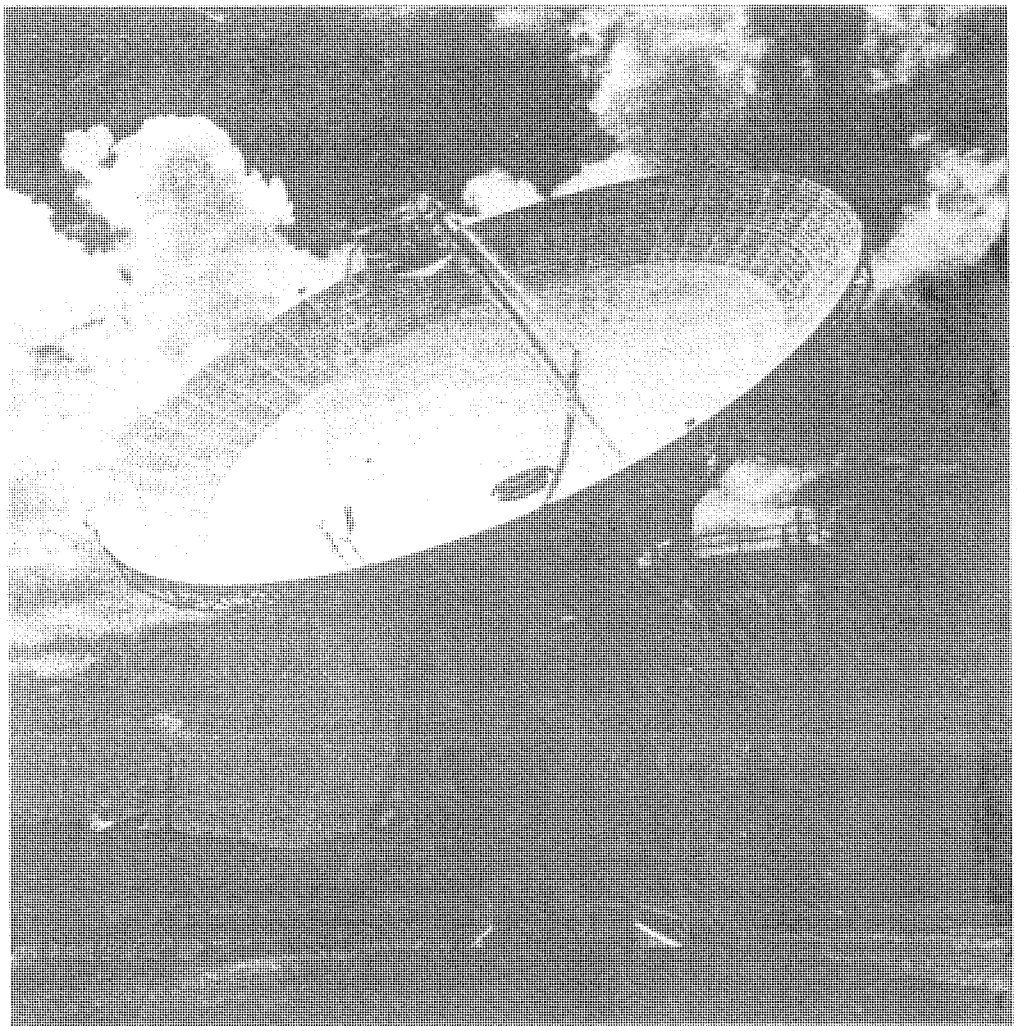
The possibility that intelligence life might exist somewhere else in the Universe has long fascinated philosophers, poets and theologians, but so far there has been no solid evidence for its existence. Unless you are a strong believer in UFOs. But most serious ETs watchers are convinced that Aliens, if there are any, will adopt, a more efficient approach and try to communicate using radio signals. But is anyone dialing Earth's interstellar access code? Frank Drake, the astronomer who in 1960 conducted the first modern radio search for ETs, the historic OZMA project, has casted his bet: " I fully expect to witness the detection of signals from an extraterrestrial civilization before the year 2000".

How then will NASA catch the signal? Imagine a radio that catches the whole spectrum of frequencies, not just FM but microwave, short-wave, radar etc. Start at the bass end of the dial and you will catch the signal of exploding stars; twiddle it up a few channels and you hear the "music" of a spinning pulsar. But dial it to the microwave part of the spectrum and you will met an almost cosmic silence. It is these quiet channels that NASA is tuned to. Scientists whose jobs can be described as "psyching out ET" think that anything smart enough to launch signals into the vastness of space knows that the only way to be heard above the background cosmic noise is to broadcast on a frequency that stars and other natural noise makers don't. This quitest portion of the spectrum lies between 1 billion to 10 billion ($1\text{-}10 \times 10^9$) Hz. The NASA's program, officially inaugurated on October 12, 1992, the 500th anniversary of Christopher Columbus in America, consists of two parts: a targeted search and a sky survey. The targeted search led by John Billingham and Jill Tarter of the NASA Ames Research Center, uses the largest radio telescope of the world suspended over a chasm in the Puerto Rico jungle and will search for signals from 1000 sun like stars within 100 light years from the Earth. This part of the survey will cover the frequency range from 1000-3000 MHz, taking a a look at the region called the "water hole". This region lies between the natural frequency of hydrogen (H) at 1,4 GHz and of the hydroxyl radical (OH) around 1,7 GHz. Naturally occurring radio noise is relatively quiet in this region and also since water makes life possible on Earth it might serve the same function elsewhere so some have speculated that this frequency region may be favored by other technological civilizations for interstellar communications.

The second part of the NASA project, the sky survey, led by Michael Klein and Samuel Gulkis of the Jet Propulsion Laboratory will scan the entire sky over the frequency range from 1000 to 10000 MHz. The sky survey will not be as sensitive as the targeted search but could detect signals from distant regions that would be overlooked by the targeted search. It will use the Goldstone radio telescope in USA and the satellite.-tracking antenna in Tidbinbilla Australia. Every second the computers are connected to the telescopes will perform 100 billion operations to sort through the frequencies, identify any channel with an excess energy and throw out those from earthly sources. In the past years some peculiar signals have been received by the radio telescopes of the Planetary Society, the only non Governmental Organization searching for years for ETs. In November 15th of 1989 a signal received from Cassiopeia looked either man or alien- made than from a star. It has not yet been traced to an earthly source. Another interesting signal was recorded by the Parkes radio telescope in Australia on the 9th of May 1990. F. Drake finds it the most like what an ET might send. The signal came from the con-stellation of Ophiuchus 28 light years away.

The possibility of a space buzzing with messages from longtime members of the galactic club raises hopes of eavesdropping on everything from how to beat mortality to how to defuse tha waste from nuclear reactors. "I can envision a rich stream of information on the history of the transmitting civilization, and on others they might be in contact with" says John Billingham. "We are here too" would by its very existence, offer hope that advanced civilizations need not self destruct with their nuclear toys. If they made it may be we can too.

And if NASA hears a Cosmos echoing only with



NASA's High Resolution Microwave Survey Project uses this 34-meter antenna located at the Goldstone Deep Space Tracking Station in California's Mojave Desert. NASA began using the antenna to search for extraterrestrial life recently.

the sound of silence? Perhaps intelligence and the technologies it creates does not help a species survive; perhaps civilizations smart enough to build phone booths to the stars are also smart enough to blow themselves up in a nuclear fire before they can send an interstellar "hello".

Or perhaps NASA's strategy is completely wrong. Perhaps no one is home on the nearest stars, and any one broadcasting from afar isn't loud enough to hear. Just because we don't hear anyone doesn't mean no- one is calling. But it might. Then it will look more and more as if intelligent life is an almost impossible thing to achieve, an improbable coming together of organic molecules on an improbably hospitable planet. In short a miracle. If no one else is here, the universe will seem much lonelier. And earthly life more precious.

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1. Asimov, I. "Extraterrestrial Civilizations" 1981 Panbooks

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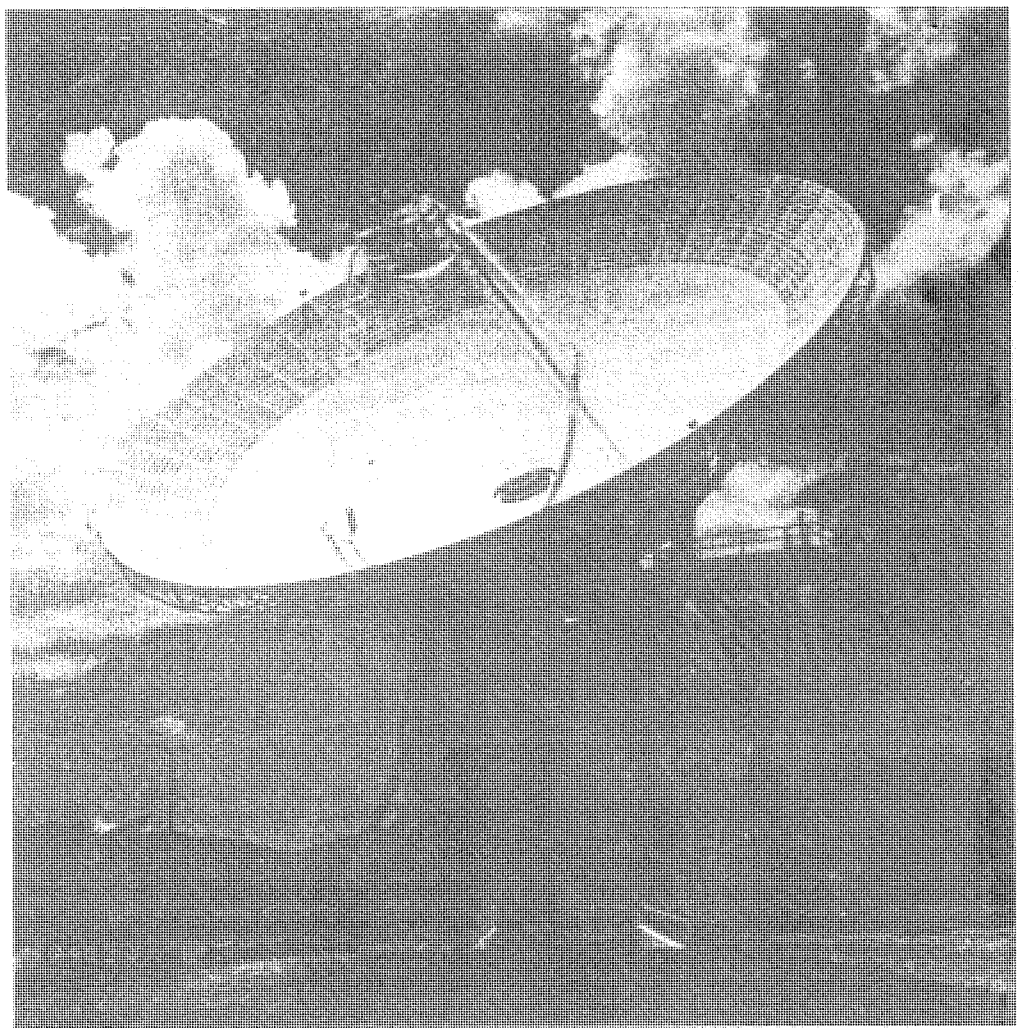
3. Gribbin, J. "Space Warps" 1984 Pelikan books

4. Mc Donough, J. "The Search for Extraterrestrial Intelligence" 1987 John Willey books

5. Wolf, F. A. "Parallel Universes" 1991 Paladin



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Signature Analysis and In-Circuit Emulation

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Lecturer, HTI

SIGNATURE ANALYSIS

INTRODUCTION

Signature Analysis is a troubleshooting technique for microcontrollers. It was developed and patented by Hewllet Packard. The method, although is simple to be used, presents some practical problems because it involves a comparison between a reference number and a number obtained using a Signature Analyser. The reference number is usually not available. The research work carried out in relation to this article was concentrated to overcome those practical difficulties.

THE PRINCIPLE OF SIGNATURE ANALYSIS

The Signature Analyser shown in Fig.1 has four input signals which are connected to a microcontroller: START, STOP, CLOCK and DATA INPUT. The aim of the Analyser is to obtain data from a microcontroller point, «compress» this data and produce a 4-digit number at the display. Under certain conditions this number is unique for that microcontroller point and is called SIGNATURE. This signature is compared with a reference signature. If the two signatures are not identical then a fault exists and a troubleshooter can locate the fault.

The «start» and «stop» inputs of the Analyser determine a time window during which data samples are obtained from a microcontroller point. The timing of the sample to be taken is determined by the clock input of the Analyser. The samples taken are fed to a feedback shift register. At the end of the time window, determined by the «stop» signal, a unique number exists in binary form in the 16-bit shift register. These 16 bits are stored in the memory, converted into the Hewllet Packard hexadecimal number system and displayed. This number is the Signature.

If someone obtains and records the signatures

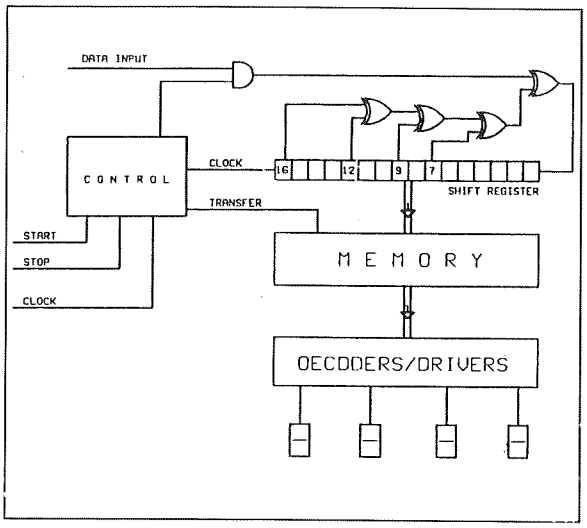

Fig.1 Block Diagram of a signature analyser

for every point of a microcontroller, then he can use these signatures as a reference when the microcontroller develops a fault. The difficulty is that if the hardware or software of the microcontroller is different or slightly different then the signatures are different. This means that every microcontroller in the world will have differrent signatures. This difficulty is overcome if the microcontroller is forced to execute a «Universal program», the FREE RUN program. Hewllet Packard published relevant information for the 8085 microprocessor. The research related to this article concentrated on Z-80 and 8031 microcontrollers.

For a microprocessor to Free Run, it should be forced to execute continuously a «No Operation» instruction. Such instructions are the NOP and LD A, A. The codes for these instructions are 00 and 7F.

SIGNATURE ANALYSIS FOR Z-80 MICROCONTROLLERS

To enable practical work to take place, the microcontroller shown in Fig.2 was constructed, programmed and tested. In order to Free Run the microcontroller, the Z-80 microprocessor

was extracted from its socket and replaced with another Z-80 mounted on a specially formed socket. On this socket the Data Bus was cut and the side towards the Z-80 was shorted to ground. This means that the Z-80 receives permanently a 00 instruction which is a "No Operation instruction", ie the microcontroller is in the Free Running mode.

The Signature Analyser was connected to the microcontroller. The Start and Stop inputs were connected to the A15 and the Clock to the Read output of the microcontroller. The signatures were obtained and recorded as shown on the circuit diagram of Fig.2. For example, the signature of A0 is UUUU, 5555 for A1 and so on. Provided that the connection between the Analyser and the microcontroller is the same, then the signature is affected by the input data. Since the Z-80 executes a «universal program», then the signatures for all microprocessor outputs should be the same for all Z-80 microcontrollers. To confirm this the experiment was repeated for another Z-80 microcontroller. The MPF-IP microcontroller manufactured by Multitech Industrial Corp was used. For all Address and Control lines the signatures were identical. The signatures obtained were also compared with the 8085 signatures provided by Hewllet Packard. The 8085 and Z-80 have identical signatures on their Address lines. The signatures on the data lines are affected by the hardware, the software and the data present at the input ports. So the Data Bus signatures of Fig.2 are valid for that microcontroller only.

SIGNATURE ANALYSIS FOR 8031 MICRO-CONTROLLERS

To investigate Signature Analysis for this type of microcontrollers, the circuit of Fig.3 was constructed, programmed and tested. Here there is a difficulty to Free-Run the microcontroller because the Data and low Address Busses are multiplexed on pins 32 to 39 on the 8031. If the Data Bus is shorted to ground, as it was done for Z-80, then when the 8031 makes pins 32 to 39 Address lines, these lines will find themselves shorted to ground. Shorting an output to ground will overheat the microprocessor and destroy it. To overcome this problem the EPROM was filled in with 00 for all its locations. In this way the 8031 fetches continously a «No Operation» instruction. The signatures were then obtained and recorded as shown in Fig.3. To confirm that those signatures are the same for all 8031 microcontrollers, they were compared with signatures from 8031 microcontrollers constructed by various students during their project work.

TROUBLESHOOTING MICROCONTROLLERS USING SIGNATURE ANALYSIS

Signature Analysis can be used to locate a number of faults. Such faults are described below:

FAULT No	*REF CCT*	*SYMPTOM*	*DIAGNOSIS*
1	Fig. 2	Vcc and clock for Z-80 OK but no signatures can be obtained	Z-80 faulty
2	Fig. 2	Signature at pin 18 of U3 is UUUU. Signature at pin 8 of U8 is 0001. All signature on Data Bus are different	A0 line between U3 and U8 is open
3	Fig. 2	Signature on A6 and A7 is 7355. All signatures on Data Bus are different.	Lines A6 and A7 are shorted
4	Fig. 2	Signature at pin 4 of NOR gate is 0001. Signatures on some Data lines are different	Relevant NOR gate is faulty
5	Fig. 3	Signature at pin 27 of the microprocessor is 0000	That pin is shorted to ground

For microcontrollers there is no ideal method for troubleshooting. Like all other methods Signature Analysis has both advantages and disadvantages.

IN-CIRCUIT EMULATION

For In-Circuit Emulation the microprocessor is removed from its socket and the Emulator is connected to the microcontroller through the empty socket, as shown in Fig.4. The Emulator is able to test individually every item of the microcontroller.

The microcontroller used was the 8031 shown in Fig.3 and the Emulator used was the ICE51 supplied by Micro Amps Limited. This Emulator is connected serially to an IBM PC and the whole operation is controlled through software provided by Micro Amps.

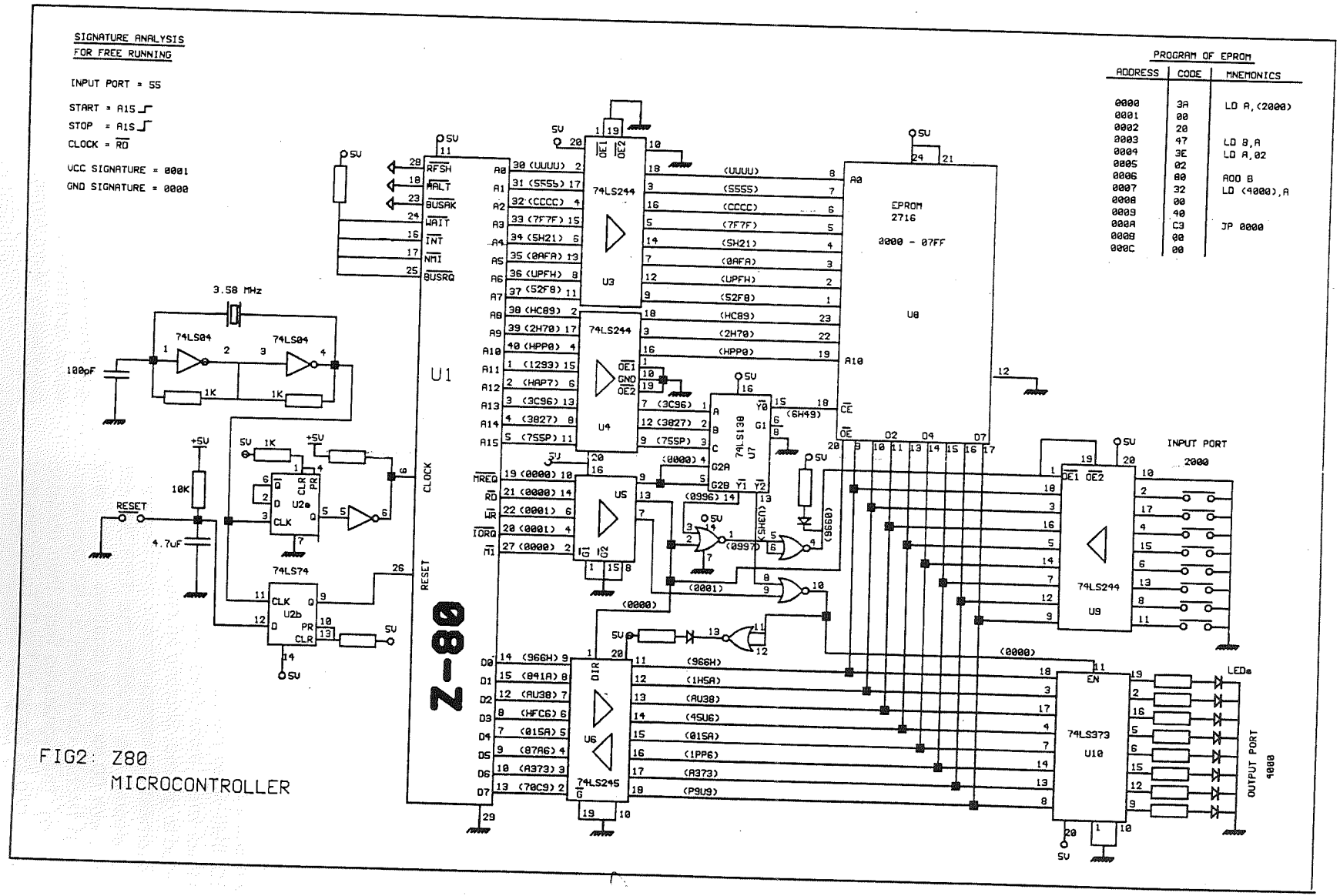

FIG2: Z80
MICROCONTROLLER

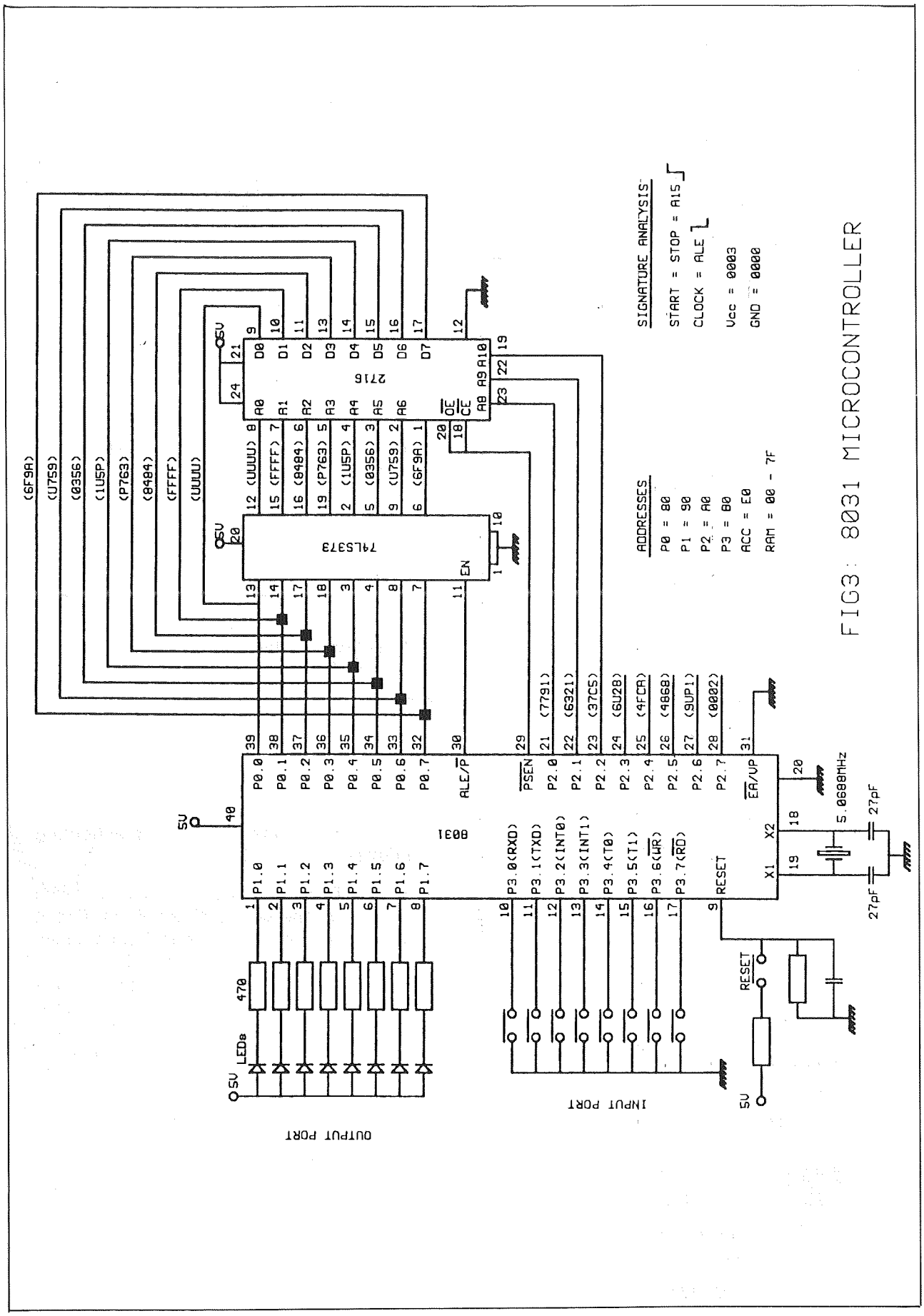
FIG3: 8031 MICROCONTROLLER
SIGNATURE ANALYSIS
START = STOP = A15
CLOCK = ALE
Vcc = 0003
GND = 0000
ADDRESSES
P0 = 80
P1 = 90
P2 = A0
P3 = B0
ACC = E0
RAM = 00 - 7F
8031
74LS373
2716
OUTPUT PORT
INPUT PORT
LEDs
RESET
5.0688MHz
27pF
470

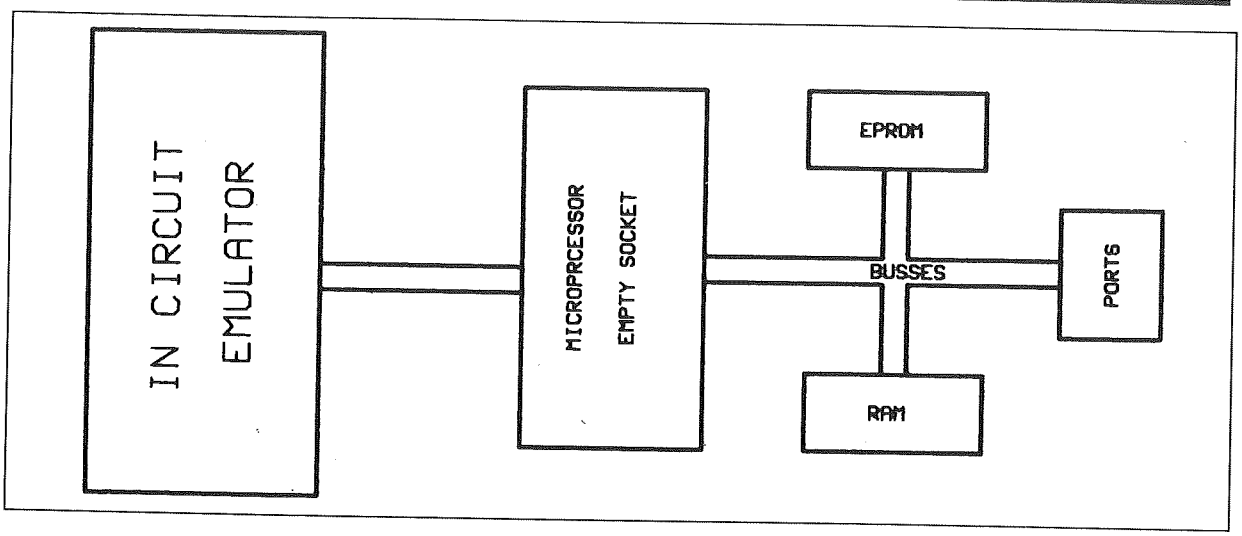

Fig. 4 IN-CIRCUIT EMULATION

The following tests were carried out:

Writting to the output port:

P1 55

The number 55 was written to the output port.

Reading the input port:

P3

The number present at the input port appeared on the screen of the PC.

Read the Eprom:

C 5000-5080

The contents of the Eprom from 0000 to 0080 appeared on the screen of the PC as shown below:

°5000 74 55 f5 90 e5 b0 f5 90 02 00 00 ff 00 ff 7f 00

°5010 ff 90 00 ff 00 ff ff ff ff ff ff ff ff ff

°5020 ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff

°5030 ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff

°5040 ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff

°5050 ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff

°5060 ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff

°5070 ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff

Disassemble the programm of the EPROM:

L 5000 - 5010

The Eprom codes were dissassembled as shown below:

°5000 74 55	mov a, #55
°5002 f5 90	mov p1,a
°5004 e5 b0	mov a, p3
°5006 f5 90	mov p1,a
°5008 02 00 00	ljmp 0000

Single step execution of the program:

PC 5000

N

The program of the Eprom was executed step by step as shown below:

°5000 74 55	mov a, #55
°: N	
°5002 f5 90	mov p1,a
°: N	
°5004 e5 b0	mov a, p3
°: N	
°5006 f5 90	mov p1,a
°: N	

Comparison of the two troubleshooting techniques:

Signature Analysis is very simple and limited knowledge is needed for using it. In Circuit Emulation can cover a wider spectrum of faults but some difficulty was encountered in making the whole system operational. Stand alone Emulators are very expensive. Their costs were brought down by using a PC. If a PC is used then the cost of the two systems is about the same.

REFERENCES:

1. Practical Microprocessors by Hewllet Packard

2. Troubleshooting of mircroprocessor systems by G. Williams (Pergamon)

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Failure Mode & Effects Analysis (FMEA)

Ioannis Iona Angeli, BEng, MPhil, I. Eng, Senior MASQC, AMIEE, GMI MechE
Laboratory Assistant, HTI

INTRODUCTION

The definition of FMEA according to BS 4778, 1987, is the «study of the potential failures that might occur in any part or a system, to determine the probable effect and results which are ranked in order of seriousness».

FMEA was first developed over 60 years ago and was adopted by the aerospace industry during the 1960. The technique can be applied to both the design and to the manufacture of components for processes and systems improvements.

Quality improvement techniques, when accompanied by proper training and implemented using self-directed work teams, enable companies to attain dramatic increases in productivity and product quality. They help people in a particular section or even from diverse areas in the company to work together more efficiently and compete more effectively with foreign and domestic rivals.

WHERE IT IS USED

A FMEA study can be carried out at any stage during the development of a product. However the ideal times to use this technique are:-

— At the original concept stage when specifications are being established.

— As soon as the design is finished but before any manufacturing, tooling, etc. is commenced.

— When the processing decision have been made.

— When major changes are to be carried out either to design or process alterations.

— After an FMEA study has been conducted and corrective action taken; re-assessment.

There are two different kinds of FMEAs, representing two different stages of analysis and conventionally are recorded separately:

DESIGN FMEA which is carried as early as possible in the life of a product. Its purpose is to ensure that the product will function properly when manufactured. Each feature is analysed for potential failure.

PROCESS FMEA study is carried out as soon as the drawings are completed. It is used to identify potential modes of failure of each process, component and assembly.

FMEA PROCEDURE AND COMMENT PREPARATION

The steps involved in preparation of a FMEA document are illustrated on the flow diagram 1. In detail those steps as well as the essential steps in the production of an FMEA study are demonstrated below:

1. **Identify** the product or the process and function for investigation.

2. **Brainstorming session.** Team work, all people involved in the design and production of a component.

3. **Production of fishbone** diagrams to aid the build up of a FMEA document.

4. Identify and describe **potential failure modes.** It is important to consider all possible failure modes. Work on the principle that if it can go wrong, it probably will.

5. Identify and assess the **potential affects** of the failure and describe the effects of the failure in terms of the fitness for purpose of the product.

6. Identify the **potential causes of failures,** and list all the assignable causes of possible failure.

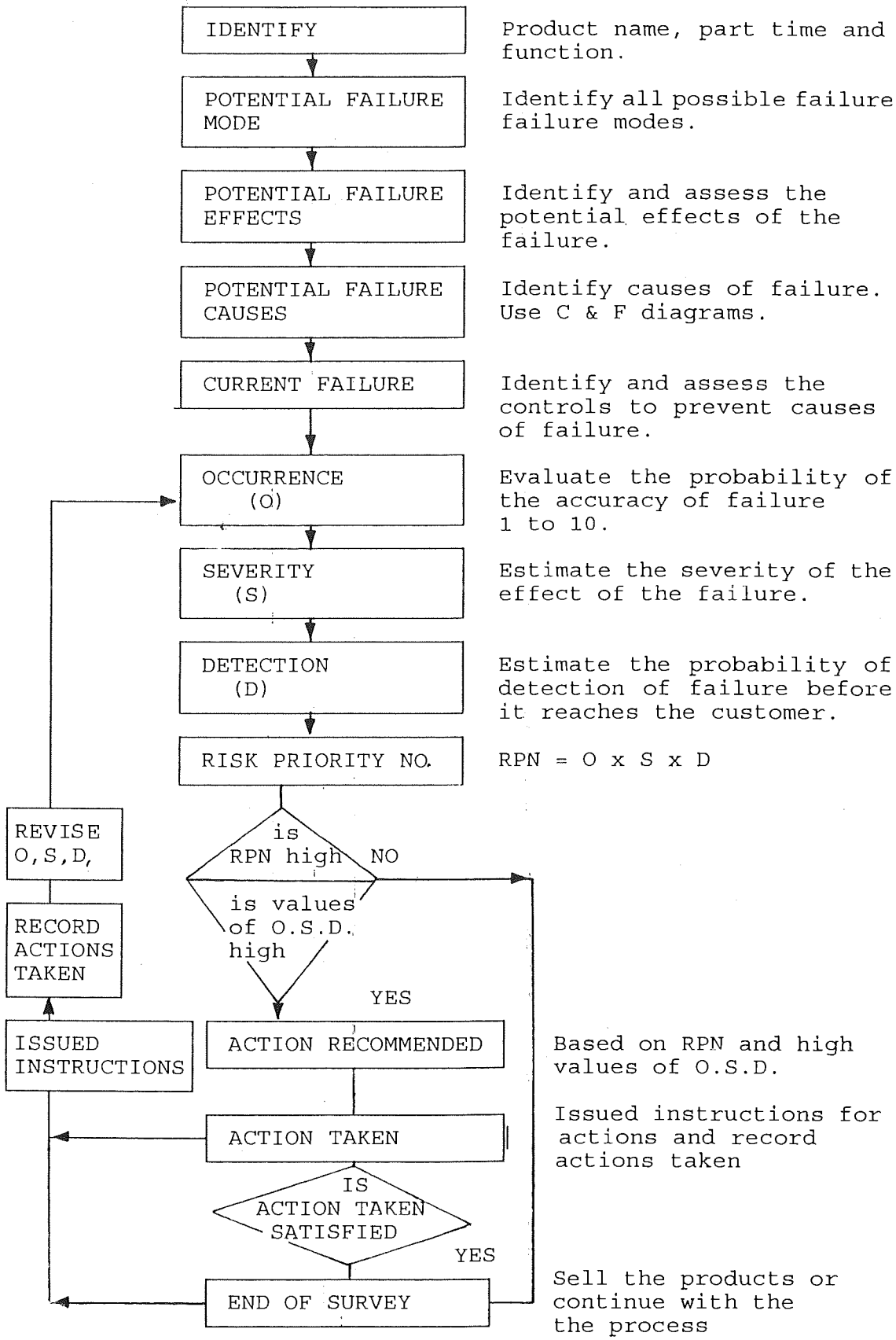


Diagram 1 PREPARATION OF AN FMEA

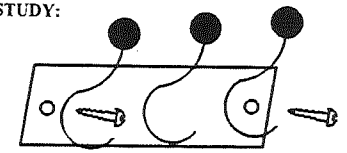
Figure 1: PROCESS FMEA PROBLEM WORKSHEET

PART/ PROCESS NAME: Multiple coat hanger
DEPARTMENT: Design

ASSEMBLY NUMBER: CH23
DATE:

AUTHORISED BY

PRODUCT UNDER STUDY:



NO.	PART/PROCESS NAME	PART/PROCESS FUNCTION	FAILURE MODE	EFFECTS OF FAILURE	CAUSES OF FAILURE	PRESENT CONTROL	O	S	D	R.P.M.	RECOMMENDED ACTION	ACTION TAKEN	O	S	D	R.P.M.	ACTION BY
1	Coat hanger	Hanging clothes	Comes off wall	Coat falls on floor	Screws too small	Advise fitter of screws to use	5	7	7	245	Supply the hanger with correct screws	Increase screw's size by 1½ cm	1	7	7	49	P.A
2	Hangers	Support coats	Deformation of hangers	Bending - coats might fall	Overloading	Weight test at 3 kg	6	7	5	210	* Use more hard material * Increase weight test to 6 kg	* Use drawn wire for hangers * Weight test 7 kg no deformation	2	7	2	28	J.A
3	Hangers ball	Protect coats	Coats slips * Several trials for hanging	Difficult to hank * Coats fall	Balls too big	Measure diameter	5	9	2	90	Decrease ball diameter	Diameter reduced by half	2	9	2	36	K.L
4	...	...															

Again cause and effect diagrams can be used.

7. Identify or list or assess the **current controls** that exist now in place which are intended to prevent the causes of failures from occurring or are intended to detect the causes of failure.

8. Assess the probability of the **occurrence (O)** of failure. Estimate the probalility of failure on a scale of 1 to 10, with 1 indicating a very low propability of occurrance and 10 a near certainty of occurrence.

9. Estimate the **severity (S)** of the effect of the failure. Again a similar evaluation scale is used with 1 indicating a minor nuisance and 10 a very serious consequence.

10. Estimate the propability of **detection (D)** of failure before it reaches the customer. The evaluation scale is still 1 to 10 but this time the weighting is reversed: 1 indicating high probability of detection and 10 indicating a low probability before the end-user finds it.

11. The **Risk Priority Number (RPN)** is simply calculated as the product of Occurrance, Severity and Detection.

RPN = O x S x D

12. The **recommended action** should be based on the value (high or low) of the calculated RPNs which has been ranked in order of priority similar to Pareto Analysis. Also significantly high individual values of occurrance, severity of detection should be considered.

13. Determine **action to be taken** to eliminate and reduce potential concerns. Issue instruction for actions to be taken and record action taken. Typical actions to be taken included design changes to the component, process change and increase the inspection requirements during the manufacturing process. If corrective action is not required, an «NR» (Not Required) entry should be made.

14. Go back to 8 and revise O,S,D, and RPN in accordance with the new information and the actions recommended to be taken.

15. Repeat the same procedure until satisfied. Remember an FMEA is a live document which records all design and process changes and why not the scale of damages. This has to be determined in relation to the commercial risk expressed in financial terms.

EXAMPLE

A small scale FMEA study for a simple component is demonstrated in Fig.1 using a typical FMEA worksheet. There are differences in FMEA documentation used in different companies. However, these are largely differences in detail only; the philosophy is the same. A FMEA study can be carried out manually which is cheaper, laborious, time consuming etc, or computerised which is expensive, fast, no paper-work, powerful etc.

BENEFITS OF FMEA

FMEA is an upstream, off-line activity and represents a quality prevention cost. It is concerned with building quality in to the product prior to manufacture. Properly conducted, it should therefore lead to:-

* A reduction of scrap, and rework activities.
* Reduction in inspection and process control activities
* Reduction of failure conditions
* Overall reduction in manufacturing costs and warranty cost
* Improve communication and encourage team work between different departments.
* Improved customer satisfaction.

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The Solarium and the Court-Yard as Climatic Modifiers in Mediterranean Vernacular Architecture

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ABSTRACT

The solarium and the courtyard are fundamental traditional structures of thermal building control, which reflect the wisdom of traditional mediterranean architecture.

This paper will examine the traditional forms of solariums and courtyards of domestic vernacular architecture in Cyprus and will explain how they create appropriate environment through their varied design and the use of natural sources of energy.

Reference will be made to results derived from optimization studies obtained by using microcomputer versions of «SERI-RES» and «5000 Method».

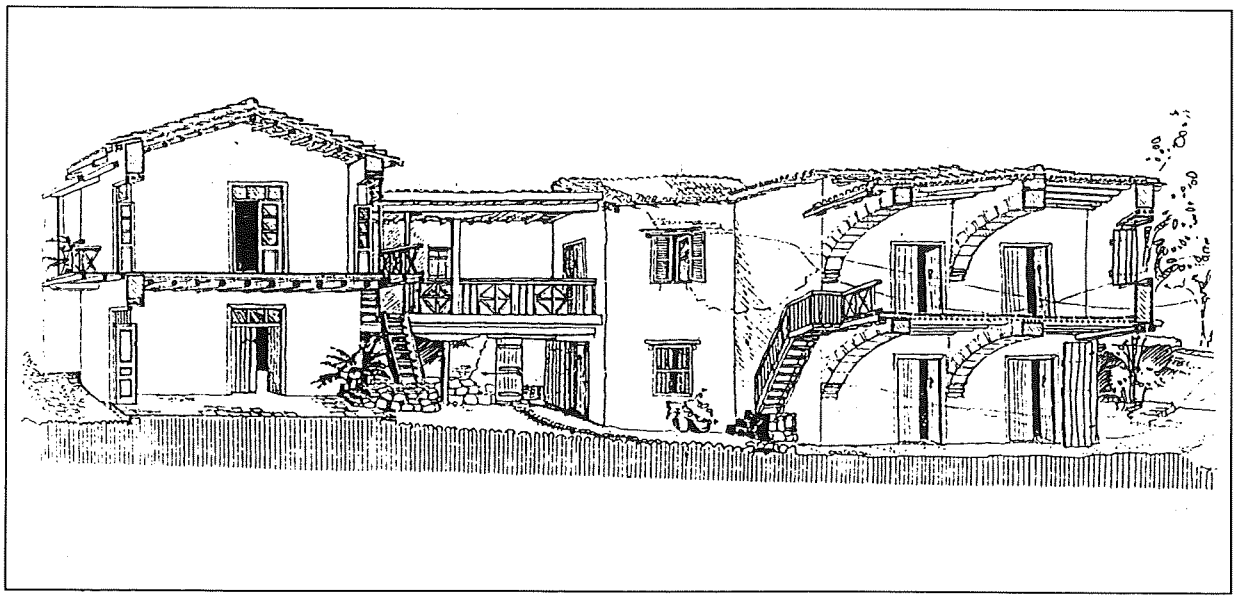
SIGNIFICANCE IN VERNACULAR ARCHITECTURE

In Mediterranean and hot climatic regions where sunshine in winter is desirable and cooling and ventilation in the summer necessary, the solarium and the courtyard are indispensable solar features of the houses and unique elements of Cypriot vernacular architecture.

Both components, although outdoor, open spaces of the building, they are focal elements around which the various activities of all the other spaces are synthesised whether the house is in the plains, in the mountains, the villages or the cities. They form the heart of the dwelling spatially, socially and environmentally.

They are significant architectural features and early instinctive approach to passive solar design, which acted as climatic modifiers in the Cypriot house. Their arrangement evolved naturally from the climatic conditions, the needs of the family and the social structure of the community.

Always adjoining each other they act as transit spaces and unite the outer with the inner building layout. They are extensions of the house outwards and simultaneously of the

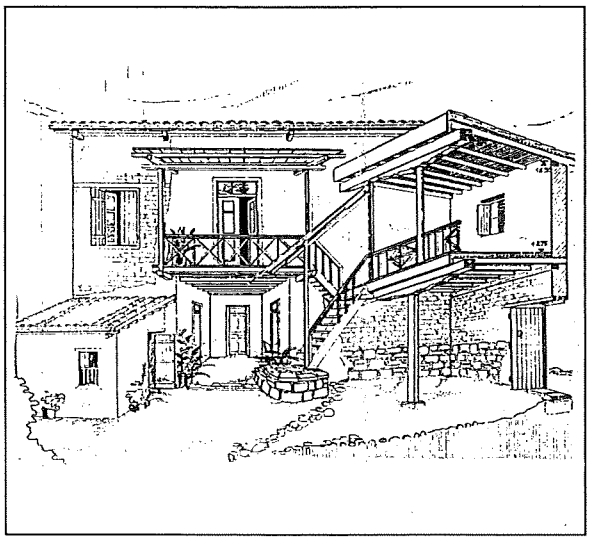


outdoors inwards.

Their form and function vary from region to region even from locality to locality as expressions of their sensitive response to the various effecting parameters.

USES

The solariums and courtyards have multiple uses in vernacular architecture varying



according to region, locality, climatic conditions and social structure.

a) Functional

(i) Inside House Activities

The solarium, an internal space with its south side open, accomodates the functions of the inner house in the summer and in the sunny winter days:

— Living space:- People spent most of their leisure time in these spaces.

— Cooking, Washing, Eating:- Furnished with an oven, washing basin, some kind of bench or table and an external fire place, it accomodates daily activities such as cooking, washing and eating.

(ii) Outside Activities

Also the outside activities are transfered to the solarium when the weather does not allow them to take place in the open air.

— Preparatory Agricultural work:- For the farmers the courtyard is used to handle agricutlural products (laying, drying of fruit etc).

(iii) Privacy

Mostly secluded at the rear of the house, protected with high abode walls or the house volume itself, both components offer privacy to the occupants.

b) Social

(i) Social Contact

When the courtyard and the solarium open on to the road they allow social contact.

(ii) Receiving Visitors

Both, the solarium and the courtyard, are used as reception spaces offering pleasant transitional environment from the outside to the inside and at the same time allowing the occupants to retain their privacy.

(iii) Status

The configuration, size and decor of the components express the social and financial status of the owners.

c) Aesthetics

When located on the facade of the house they offer decorative potential with the use of the materials, the archades, the gardens and their other constituents.

d) Spatial

The solarium is a predominant architectural feature of the house whether acting as:

(i) A Portio

(ii) An Archaded Corridor

(iii) A Central Axis or even when it evolved in a

(iv) Self Contained Space

It always provided the house with its focal space even in periods of prosperity when the construction of bigger houses was financially and technically possible.

THE SOLARIUM AND THE COURTYARD AS CLIMATIC MODIFIERS

The solarium and the courtyard, besides their aforementioned functions, are two fundamental means used in traditional building design to temper extreme weather conditions. Combined with their other uses they always create a

microclimate that moderates the climate surrounding the building.

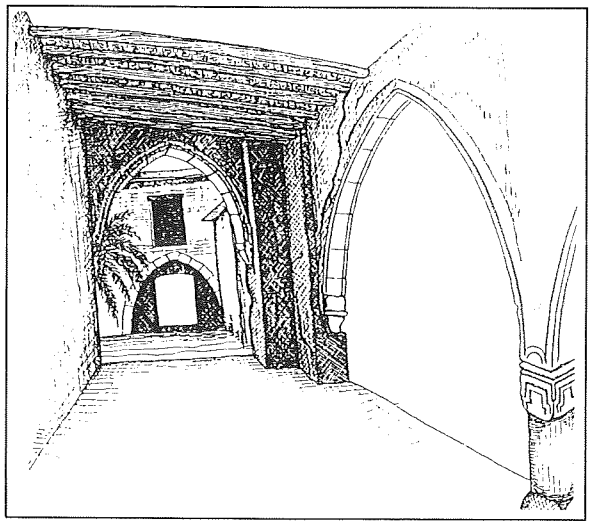
A. WINTER

The design of courtyards and solariums varies according to the degree, frequency and pattern of solar radiation, winds, rain and snow.

a) Solar Access

In old houses the main concern of the courtyard and the solarium was to ensure privacy while also providing good conditions for solar access to the southern elevation.

The configuration of courtyard and solarium form houses are key devices for achieving this aim by providing enclosed private spaces. Also



this geometry of houses makes explicit the intention to provide insolation to different rooms at times when sunshine may be most beneficial.

However the proportions of both components can play a crucial role in solar access.

(i) Courtyard

When the courtyard faces South it acts as sun-space receiving desired solar radiation in winter. The solar access, in «patio» type courtyard, depends on:

— The spacing between buildings (courtyard's width)

- Sun's position at its lowest sun-path

— The height of the building

From optimization studies carried out with SERI-RES amongst Cypriot houses, with and without courtyards, it was found that introduction of courtyards and south aspecting windows incurs more savings. More specifically a Π-shape courtyard saves more energy in the house than an L-shape one.

These are more complex shapes resulting to additional factors intervening in their thermal behaviour leading to their extra heating in the building. Such additional factors are:

a) The more composite internal layout encompassing more spaces and surfaces facing south.

(b) Larger internal thermal mass whose positions, size and distribution reduces temperature fluctuations by retaining heat within it.

(c) Enhanced thermal protection on external envelope as a result of the courtyard morphology of the two more complex shapes especially the Π-shape.

(d) More useful exchanges through openings and surrounding walls.

(ii) Solarium

The extent of the solarium cover admits the rays from the winter sun to penetrate and so solar radiation can be utilized in winter. For this reason the solariums on the mountainous areas move in the upper levels for better winter insolation.

Of course in vernacular architecture the width of projection of the cover varied and it was intuitively sized by the indigenous builders.

Nowadays the sizing of the solarium projection and the side walls can be effectively designed to permit solar access in winter with the use of dynamic computer building simulations.

Optimizations SERI-RES studies show that the introduction of the permanent solarium overhang on the fenestration of Cypriot houses, results to a reduction of heating savings only by 8%. This is attributed to the loss of useful solar gains intercepted by the permanent solarium over-hangs.

However, the summer shading benefits are exceedingly more to justify the incorporation of solariums of the houses' facades.

b) Buffer to winds and cold air temperatures

When the courtyard and the solarium are facing towards exposed, vulnerable in winter sides they

act as buffer to the building creating calm corners protected from cold prevailing winds and low air temperatures.

(i) Surrounding Buildings

The surrounding buildings of the courtyard protect it from cold winds; their height however determines the occurance or not of wind turbulance. If the width of courtyard (W) is smaller than twice the height of surrounding buildings (h) no turbulance occurs.

If W = 2h - 4h Turbulance and down draughts occur.

(ii) Plantation

Vegetation fences in the form of wind breakers, and wind channels, could obstruct the winter winds, or at least reduce their velocity and consequently the heat losses from the building.

Walls and tall dense planting close to the building could screen of, or direct cold winter winds over the building.

B. SUMMER

The courtyard and the solarium form a key issue in building design. In multiple thermal modes and varied design, they moderate high summer temperatures; their careful construction combined with the surrounding landscaping lower the temperatures around the building.

a) Radiation

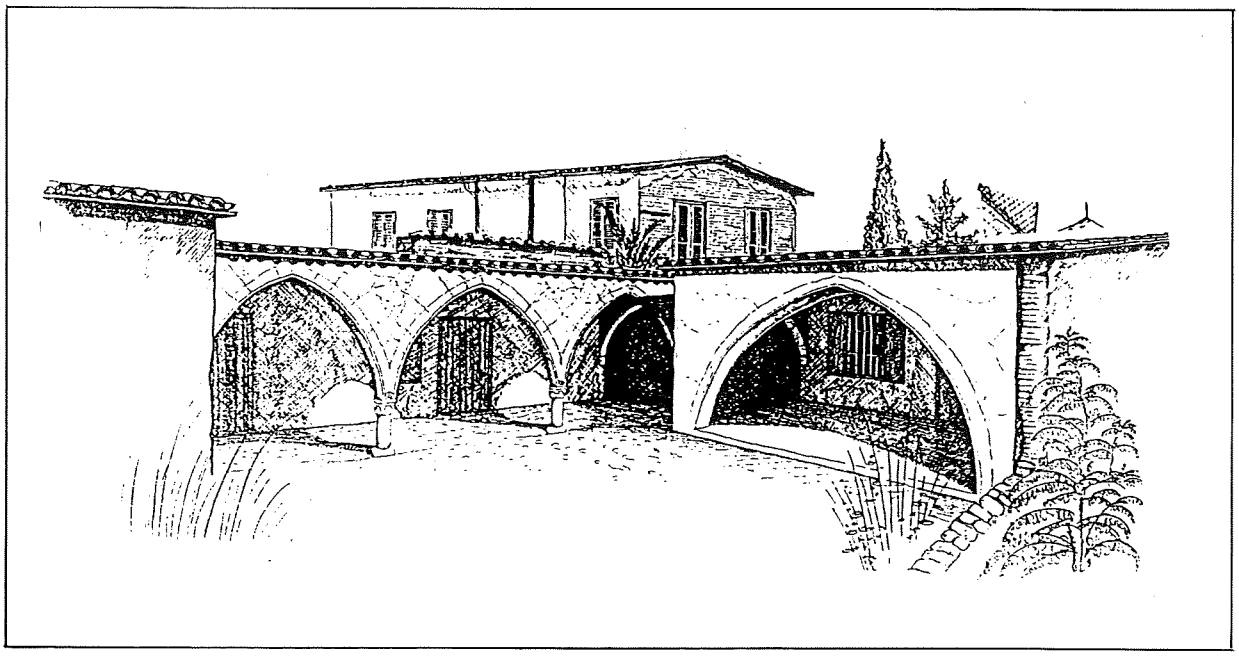
The temperatures in and around the building can be tempered or aggrevated by the design and nature of the surrounding surfaces combined with the night sky radiation. The surfaces exposed to the clear sky cool down by radiation and the air immediately in contact with them also become cooler.

(i) Configuration

In the summer the courtyard building configuration is of particular significance for the Mediterranean hot arid regions such as the inland of Cyprus characterised by large diurnal temperature fluctuations (15 to 25 degrees Centigrade) and the potential inherent in the courtyard to act as cold sink by radiating heat, during the night, to the cold sky. The cool air replaces the hot air around the surfaces and the bottom of the yard. This cooling effect lingers during the following day resulting to comfortable ambient air.

(ii) Mass

Furthermore, the additional mass of the courtyard



and the solarium absorbs and stores heat during the day and releases it during the night to the cooler exterior ambient air. The massive construction incurs damping and time lag of the high day temperatures.

b) Ventilation - Winds and Breezes

Ventilation is necessary for indoor comfort and hygiene.

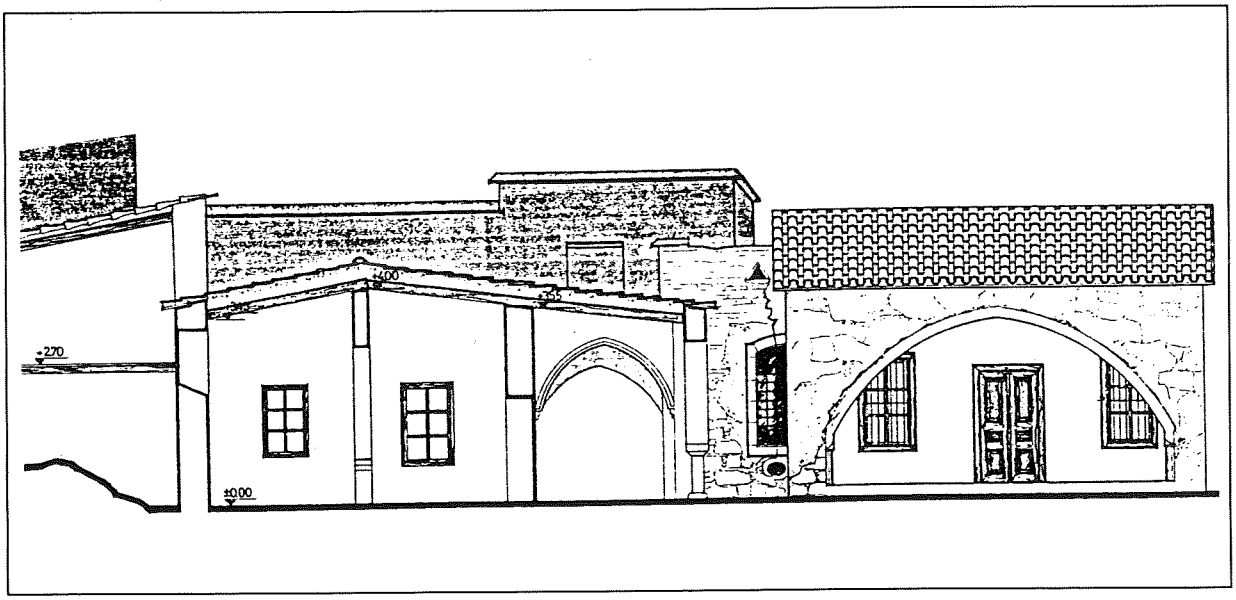
Comfort ventilation is required in buildings even on hot summer days when the outdoor is warmer than the building interior.

In traditional buildings a great deal of attention was given to ventilation especially to the pre-

However, for the efficient functioning of the form and layout, proportions of inlet and outlet areas, their cross-section, wind speeds and direction, and surface mass are necessary to be considered.

(ii) Coastal Areas

At coastal areas the courtyards are positioned at higher level and directed towards the sea breezes. During the day the breezes blow from the sea towards the land; the cool air from the sea replaces the warmer air over the land; as the land reacts quicker to heat than the sea, it heats up during the day from the sun and cools down during the night when the reverse process takes place.



treatment of ventilation air. The courtyard and solarium plan and landscaping regulate air movement by bringing in fresh air when it is cooler than the building.

(i) Form-Layout

When the solarium is designed in the form of central or horizontal corridors and central hallways, the exposure of the sides of the rooms to the passing wind flow increases and the solarium acts as a breezeway.

The large corridors allow enough cool air to flow past the surfaces of the building sides and the building enjoys the summer breezes. Also with this form of layout , the heat accumulated during the day in the walls is removed to the outside cooler spaces during the night. In addition this arrangement offers the possibilities of window placement for cross-ventilation.

(iii) Wind Towers-Fountains - Sprinklers

With the introduction of elements such as wind towers, fountains and sprinklers, the courtyard and in furtherance the building, enjoy cool channeled winds.

(iv) Overhangs-Porches

The overhangs and porches when on the windward sides maximize air flow. They dam the airstream in a pocket in the wall and consequently increase the pressure on the openings of the walls providing ventilation inside the building and replacing the hot air.

(v) Vegetation

The vegetation and fences in the form of wind channels increase the velocity of winds by funnelling the summer breezes in the courtyards.

c) Shading

The treatment of courtyards and solariums are important techniques in providing shading and in extend for the thermal building control.

The introduction of solarium overhangs and side walls, as solar protection devices, achieves high energy conservation. The unwanted summer solar radiation is intercepted, whilst the desired winter solar gains are almost unaffected, thus reducing considerably the cooling load. From simulation SERI-RES studies on fenestration shading devices this is found to be 37%.

In the simulation studies, the solarium overhangs and side walls are permanent features of the building design; the width of their projection has been defined so that in the summer the solar aperture of the glazing is completely shaded from the high summer sun, while permitting rays from the low winter sun to penetrate and so solar radiation could be utilized.

(i) Enclosing Elements

If the enclosing elements of the courtyard such as the fence wall or the structure of the building itself is higher than its width the walls will enjoy some shading during the day even with the high summer sun.

(ii) Arches and Overhangs

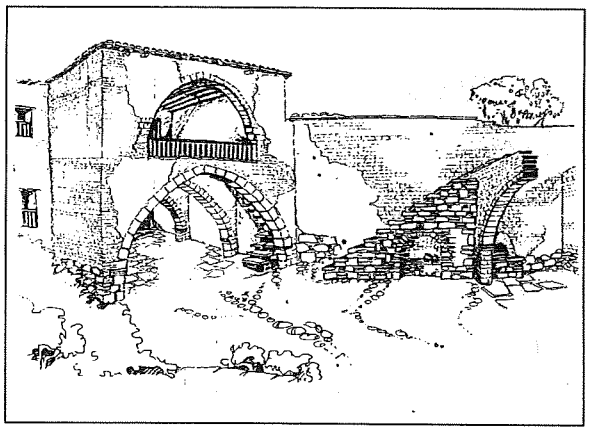
In the form of a porch or when arcaded the solarium provides an effective method of sun-control. The arched arcades at the perimeter of courtyards are indispensable to shield the overhead midday sun. The projection of the roof or the overhang of the solarium is extended far enough to provide shading from the high summer sun. The sizing of the extension varies in vernacular buildings from 1.00 meter to 2.00 meters. Our predecessors over the years developed this sizing intuitively and by trial and error.

From optimization studies carried out with SERI-RES it is found that a width of 1.20m provides effective shading on the south facade of the building from the end of March until the end of September.

(iii) Vertical Side-Walls and Fins

In the early summer mornings and late-afternoons, when the sun is very low, the horizontal overhangs are not sufficient to provide shading to the porches and the archaded solariums.

Vertical fins in the form of side walls prevent summer solar radiation from East and West. The efficient sizing of the vertical fins depends on the length of the required shadow, the azimuth of the opening and the period the fin is intended to provide shading. From building simulations the effective extend of the vertical fins is found to range between 1.00 meter to 1.20 meters.



(iv) Vegetation

Shading can also be provided with the introduction of trees and vegetation. The vernacular courtyards, planted mostly with deciduous vegetation like grape-vines, pomegranates, fig trees etc., offer shade in the summer and admit sun in the winter.

- Pergolas or trellises and climbing vegetation are used to shade walls and fences and to reduce the reflected gain.
- Tall trees in South courtyards shade the walls and roofs.
- Dense trees, shrubs, hedges and climbers on East and West courtyards intercept the early morning and late afternoon sun.

d) Evaporation

In the hot arid Mediterranean regions, such as the inland of Cyprus, evaporation for air humidification is necessary for comfort. This is possible by water sprays over the solarium and courtyard walls as well as the vegetation.

(i) Ground Finishings

Natural covers of the courtyard such as grass and plants reduce high summer temperatures and encourage evaporative cooling effect; whereas man-made finishings such as paving increase the air temperature and reduce humidity levels.

(ii) Wall Spray-Pipes

Spray-pipes on courtyard wall is an excellent and inexpensive way of providing evaporative cooling in a courtyard. Moreover, spay cools air as well as the wall surface, thereby reducing both ambient and mean temperatures.

(iii) Fountains, Pools and Sprinklers

In richer old houses the courtyard is furnished with a water fountain which may further provide evaporative cooling and increase the level of humidity to comfort conditions.

Furthermore, the local habit of the inhabitants to sprinkle or throw water on the courtyard floor and vegetation evaporates and cools the air, sets up air convection currents and adds to the humidity.

EPILOQUE

The traditional design of courtyards and solariums embodies very simple and basic concepts of bioclimatic approach, which evolved over many years through a process of trial and error.

However, to achieve fine tuning of these two fundamental components of Mediterranean building design, in order to become successful climatic moderators, it is necessary to develope a deep understanding through scientific comprehension. This approach implies:

- Bioclimatic analysis
- Optimization of their regulatory systems
- Evaluation of their effect on the building performance in search for
- Efficiency and
- Cost-effectiveness.

The above considerations necessitate detailed and at same time robust, dynamic and interractive design approach for courtyards and solariums.

This is nowadays possible through modern materials, computer technology and innovative construction techniques. However to ignore the traditional heritage and to disregard the accumulated wisdom of the past is at best illinformed and at worse arrogant.

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Effect of Collector Tilt Angle on the Performance of Solar Heating Systems

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ABSTRACT

This paper is concerned with the investigation of the effect that the solar collector tilt angle has on the performance of a combined solar hot water and space heating system. This will enable the investigation of the optimum collector tilt angle for such systems in Cyprus.

INTRODUCTION

The orientation and tilt angle of a solar collector should be dealt with carefully when designing a solar heating system. A collector should be mounted to face due south (northern hemisphere) for maximum solar gain, although any orientation within 20° off-south does not affect considerably the collector performance (Felske, 1978).

The effect of collector tilt angle on the performance of solar heating systems has been studied by many researchers and there is a wide range of optimum collector tilt angles as recommended by different investigators, for combined water and space heating systems. Lunde (1980), for example, suggests that the optimum tilt angle for a year round water and space heating system is $\varphi \pm 15°$, where φ is the location latitude; Carg (1982) suggests 0.9φ to φ, while Lof and Tybout (1973) recommend φ +(0 to 30°). For Cyprus, the above recommendations would mean 20 to 50°, 32 to 35°, and 35 to 65°

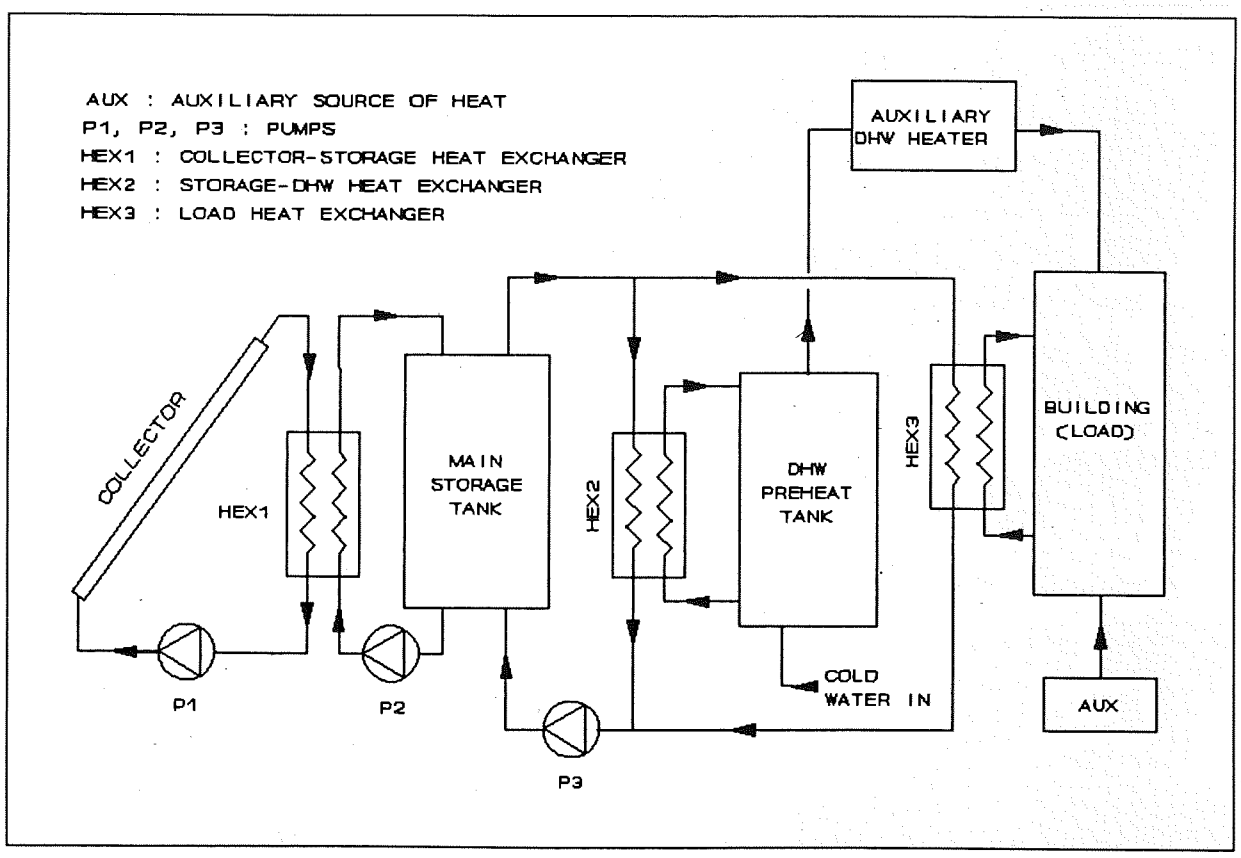

Fig.1 Schematic diagram of a combined solar water and space heating system

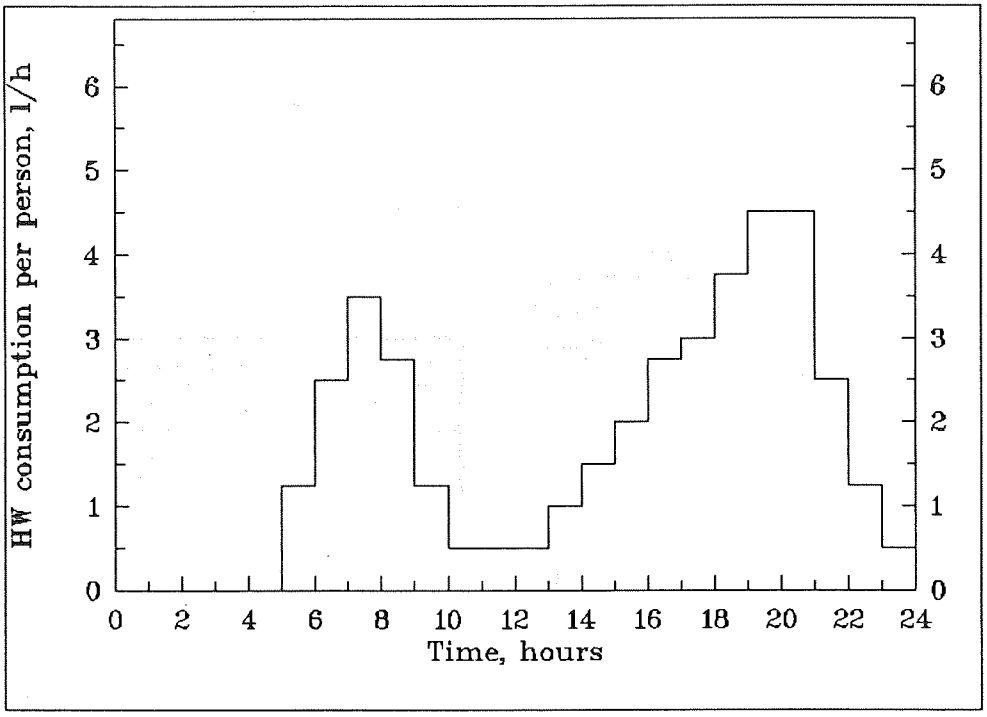

Fig. 2 Hot water consumption profile

respectively, i.e, a range from 20 to 65°, which is very wide to be considered as a recommendation for design purposes.

Computer simulations have shown that for a solar hot water system, which is a year round application, the optimum collector slope for Cyprus is 35°, i.e the location latitude, while for a space heating system, which is a winter application only, the optimum collector tilt angle is 50°, i.e. location latitude plus 15° (Michaelides, 1993). The above findings may lead to the conclusion that for a combined hot water and space heating system, which implies year round utilisation of solar collectors, the optimum collector tilt should be within the range of 35 to 50°, i.e φ to φ +15°.

SYSTEM CONFIGURATION

Fig. 1 illustrates the schematic diagram of a combined solar space and water heating system capable of meeting the requirements of both, domestic hot water and space heating of a building. It comprises the collector and storage subsystem, the domestic hot water subsystem, separate auxiliary sources of energy for domestic hot water and space heating, heat exchangers, pumps and control devices.

The system is arranged to collect solar energy in a non-freezing liquid, such as water with antifreeze additives, via an optional collector-storage heat exchanger, and supply heat from storage to the space heating and service hot water equipment. When solar energy cannot meet the demand of either domestic water or space heating, auxiliary heat is added from one or both of the conventional auxiliary units shown. Heat from the solar storage tank may be distributed to the living spaces either in hot water or in warm air. In the simulations conducted for this study, a water to air load heat exchanger has been assumed and the collector-storage heat exchanger is omitted in order to maximise the system performance (Michaelides, 1993).

THE SIMULATION MODEL

The present investigation is made through computer simulation , using the TRNSYS programme (Klein et al., 1990). A combined solar water and space heating system is modular and the simulation model for the system is formulated by connecting the models of each of the system components.

The simulation platform is synthesized from a number of TRNSYS components which include the following subroutines:

(a) Collector-storage subsystem; this unit consists of a flat plate solar collector, an optional heat exchanger (in this case it is omitted), a water storage tank, pumps and controls.

(b) Domestic water heating subsystem; it consists of a preheat tank that supplies solar pre-heated water to an auxiliary heater which heats the water to the required supply temperatures. There is also a heat exchanger, built into the model.

(c) Energy/(Degree Day) space heating load, which calculates the space heating load of the building.

(d) Weather generator, to produce hourly weather data from monthly averages.

(e) Solar radiation processor, to convert the solar data into a form usable by the collector-storage subsystem.

(f) Quantity integrator, to integrate energy quantities.

(g) Domestic hot water load, which describes the daily hot water consumption pattern.

(h) Printer, to output the monthly or yearly results of the simulation.

With regard to service hot water load, although the hot water demand is subject to a high degree of variation from day to day and from consumer to consumer, it is impractical to use anything but a repetitive daily profile. For the present simulation, it is assumed that the daily hot water consumption per person is 40 l and the consumption pattern is as shown in Fig. 2.

A large number of parameters are required as inputs to the system model and some of these are shown in Table 1. The simulation concerns residential applications of combined water and space heating. For this purpose a typical Cypriot house having a floor area of 200 m^2 and characterised by a heat loss coefficient, UA, of 4000 kJ h^{-1} $^oC^{-1}$ is used. It must be noted, however, that the simulation model can be used to simulate the performance of any other building and at any other conditions, provided the appropriate inputs and parameters are used.

The performance index will be the system solar fraction, f, which is defined as the fraction of the load provided by solar energy and is given by the equation:

$$f = \frac{Q_{load} - Q_{aux}}{Q_{load}} \qquad (1)$$

where, Q_{load} is the total heating load (water and space heating), and

Q_{aux} is the total auxiliary heat supplied to the system.

1. Collector–storage subsystem	
A_c	60 m^2
G_{test}	54 kg h^{-1} m^{-2}
G	50 kg h^{-1} m^{-2}
$F_R(\tau\alpha)_n$	0.78
F_RU_L	24.4 kJ h^{-1} K^{-1} m^{-2}
V_s	3 m^3
U_s	1.2 kJ h^{-1} K^{-1} m^{-2}
2. Domestic water heating subsystem	
V_p	180 l
U_p	1.2 kJ h^{-1} K^{-1} m^{-2}
T_{req}	50 °C
ε	0.75
3. Building space heating load	
UA	4000 kJ h^{-1} K^{-1}
T_R	20 °C
$\varepsilon_L C_{min}$	8000 kJ h^{-1} K^{-1}

Table 1 System simulation parameters

RESULTS AND DISCUSSION

Simulation results showed that at small collector slopes the solar fraction is very low in winter and higher in summer while at large tilt angles approaching the vertical position, the solar fraction is maximised in winter and minimised in summer. The ideal situation, therefore, would be a variable tilt angle which would keep the collector surface normal to the sun rays. Such an arrangement results to maximum collection of solar energy throughout the year, but it requires a sun-tracking mechanism which is associated with high capital costs and increased maintenance and running costs. It is therefore necessary to

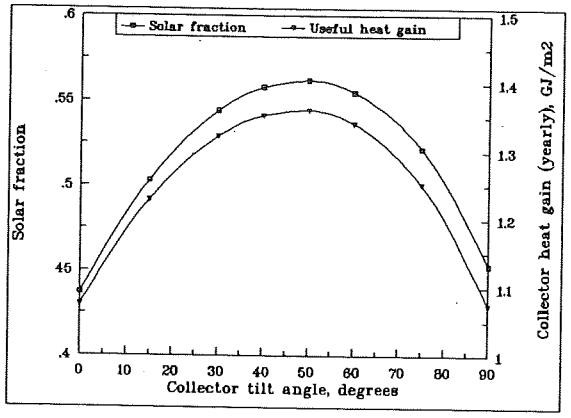

Fig. 3 Variation of annual solar fraction and collector heat gain with collector tilt angle

investigate that slope or range of slopes which result to the maximum solar fraction on a yearly basis.

The optimum tilt angle is investigated on the basis of the yearly performance of the system. For this purpose, the system solar fraction and the yearly heat gain by the collector are taken as the indices of comparison. A number of simulations were run for different tilt angles from 0 to 90°. Computations are carried out assuming that the collector is oriented to face due south and the ground reflectivity is taken equal to 0.2 (Lof and Tybout, 1973). The results of the simulations were used to plot the graphs of Figs. 3 and 4.

Fig. 3 shows the variation of the annual solar fraction and the collector useful heat gain with the collector tilt angle. Both plots have a maximum which corresponds to a tilt angle of about 50° from horizontal, which is the optimum tilt angle. Compared to the location latitude, φ, this tilt is φ +15°. However, there is a range of tilt angles from 45° to 55° which brings about maximum performance; within this range of values the yearly solar fraction and useful heat gain do not deviate considerably from maximum. This is attributed to the fact that at tilt angles between 45° and 55° the incident solar radiation falls on the collector almost perpendicularly, therefore minimising the reflected radiation and maximising the transmitted radiation component. At collector tilt angles outside this range of values, the solar fraction falls off rapidly. This is mainly due to the displacement of the collector plane away from the normal conditions of the incident solar beam.

The above is clearly demonstrated in Fig.4 which shows the variation of relative solar fraction with deviation of tilt angle from optimum. Relative solar fraction is defined as the ratio of the system annual solar fraction at any tilt angle to the solar fraction corresponding to the optimum tilt angle. It is clearly shown that the solar fraction is reduced by approximately 1% when β_{opt} is changed by ±10°, and by less than 2% when β_{opt} is changed by ±15°. This may lead to the conclusion that the solar system may perform at nearly maximum performance if the tilt angle is within the range of φ and φ +30°, i.e, β_{opt} =(φ +15) ± 15°. This is in agreement with what has been suggested by Tybout and Lof (1970), who recommend φ +(10 to 20) ±10°.

The graphs of Figs. 3 and 4 are very useful in cases where the collector slope is dictated by architectural considerations. In such instances, these plots can be used to demonstrate the effect that the imposed slope will have on the

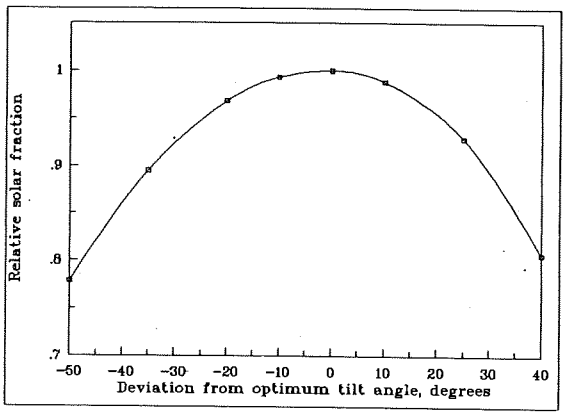

Fig. 4 Variation of relative solar fraction (f/f_{opt}) with deviation of collector tilt angle from optimum tilt

annual solar fraction and consequently on the thermal performance of the system.

CONCLUSIONS

The performance of a combined solar water and space heating system is sensitive to the collector tilt angle. The annual solar fraction of the system is maximised at a collector tilt of about 50° from horizontal which corresponds to the location latitude plus 15°. A deviation of ±10° from the optimum tilt angle brings about a reduction of only 1% in the annual solar fraction of the system.

NOMENCLATURE

A_c	Collector area, m^2
f	Solar fraction (fraction of the load that is met by solar)
F_RU_L	Slope of the collector efficiency curve, kJ h^{-1} K^{-1} m^{-2}
$F_R(\tau\alpha)_n$	Intercept of the collector efficiency curve
G	Collector mass flux, kg h^{-1} m^{-2}
G_{test}	Collector mass flux at test conditions, kg h^{-1} m^{-2}
Q_{aux}	Auxiliary energy supplied to the system, kJ
Q_{load}	Thermal load (hot water and/or space heating), kJ
T_R	Room temperature, °C
T_{req}	Minimum required hot water delivery temperature, °C
UA	Constant characterising the building, kJ h^{-1} K^{-1}
U_p	Heat loss coefficient of hot water preheat tank, kJ h^{-1} K^{-1} m^{-2}
U_s	Heat loss coefficient of storage tank, kJ h^{-1} K^{-1} m^{-2}
V_p	Volume of hot water preheat tank, m^3
V_s	Storage tank volume, m^3
α	Absorptance
β	Collector tilt angle, degrees
β_{opt}	Optimum collector tilt angle, degrees
ε	Heat exchanger effectiveness
ε_L	Effectiveness of the space heating load heat exchanger
τ	Transmittance
φ	Latitude, degrees

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Computer Modelling of a Solar Collector System

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ABSTRACT

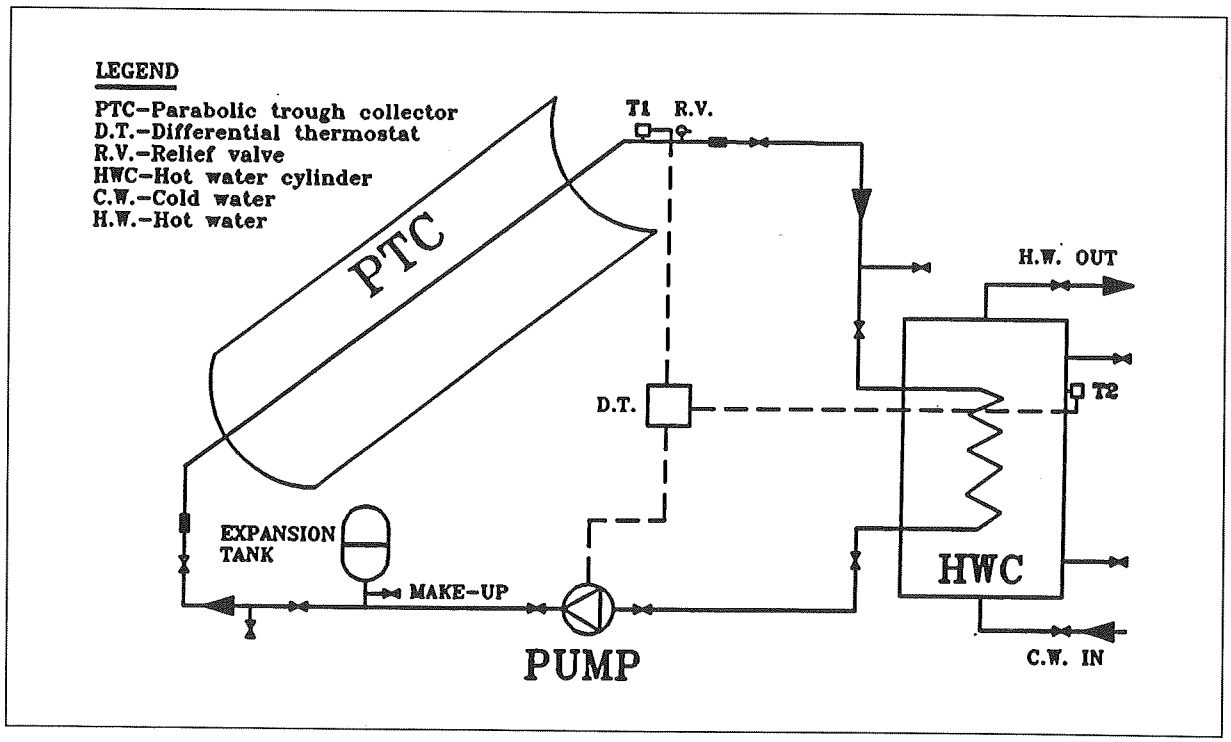
The modelling of a Parabolic Trough Collector System for hot water production is presented. This is followed by an experimental verification of the model and analysis of the experimental results. The difference between the predicted and actual results is about 7%. This variation is attributed to the difference of the actual weather during the tests compared to standard data taken from a "reference year" and the convection losses from the collector receiver which were not constant as accounted by the program.

INTRODUCTION

Cyprus began manufacturing solar water heaters in the early sixties. It is estimated that about 130,000 such heaters are in operation today which correspond to one heater for every 5 people on the island. These systems are almost exclusively of the flat-plate type. Opportunities still exist on the island for large scale hot water production for which the Parabolic Trough Collector can be used more economically [1].

Cyprus enjoys an abundance of solar radiation which for a year with average weather conditions reaches 1725 kWh/m^2 (global), of which 69% (1188 kWh/m^2) is direct and the rest 31% (537 kWh/m^2) is diffuse radiation. All values apply for radiation falling to a horizontal surface.

Parabolic Trough Collectors (PTC) are generally employed for a variety of applications such as industrial steam production [2], hot water production [1] and solar detoxification [3]. It has been shown that the use of PTC for hot water production can be more viable than the flat-plate type owing to its higher operating



Fig, 1 The PTC system

Table 1 REFERENCE YEAR

(UNITS: Beam Radiation in W/m2 and Temperature in Deg. C)

TIME	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
	RAD	TEMP	RAD	TEMP	RAD	TEMP	RAD	TEMP	RAD	TEMP	RAD	TEMP	RAD	TEMP	RAD	TEMP	RAD	TEMP	RAD	TEMP	RAD	TEMP	RAD	TEMP
1.00	0	7.1	0	7.9	0	10.1	0	12.6	0	16.9	0	20.7	0	23.3	0	23.1	0	20.8	0	17	0	11.3	0	8.8
2.00	0	7	0	7.6	0	9.7	0	12.3	0	16.6	0	20.4	0	23	0	22.7	0	20.4	0	16.6	0	11	0	8.6
3.00	0	6.8	0	7.3	0	9.4	0	12	0	16.2	0	20.1	0	22.6	0	22.3	0	20	0	16.3	0	10.7	0	8.4
4.00	0	6.6	0	7	0	9.1	0	11.8	0	15.9	0	19.7	0	22.3	0	21.8	0	19.6	0	16	0	10.7	0	8.3
5.00	0	6.4	0	6.9	0	9	0	11.5	0	15.7	0	19.6	0	22	0	21.4	0	19.2	0	15.8	0	10.4	0	8.2
6.00	0	6.4	0	6.8	0	8.7	2	11.8	12	16.9	37	21.3	22	23.1	4	21.8	0	19.1	0	15.6	0	10.3	0	8.2
7.00	0	6.4	2	7.1	8	9.3	38	14.2	81	19.6	141	23.9	135	25.9	82	24.5	44	21.2	12	16.8	0	10.4	0	8.2
8.00	7	7	19	8.3	69	11.1	146	16.8	206	21.9	300	26.3	310	28.6	244	27.4	196	24.5	103	19.9	28	12.2	13	8.9
9.00	73	9.4	94	10.9	186	13.5	295	18.9	354	24.1	472	28.3	489	30.5	415	29.5	370	27.1	244	22.9	112	15.4	106	11.3
10.00	161	11.5	174	12.8	303	15.5	420	20.3	493	25.7	607	29.9	630	32.2	567	31.5	506	29	365	24.9	223	17.7	217	13.3
11.00	209	12.9	254	14.1	382	16.7	508	21.3	558	27	684	31.1	729	33.6	664	33	604	30.4	447	26.1	305	19	292	14.5
12.00	241	13.5	327	14.8	419	17.6	492	22	556	27.7	708	31.9	765	34.7	705	34.2	637	31.5	478	27	317	20	300	15.2
13.00	246	13.9	307	15.1	389	18.2	463	22.1	477	27.7	666	32	735	35.1	668	34.6	597	31.9	453	27.3	308	20.3	285	15.5
14.00	212	14.1	243	15.3	339	18.8	402	22.3	406	27.8	577	32.4	664	35.4	586	34.9	486	32	392	27.5	243	20.4	225	15.7
15.00	136	13.7	162	14.8	277	18.3	311	21.5	324	26.7	454	31.1	519	34.4	453	33.7	357	30.8	284	26.3	167	19.6	153	15.1
16.00	56	13.1	96	14.3	182	17.4	186	20.5	215	25.9	328	30.4	348	33.4	313	32.6	235	29.5	141	24.9	67	18.6	64	14.4
17.00	7	11.9	27	13.2	72	16.5	79	19.3	127	24.5	193	29.5	196	31.9	163	31	105	28.3	40	23	7	17.1	7	13.1
18.00	0	10.7	0	11.9	10	15.3	17	17.6	49	22.7	98	27.2	86	30	49	28.9	14	25.8	3	21.5	0	15.7	0	12
19.00	0	9.7	0	10.8	0	14	1	16.3	7	20.9	25	25.1	12	27.8	2	26.9	0	24.4	0	20.4	0	14.7	0	11.2
20.00	0	8.9	0	10.1	0	13	0	15.4	0	19.8	0	23.6	0	26.1	0	25.7	0	23.5	0	19.6	0	13.7	0	10.5
21.00	0	8.4	0	9.5	0	12.3	0	14.6	0	19	0	22.8	0	25.2	J	24.9	0	22.8	0	18.9	0	13	0	10
22.00	0	8	0	9	0	11.7	0	14.1	0	18.4	0	22.1	0	24.3	0	24.4	0	22.3	0	18.3	0	12.4	0	9.6
23.00	0	7.6	0	8.5	0	11.1	0	13.6	0	17.9	0	21.6	0	24.1	0	23.9	0	21.8	0	17.7	0	11.9	0	9.3
24.00	0	7.3	0	8.2	0	10.6	0	13.2	0	17.5	0	21.2	0	23.8	0	23.5	0	21.3	0	17.2	0	11.5	0	9
TOTAL RADIATION	1348		1705		2636		3360		3865		5290		5640		4915		4151		2962		1777		1662	

efficiency [1].

The scope of the modelling presented here is to investigate the performance of a PTC system and compare the results with the actual system performance.

Computer modelling of thermal systems present many advantages. The most important ones are:

- Eliminate the expense of building prototypes.
- Complex systems are organised in an understandable format.
- Provide thorough understanding of system operation and component interactions.
- Optimisation of system components.
- Modelling or simulation can be used to estimate the amount of energy delivered from a solar system. The simulation model can also indicate whether the temperature variations of a particular system design are reasonable i.e. the fluid temperature is not rising above the boiling point.
- Simulation models can also provide information on effects of design variable changes on system performance by using the same weather conditions.

THE REFERENCE YEAR

The operation of solar collectors and systems depends on the solar radiation input and the ambient air temperature. A typical year, called a Reference Year, is defined as a year which sums up all the climatic information characterising a period equivalent to the mean life of the system. In this way the long term performance of a system can be calculated by simulating its performance over the reference year.

The reference year for the town of Nicosia, Cyprus was developed [4]. The actual reference year is a table of the hourly solar beam radiation and ambient air temperatures (see Table 1). The beam radiation is used here as PTCs with concentration ratios above 10, can only utilise this type of radiation [5].

SYSTEM MODELLING

The PTC system modelled here includes components as shown in Fig. 1 i.e. a PTC, a hot water storage tank, a circulating pump and a differential thermostat. The PTC system specifications are shown in Table 2.

A BASIC program was developed which used the data from the reference year (Table 1) and, the thermal and optical characteristics of the PTC system. These characteristics are determined from first principles by the specifications given in Table 2. The hourly solar radiation values are modified by the program to account for the collector inclination. The mode of tracking employed by the collector is the polar i.e. the axis of the collector is at an angle equal to the local latitude (35°) and tracks the Sun from East to West. For simplicity, it is assumed that no hot water is used. Also, the initial storage temperature is considered equal to the ambient temperature at the first hour of the day. The program calculations are performed for each minute throughout the day, whilst the output from the program is given for every hour. The program flow chart is shown in Fig. 2.

ITEM	VALUE
Collector aperture area	1 m^2
Collector aperture	0.8 m
Aperture to length ratio	0.64
Rim angle	90°
Glass to receiver dia. ratio	2.17
Concentration ratio	21.2
Optimum water flow rate	0.012 kg/s
Differential thermostat setting	5°C
Storage capacity	90 l

Table 2 Parabolic trough collector system specification

Standard relations are used in the program for the calculation of the heat transfer coefficients. The useful power delivered by the collector is estimated by:

$$q_u = A_a F_R \left[n_o I - \frac{U_L (T_i - T_a)}{CR} \right] \quad (1)$$

The thermal efficiency can be obtained by dividing q_u by I A_a. The optical efficiency is given by:

$$n_o = \rho \tau \alpha \gamma F_t [(1 - A_f \tan(\theta)) \cos(\theta)] \quad (2)$$

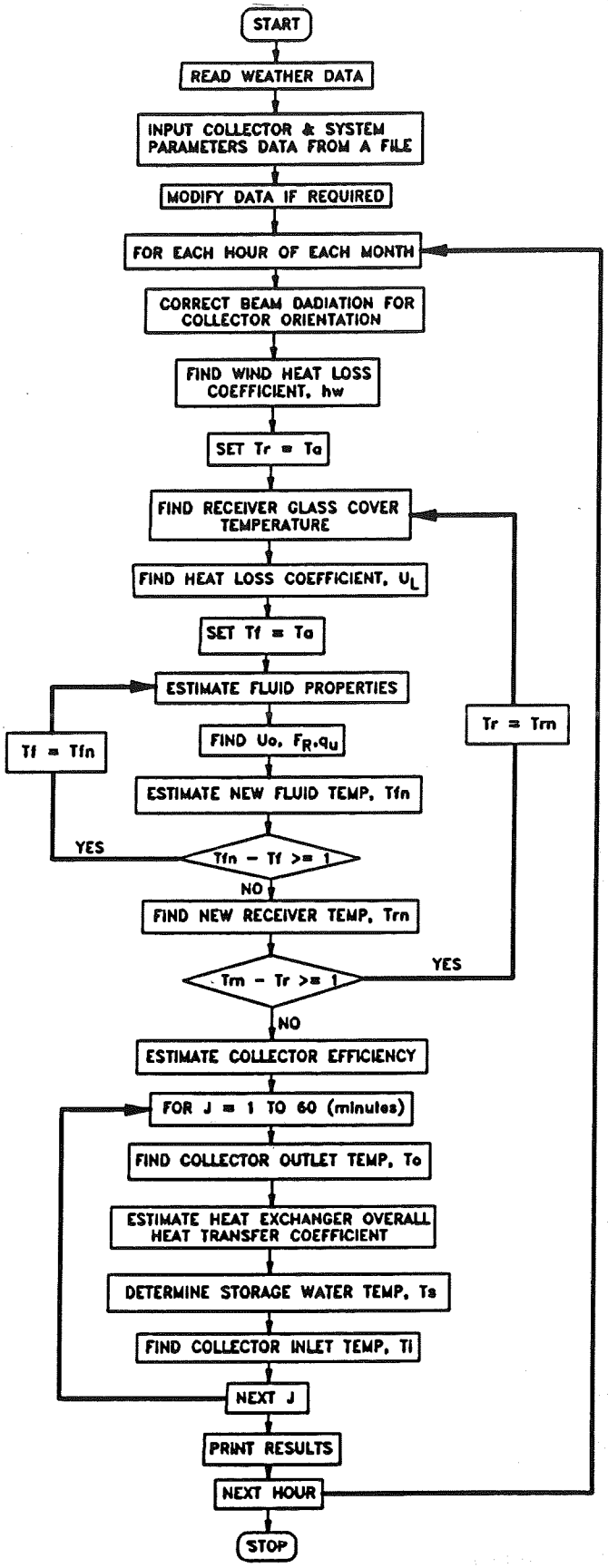


Fig. 2 Program flow chart

where A_f is the geometric factor determining the loss of area due to abnormal incidence effects and is given by:

$$A_f = \frac{\frac{2}{3} W_a h_p + f W_a \left(1 + \frac{W_a^2}{48 f^2}\right)}{A_a} \quad (3)$$

For the heat loss coefficient, U_L, of the glazed tube receiver the formulation presented by Mullick *et al.* [6] was adopted.

A fully mixed hot water storage tank is assumed. For submerged coils which is the case of the heat exchanger in the storage tank, the heat transfer coefficient, for the outside diameter of the heat exchanger pipe, can be obtained from [7]:

MONTH =MARCH

TIME	COL. OUT. TEMP.	THERM. EFFIC.	USEFUL POWER	STORAGE TEMP.
8.00	14.43	64.83	112.53	12.17
9.00	18.37	64.89	213.66	14.19
10.00	22.41	64.85	283.90	16.88
11.00	26.10	64.76	321.02	19.92
12.00	29.68	64.65	340.80	23.15
13.00	32.55	64.51	328.78	26.26
14.00	35.45	64.36	321.81	29.31
15.00	38.62	64.15	326.09	32.40
16.00	41.29	63.88	311.63	35.35

MONTH =APRIL

TIME	COL. OUT. TEMP.	THERM. EFFIC.	USEFUL POWER	STORAGE TEMP.
8.00	21.58	61.45	164.75	18.36
9.00	25.79	61.44	256.55	20.79
10.00	29.72	61.37	311.77	23.74
11.00	33.71	61.28	346.96	27.03
12.00	36.44	61.14	329.52	30.15
13.00	39.38	60.97	323.36	33.21
14.00	42.15	60.80	313.36	36.18
15.00	44.57	60.52	293.93	38.96
16.00	45.89	60.08	241.11	41.25

MONTH =MAY

TIME	COL. OUT. TEMP.	THERM. EFFIC.	USEFUL POWER	STORAGE TEMP.
8.00	26.95	55.48	174.12	23.55
9.00	30.46	55.50	240.79	25.83
10.00	34.26	55.44	292.92	28.61
11.00	37.48	55.36	308.93	31.53
12.00	40.24	55.27	303.63	34.41
13.00	42.16	55.10	271.37	36.98
14.00	44.28	54.93	255.71	39.40
15.00	46.33	54.66	242.70	41.70
16.00	47.80	54.33	212.06	43.70

MONTH =JUNE

TIME	COL. OUT. TEMP.	THERM. EFFIC.	USEFUL POWER	STORAGE TEMP.
8.00	32.76	52.23	225.04	28.43
9.00	36.69	52.21	287.31	31.15
10.00	40.40	52.16	323.94	34.22
11.00	43.92	52.08	340.22	37.44
12.00	47.31	51.98	346.47	40.73
13.00	50.34	51.83	337.97	43.93
14.00	53.08	51.68	321.40	46.97
15.00	55.47	51.42	296.40	49.78
16.00	57.62	51.15	274.88	52.38

Table 3 Simulation program output for months March to June

MONTH	ENERGY (Wh)
JAN	1544
FEB	1941
MAR	2587
APR	2577
MAY	2307
JUN	2755
JUL	3051
AUG	3406
SEP	3730
OCT	3221
NOV	2026
DEC	2006

Table 4 Mean daily energy collected

$$Nu_D = 0.53 (Gr\ Pr)^{0.25} \quad (4)$$

The overall heat transfer coefficient in this case based on the outside pipe diameter is given by [7]:

$$U = \left[\frac{D_o}{D_i}\frac{1}{h_f} + \frac{D_o \ln(D_o/D_i)}{2k} + \frac{1}{h_o}\right]^{-1} \quad (5)$$

The computed output from the program for the months April to June inclusive is shown in Table 3 whereas the mean daily energy collected for each month is shown in Table 4.

EXPERIMENTATION

A prototype model was constructed and tested over four months. Hence the accuracy with which the simulation program predicts performance can be assessed. From the standard collector performance testing [8], some differences were observed between the

ITEM	TEST SLOPE	TEST INTERCEPT
Predicted performance	0.353	0.656
Actual performance	0.441	0.642
% difference	24.9	2.1

Table 5 Collector performance

MONTH	PREDICTED PERFORMANCE (using actual optical efficiency)	ACTUAL PERFORMANCE	ENERGY GAIN % DIFFERENCE
MARCH	2506 Wh	2403 Wh	-4.1
APRIL	2527 Wh	2351 Wh	-6.9
MAY	2254 Wh	2241 Wh	-0.6
JUNE	2696 Wh	2713 Wh	+0.6

Table 6 Comparison of actual and predicted system performance

theoretical values of the slope and intercept, and the experimental values. The results are shown in Table 5. A small difference is seen between the theoretical and experimental values with respect to the test intercept, whereas there is a large variation in test slope. Therefore the optical efficiency, n_0, which is deduced from the graph intercept is accurately predicted. The large variation of the test slope is due to a difference in the heat loss coefficient, U_L, which may be accounted for by the conduction/convection losses through the receiver support brackets. This difference is reduced from 24.9% to 5.7% [9] when these losses are accounted for.

The results from the experiments carried out with the PTC system are presented in Table 6. The values shown are the mean values of the tests performed over a five day period during each month. As can be seen from this table the difference in the predicted and actual energy gain for all the months investigated is below 7% which may be considered reasonable.

Some of this difference may be accounted for by the following reasons:

1. The amount of cloud to sunshine hours. The amount of direct to diffuse radiation and the ambient air temperature may be different from those which are taken from reference year. This is strengthened by the fact that for the two Spring months of May and June, the difference is much smaller because the possibility of cloud is less.

2. Convective losses. There was light wind in all test cases but its velocity varied. In the program a wind velocity of 1 m/s was considered as being constant.

CONCLUSIONS

The simulation program can predict the PTC system performance to an accuracy of 7% and therefore the model can be successfully used for long term parabolic trough collector system performance prediction.

NOMENCLATURE

A_a	Aperture area, m^2
A_f	Geometric factor
A_r	Receiver area, m^2
CR	Concentration ratio
D	Receiver diameter, m
D_i	Inside receiver diameter, m
D_o	Outside receiver diameter, m
f	Focal distance, m
F_R	Heat removal factor
F_t	Factor accounting for inaccurate tracking
Gr	Grashof number, dimensionless
h	Loss coefficient, $W/m^2 K$
h_f	Heat transfer coefficient inside tube, $W/m^2 K$
h_o	Heat transfer coefficient outside tube, $W/m^2 K$
h_p	Parabola height, m
k	Thermal conductivity, W/mK
I	Beam solar radiation, W/m^2
Nu	Nuselt number, dimensionless
Pr	Prandtl number, dimensionless
q_u	Useful power, W
U_L	Heat loss coefficient, $W/m^2 K$
T_i	Collector inlet temperature, K
T_a	Ambient temperature, K
W_a	Collector aperture, m

Greek letters:

α	- Absorptance of receiver surface coating
ρ	- Mirror reflectivity
τ	- Transmittance of receiver cover
γ	- Intercept factor
Θ	- Angle of incidence, deg.
η	- Thermal efficiency
η_o	- Optical efficiency

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The Development of Civil Engineering in Cyprus

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ABSTRACT

Historical events such as the Independence of Cyprus in 1960 and the Turkish invasion of Cyprus in 1974 produced a rapid expansion in Civil Engineering construction and consequently an increase in demand for professional Civil Engineers. These significant factors are given specific consideration in this article and the current position of the Civil Engineer is examined.

THE DEVELOPMENT OF CIVIL ENGINEERING CONSTRUCTION

Since the 1950s and especially during the last two decades there has been a considerable increase in the development of Civil Engineering construction in Cyprus.

The Census of Cyprus 1960, indicated that over 40% of all housing units were built in Cyprus during the 15 years following the Second World War[1]. Naturally during the War there was hardly any construction activity. However, the end of the war brought about significant economic changes, which resulted in the flow of rural workers to the towns and also in a major increase in the construction of dwelling houses.

In addition the British Administration of the island introduced major infrastructure projects primarily for the needs of the military estates and installations on the island. These projects generated substantial activity in the construction industry, thus increasing the demands and role of the Civil Engineer.

Cyprus as an independent republic

In 1960, the newly formed Republic of Cyprus was undergoing a period of economic recession. The government worked intensively in the implementation of a series of five-year development plans aiming to restore economic growth. The decline in agriculture and the consequent growth of manufacturing and tourism resulted in considerable increase in the construction industry.

Basic infrastructure projects were needed in order to meet the demands of the major sectors of development. They mainly included port development, new airport terminal buildings, the improvement and extension of the road network, the development of telecommunications, the expansion of the electricity grid-system and water works. In addition new hotels and hotel apartments were built for tourism purposes.

The new government of Cyprus realised the need for technically trained personnel. The existing technical schools were expanded and new ones were established in all Districts of Cyprus. In 1968, the Higher Technical Institute was established aiming to meet the demands of industry for qualified Technician Engineers, in the fields of Civil Engineering, Electrical Engineering and Mechanical Engineering.

The Turkish invasion

The effects of the Turkish invasion and the consequent changes in the structure of the economy favoured the construction industry. The economy of Cyprus in the post invasion years was led by manufacture, tourism and construction. In 1980 the share of construction on the Gross Domestic Product (G.D.P.) was 14 per cent and occupied 11.7 per cent of the gainfully employed population.

The following factors were responsible for the construction boom between the years 1976 and 1980[2].

a) ***The housing of refugees:*** The five year development plans of the government included the rehousing of 200.000 refugees and the reactivating of the economy as the first priorities. The building of new homes was undertaken jointly by the central government and the private sector. In addition the government established favourable financing schemes for supporting those willing to undertake self-build housing.

b) ***Provision of infrastructure:*** The concentration of the population in the south of the island, the loss of vital infrastructure as well as the growth of trade and tourism necessitated provision of major infrastructure. These mainly included: The construction of a new airport and airport terminal buildings, the development of new port facilities, the improvement and development of a new road network.

c) ***Irrigation projects:*** The development of agriculture and tourism as well as the dry climatic conditions of the island necessitated the proper and effective use of water resources and the construction of large water storage dams.

d) ***Tourist facilities:*** The spectacular growth of tourism, after 1980 became the leading sector of the economy and contributed significantly to the increase of construction. This growth resulted in the construction of major Civil Engineering and Building projects in order to meet the increasing demands for tourism.

In addition, the favourable financing schemes offered by Banks and other financing Institutions contributed to a considerable increase in the building of dwellings. From 1976 todate housing construction has been absorbing more than 50 per cent of the money invested in the construction industry [3].

By 1980, the projects for the housing of refugees were completed and the construction sector returned to its pre-invasion levels of approxi-mately 10 per cent of the Gross Domestic Product [4].

THE POSITION OF THE CIVIL ENGINEER

The growth in the number of Civil Engineers

The first known Cypriot Engineer was Th. Fotiades, who completed his studies in Athens in 1905[5]. He was awarded the Degree of Engineering, which at the time was covering the fields of Architecture and Engineering.

After 1944, economic changes produced an expansion in the construction sector and a subsequent increase in the number of Cypriots who chose to study Civil Engineering.

In 1963, when the Register of Architects and Civil Engineers was first introduced, 24 Civil Engineers were registered; 23 men and one woman. The number of Architects registered in 1963 was 38, all men. The first woman Architect graduated in 1960, but she applied for registration after 1970.

The change of the economy after 1960 and the considerable growth in the construction sector led to a significant increase in the number of Cypriots who followed Civil Engineering careers.

By 1974, 163 Architects and 262 Civil Engineers were registered, including 39 Turkish-Cypriot Architects and 34 Turkish-Cypriot Civil Engineers. The total number of women registered were 11 Architects and 13 Civil Engineers.

The number of Architects and Civil Engineers quoted after 1974, do not include Turkish Cypriots, since the Turkish invasion in 1974 has kept the Turkish minority inaccessible.

The number of Cypriot Civil Engineers and Architects registered yearly during the years 1970 and 1991 is shown in Figures 1 and 2.

The drop in the number of Civil Engineers registered during the years 1974 and 1975 was the result of the consequences of the Turkish Invasion, which had a major impact on the construction sector and the economy of Cyprus. Most of the graduates in Civil Engineering found employment abroad and primarily in the Middle East countries.

The construction boom after the post invasion years brought about a rapid increase in the rate of Civil Engineers registered between 1976 and 1985. This was followed by a significant drop due to the decline in construction projects.

By 1992, the total number of male and female Civil Engineers registered came to 1638; 1344 males and 294 females. Women constituted 18 per cent of the total number of Civil Engineers. The corresponding number of Architects registered was 882; 612 males and 270 females. Women constituted 31 per cent of the total number of Architects.

In Cyprus and indeed in many other countries, women's participation in Architecture is higher to their participation in Civil Engineering, as well as in other Engineering fields. In Greece, by 9 of February 1993 women constituted 26 per cent of the Architects and 12.6 per cent of the Civil Engineers registered by the Technical Chamber of Greece[6].

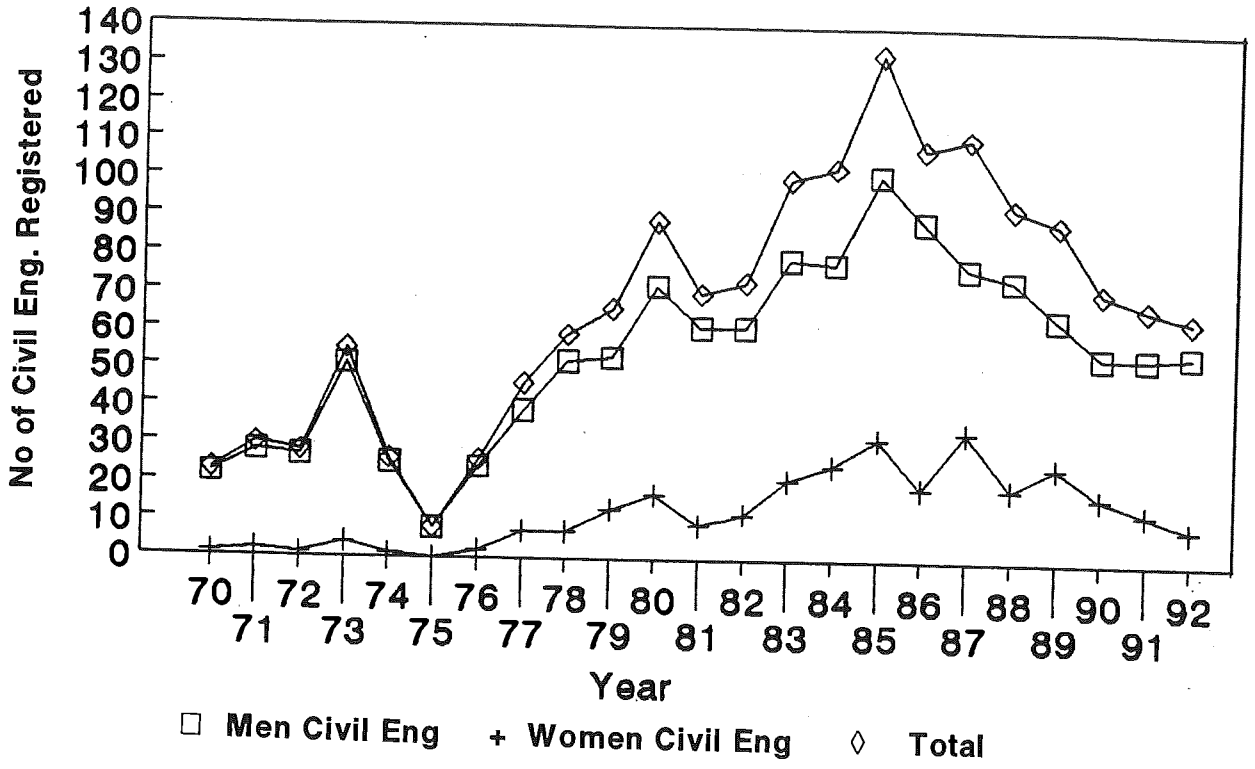

Fig. 1 Cypriot Civil Engineers registered yearly by the Council of Architects & Civil Engineers 1970-1992

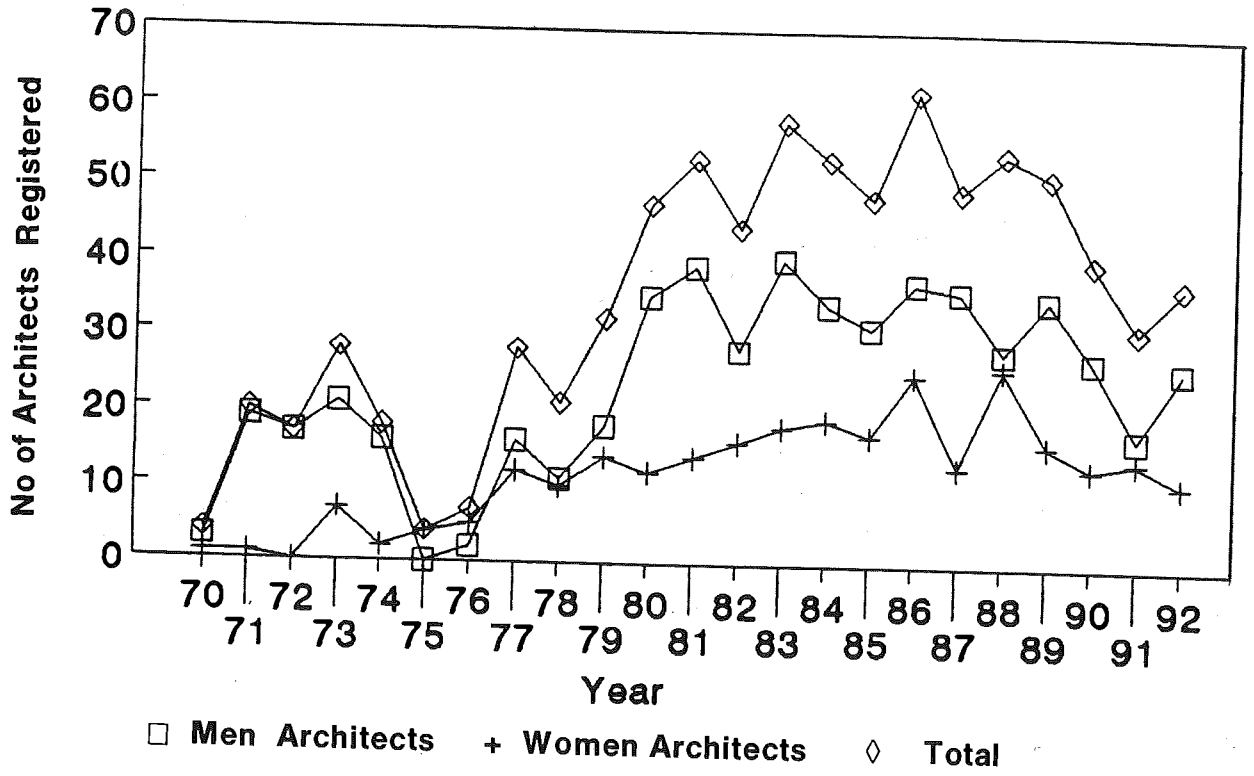

Fig. 2 Cypriot Architects registered yearly by the Council of Architects & Civil Engineers 1970-1992

Enrolments in Civil Engineering

Economic changes after the post invasion years and the sharp increase in the number of students who followed tertiary education, contributed to a rapid increase in the number of students who enrolled in Engineering Technology in Cyprus and abroad. According to the Statistics of Education, during the 1980s, Engineering Technology ranked first in the preferences of Cypriot students, studying abroad[7].

In Cyprus, Civil Engineering together with Electrical and Mechanical Engineering have been absorbing the majority of students enrolled in Engineering Technology. Civil Engineering has been the most traditional specialisation and occupied the first place in all Engineering specialisations until the mid 1980s, absorbing more than 30 per cent of all the students in Engineering Technology.

Since 1985, there has been a change in the distribution of students in the three major Engineering fields. There has been a decline in Civil Engineering, while Electrical Engineering has taken the lead, followed by Mechanical Engineering.

The change in the distribution of students in the specialisations of Engineering Technology can be attributed to:

i. The decline in the construction industry.

ii. The variety of employment opportunities offered to Electrical Engineers due to the increasing applications of Electrical and Electronic Engineering.

iii. The use of modern technology in industry and the other sectors of the economy, as well as the development of the manufacture industry which necessitated a new generation of professionals in Electrical and Mechanical Engineering.

The fact that there has been a drop in the attendance of students in Civil Engineering after 1985, though there has been a decline in the construction industry since 1980 puts under question the effectiveness of the professional guidance offered to secondary school graduates.

The position of the Civil Engineer

In Cyprus, most people still cannot distinguish a Civil Engineer from an Architect. In the past, things were not well defined. Engineers were expected to have knowledge on all matters relating to Engineering. It is characteristic that during the 1940s a Mechanical Engineer was in charge of structural design in the biggest Architectural office in Nicosia.

At this time Engineering and certain other related professions were not understood by Cypriot society. This was attributed to the low level of education and hence it was more difficult to distinguish between Craftsmen, Technicians and Engineers. In 1946 only 1.7 percent of the total population aged 20 and over received higher education, while the first technical schools were established in 1951[8].

In addition a Civil Engineer was required to train craftsmen into new techniques. Thus, Th. Fotiades, the first Cypriot Engineer, was considered by the builders and the craftsmen on site, as a "master mason".

Since 1945, Civil Engineering has been recognised as a qualified profession with a good income. The appointment of Cypriot Civil Engineers to well paid governmental posts, previously occupied by British Civil Engineers, contributed towards elevating the status of the Civil Engineering profession and led to an increase in their numbers during subsequent years[9].

In 1963, the number of registered Architects was larger than the corresponding number of Civil Engineers. However, there has been a much greater growth in the number of Civil Engineers in subsequent years.

This may be explained as follows:

i. Up until 1960, the scale of construction was relatively small and the structural design and site supervision of the works was normally carried out by an Architect.

ii. From the independence of Cyprus in 1960, the scale and form of construction became more complex and this necessitated the appointment of qualified and experienced Civil Engineers in the design and construction of the project.

iii. The growing construction industry demanded qualified personnel and it has therefore offered to Civil Engineers a wider range of employment opportunities than Architects.

iv. Since independence the government of Cyprus embarked major development programs, including roads, dams and other infrastructure works. This type of project was primary directed towards Civil Engineers specialising in such fields as: Highway Engineering, Traffic Engineering, Public Health and Water Engineering and many others.

Until recently there was no distinction between the responsibilities of Architects and Civil Engineers. According to the requirements set up by the Council of Architects and Civil Engineers, architectural and structural designs could be submitted and signed either by an Architect or a Civil Engineer. The newly established Scientific Technical Chamber of Cyprus, which started its operation in 1992, intends to separate and safeguard the duties and responsibilities of Architects and Civil Engineers.

The development of Civil Engineering and construction in general resulted in the establishment of several major organisations. In the private sector consulting firms of international reputation were established and major construction firms undertaking projects both in Cyprus and overseas were also established. In the Public sector government related development work necessitated the establishment of large government departments and public corporations such as: Water Development Department, Public Works Department, Ports Authority, Sewerage Board e.t.c.

All the above development demanded a high caliber of managerial ability and Civil Engineers have become a natural choice. For example the post of Minister of Communications and Public Works, is generally offered to a person qualified in Civil Engineering.

As the Civil Engineering profession developed and more experience was gained both in the fields of design and construction the need for foreign consultants diminished.

In addition, in the post invasion years many Cypriots, graduates in Civil Engineering acquired experience and skills by working abroad primarily in the Middle East countries. This experience proved a valuable professional investment when they returned to Cyprus as fully qualified and experienced Civil Engineers.

Employment of Civil Engineers

In 1989, Registration of Establishments showed that 78 per cent (541) of the employed Civil Engineers (698) were employed by the private sector and 21 per cent (148) by the Public sector. Women comprised 15 per cent of the total number of Civil Engineers employed.

Approximately 20 per cent of the Civil Engineers in the private sector were self employed. Women comprised 10 per cent of the total number of self employed Civil Engineers.

A comparison of the number of employed Civil Engineers to the number of Engineers registered by the Council of Architects and Civil Engineers indicates that the total number of Civil Engineers registered exceeded the number of those shown in the Registration of Establishments.

The above difference may be explained as follows:

a) There are Civil Engineers registered by the Council of Architects and Civil Engineers who work abroad.

b) A large number of Civil Engineers may be classified under a different occupational category. For example Civil Engineers holding administrative and managerial posts or teachers in secondary technical and higher technical education.

c) Other reasons. A number of qualified Civil Engineers may be doing different jobs altogether.

d) The Turkish Cypriot Civil Engineers whose number, until 1974, was 39 are not included in the Registration of Establishments.

In 1989, 245 Architectural practices and 92 Civil Engineering practices were registered in Cyprus employing 655 persons. They mainly employ 1 to 4 persons while only 7 Architectural practices employ more than 15 persons.

The number of Building and Road Construction companies was 2061, with a total employment of 23037 persons, comprising 11% of the total employment. They were mostly small companies employing 1 to 10 persons. Only 17 companies were employing more than 100 persons.

In 1983, legislation was enacted, Law 97/1973 and 32/1982 titled "Law for the Registration and

Control of Contractors". The primary objective of this legislation was to regulate and control Civil Engineering and Building Contractors and thus maintain quality in construction. This legislation increased the demand for Civil Engineers. By 1992, the total number of Civil Engineering and Building Contractors covered by this legislation was 1702.

In addition, during the last 5 years there has been a considerable increase in the number of Civil Engineers and Civil Engineering Technicians, who are registered as Directors of construction companies. Their total number is estimated to be about 500, including 5 women.

CONCLUSION

In Cyprus, political and socio-economic changes had a direct effect on the development of the construction industry and increased the demand for Civil Engineers.

From 1970, particularly during the early post invasion years in 1976, there has been a rapid growth in the construction industry and a significant increase in the number of Civil Engineers.

Women Engineers entered the Civil Engineering profession in 1960, but their number has increased significantly in subsequent years. By 1992 women Civil Engineers comprised 18 per cent of the total number of Civil Engineers registered by the Council of Architects and Civil Engineers.

The enrollments of tertiary education students in Civil Engineering courses and other related subjects is influenced by the employment opportunities offered in the various sectors of the economy, in those fields.

Until 1985 Civil Engineering was the popular choice of career by Cypriot students. However, by 1985 economic changes and the consequential decline of the construction industry resulted in a reduction in the number of students studying Civil Engineering in Cyprus and abroad. It should be noted that there has been a noticeable increase in the number of students following courses in Mechanical and Electrical Engineering.

In 1992, the Technical Chamber was established and supported by legislation with the objective of defining the duties, obligations and responsibilities of Architects, Civil Engineers and Engineers of other specialisations.

In Cyprus and indeed in many other countries the status of the Civil Engineer is high and consequently good employment prospects exist.

The number of Civil Engineers continue to increase at a high rate until the early 1980s. However, subsequent decline of construction industry created a disparity between supply and demand. This resulted in a noticeable reduction in the employment opportunities available to Civil Engineers.

It is evident that during the last 20 years the Cypriot Civil Engineer acquired a high level of academic qualifications, professional development and wide ranging experience in the design and construction of major Civil Engineering and Building projects. These obviated the need for appointment of foreign consultants which was previously the case.

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2. *The Second Emergency Economic Action Plan (1977-78),* Planning Bureau, Nicosia, 1977, pp.101-122.

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5. Th. Fotiades introduced the use of concrete in building construction as well as the neoclassical style in dwelling houses and other buildings. . (Information was received from Dr H. Stavrides, Head of the Civil Engineering Department, HTI.)

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Medical Ultrasound

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INTRODUCTION

Medical ultrasound as a diagnostic tool uses sound waves of high frequencies, well above the range of hearing of the human ear, which are directed into the body.

Some of the energy of the sound waves is reflected back and these reflected waves or echoes are detected, amplified, analysed and processed as to build an image which can give diagnostic information to the doctor about the internal structures and dynamics of organs in the body.

Ultrasound is also used, to a lesser degree, for therapeutic purposes as well, with lower frequencies and higher intensities than those used for diagnostic purposes.

The article attempts to give a brief review of the engineering principles in medical ultrasound techniques including the Doppler Effect and a general overview of the various imaging modes used.

BASIC ENGINEERING PRINCIPLES OF DIAGNOSTIC ULTRASOUND

Ultrasound is of the same nature as sound waves but of frequencies higher than the audible range, namely greater than 20 KHz.

In fact the frequencies used for diagnostic ultrasound are:

1-3 MHz for Abdominal and Neurological examinations.

2- 5 MHz for Cardiovascular examinations and

6 - 20 MHz for Opthalmologic examinations.

(Ultrasound used for therapeutic purposes employ frequencies of about 1 MHz).

Ultrasound waves require a medium through which to travel. They may be considered as pressure waves causing the particles of the medium through which they propagate to vibrate to and fro. As the particles vibrate, energy is transferred through the medium in a direction parallel to that of the virbation or oscillation of the particles.

The distance travelled by the particle about its mean or equilibrium position is called Particle Displacement which is normally about a few microns.

The maximum particle displacement shows the peak pressure, P, of the particle wave.

The rate at which the particle vibrates to an fro is the particle velocity, V, which is different than the speed of propagation, c, of the ultrasound wave through the medium.

The sketch in Fig.1, shows the displacement of each particle in a medium as the sound wave propagates through that medium.

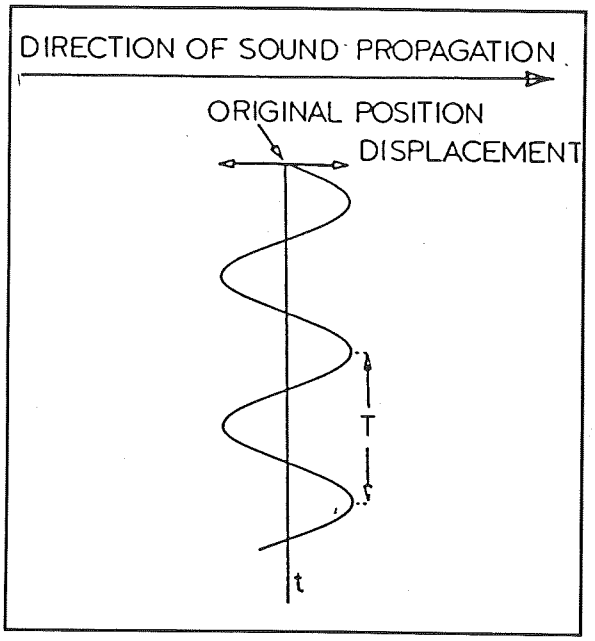

Fig. 1 Displacement of particle as the sound wave propagates

It should be noted that the particles do not travel through the medium as the ultrasound wave does.

As already mentioned as the ultrasound waves travel through the medium energy transfer takes place.

The speed of propagation, c, of the ultrasound waves as they travel through a medium depends on:

a) The density, ρ, of the medium measured in grams per cm^3 (which shows the compactness of the particles in that medium), and

b) The Elasticity, E, of the medium, which shows the ability of the material to return to its original shape and size after it has been stretched or compressed.

The relationship between c, E, and ρ, is:

The proof of this relationship involves Newton's Laws of the equations of motion using partial derivatives. The particle velocity, V, on the other hand depends on the amplitude of the displacement or pressure, P, of the particle and the characteristic impedance, Z, of the medium.

$$V = \frac{P}{Z} \text{ m / sec}$$

CHARACTERISTIC IMPEDANCE, Z

This is also called acoustic impedance and it is the opposition offered to the ultrasound wave as this propagates through a medium. It is measured in kg / m^2 / sec.

In terms of the speed of propagation, c, the charasteristic impedance $Z = \rho c$, where ρ is the density of the material through which the ultrasound wave travels.

The speed of propagation, c, and the characteristic impedance, Z, differ from medium to medium but for a given medium these remain constant.

The table below shows c and Z for some biological materials:

Tissue	Propagation speed c (m/s)	Acoustic impedance Z (10^6 xkg/m^2/s)
Fat	1460	1.39
Water	1530	1.52
Brain (25C)	1520	1.57
Nerve (Optic)	1616	1.68
Muscle	1630	1.73
Liver (24C)	1570	1.65
Kidney	1560	1.64
Aq. tumour	1500	1.51
Lens	1620	1.84
Lung	650	0.26
Bone (skull)	3050	5.0
Enamel	5800	17.1

Table 1 Speed of propagation and characteristic impedance for some biological materials

INTENSITY OF ULTRASOUND BEAM

The intesity, I, of an ultrasound beam shows the rate at which wave energy is transported through a medium and in practice it is measured in milliwatts per cm^2.

The intensity, I, depends on the amplitude of the pressure, P, of the wave and the characteristic impedence, Z, of the medium.

$$I = PV = \frac{P^2}{Z}, \text{ since } Z = \frac{P}{V}$$

INTERACTION OF ULTRASOUND BEAM WITH MATTER

When an incident wave beam of intesity I_i encounters a well defined or smooth boundary or interface between two media at right angles, as shown in Fig.2, some of the beam intesity I_r, will be reflected back and some will be trasnsmitted I_t, into the second medium.

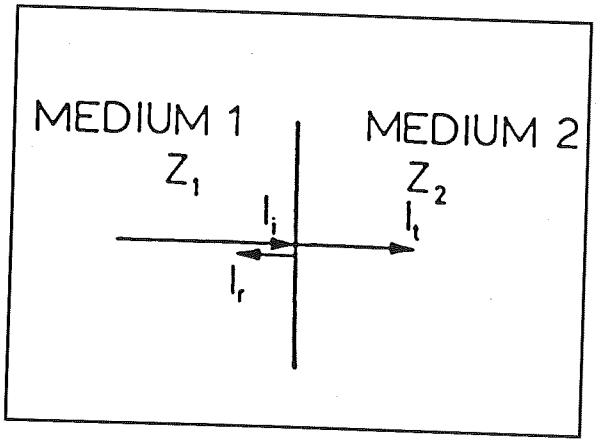

Fig. 2 Reflection and transmission of beam intensity when encountering another medium

(**Note:** Reflections from a smooth boundary are called specular reflections).

How much energy will be reflected back and how much will be transmitted into the second medium depends on the characteristic impedances Z_1 and Z_2 of the two media, (such as liver and kidney say), and in particular on the Intesity Reflection Coefficient, R_c, and on the Intensity Transmission Coefficient, R_t, where:

$$R_c = \frac{I_r}{I_i} = \left(\frac{Z_1 - Z_2}{Z_1 + Z_2}\right)^2$$

$$R_t = \frac{I_t}{I_i} = \frac{4Z_1Z_2}{(Z_1 + Z_2)^2}$$

These equations hold good if the incident beam, I_i encounters the two media at right angles as shown in Fig.2.

From the above relationships it can be deduced that:

a) The intensity of the reflection and transmission coefficients depend only on Z.

b) It is these coefficients which will decide what will happen at the interface, namely:

Case I: If $Z_1 = Z_2$, $R_c + O$ and $R_t = 1$.

No reflection will occur.

No image will be displayed.

Case II: If $Z_2 >> Z_1$ (such as the boundary of air/water).

$R_c = 1$, $R_t = O$

Ultrasound wave comes in but no transmission into the water takes place.

Case III: If $Z_1 >> Z_2$, (such as a boundary of water/air)

$R_c = 1$, $R_t = O$

100% reflection occurs.

No ultrasonic energy enters the air.

Therefore, if there is a large mismatch of the acoustic impedances, no transmission of ultrasound energy occurs. If there is air between the transducer and the skin say, there will be no trasmission.

But if a lubricating jelly, $Z_1 = (Z_t \ Z_s)^{0.5}$ is placed between the skin and the transducer, matching of the impedances occurs and the transmission of the beam into the body will be maximum.

Z_t = transducer impedance and Z_s = skin impedance. With such matching of impedances image of the structures of the internal organs can take place on the display monitor.

If the angle of incidence is less than 90 degrees as shown in fig. 3 below, then the equations for R_c and R_t will be different.

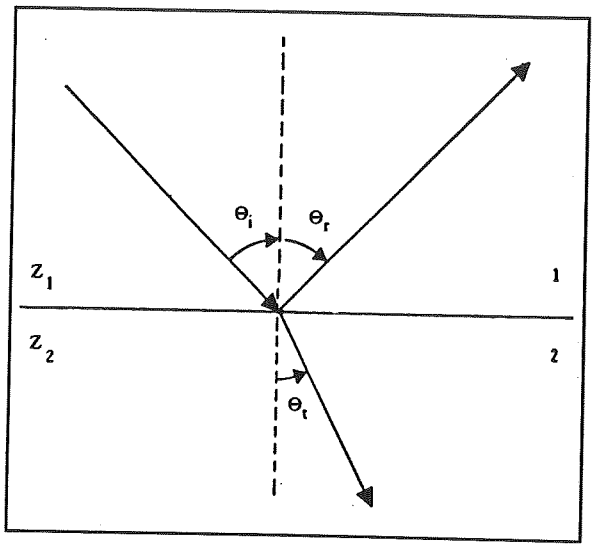

Fig. 3 Angle of incidence of beam intensity

In this case:

$$R_c = \frac{I_r}{I_i} = \left[\frac{\frac{Z_1}{\cos\theta_i} - \frac{Z_2}{\cos\theta_t}}{\frac{Z_1}{\cos\theta_i} + \frac{Z_2}{\cos\theta_t}}\right]^2$$

$$R_t = \frac{I_t}{I_i} = \frac{4\left(\frac{Z_1}{\cos\theta_i} \times \frac{Z_2}{\cos\theta_t}\right)}{\left(\frac{Z_1}{\cos\theta_i} + \frac{Z_2}{\cos\theta_t}\right)^2}$$

The above equations are derived assuming that:

a) The pressure on either side of the boundary is continuous.

b) For interfaces to remain in contact, the velocities on either side perpendicular to the boundary are equal).

ABSORPTION AND ATTENUATION

As the ultrasound beam propagates through a medium some of the ultrasound is converted into heat with consequent energy loss. Other factors which can cause loss of energy in ultrasound are scattering and specular reflection.

The three contributing factors stated above give rise to an overall attenuation of intensity of the energy of the beam, so that as the ultrasound wave beam travels along a medium a progressive loss or attenuation takes place which follows an exponential decay as shown in Fig. 4.

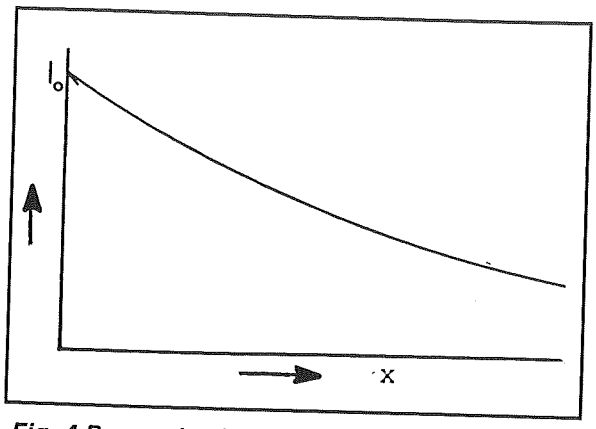

Fig. 4 Progresive loss of intensity of the energy of the beam

Thus if x is the distance travelled by the ultrasound beam in a given medium, the intensity Ix at distance x is given by the relationship:

$$I_x = I_o\, e^{-\alpha x}$$

where: I_o =original intensity on entering the medium

α = Overall attenuation coefficient.
= attenuation due to absorption, plus attenuation due to scattering, plus attenuation due to reflections.

$$\frac{I_x}{I_o} = e^{-\alpha x}, \quad \frac{I_o}{I_x} = e^{\alpha x}$$

$$Ln\left(\frac{I_o}{I_x}\right) = \alpha x,$$

$$Log_{10}\left(\frac{I_o}{I_x}\right) = -\left(\alpha Log_{10} e\right) x,$$

$$10\, Log_{10}\left(\frac{I_o}{I_x}\right) = -\,10 \times 0.43\, \alpha x,$$

$$10\, Log_{10}\left(\frac{I_o}{I_x}\right) = -\,4.3\, \alpha x,$$

$$10\, Log_{10}\left(\frac{I_o}{I_x}\right) = \mu x$$

where $\mu = -4.3\alpha$

The attenuation coefficient, μ, depends on the frequency used for a given medium as shown in

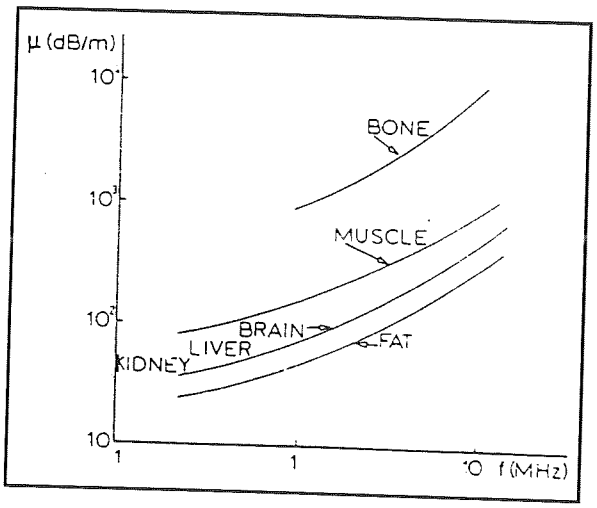

Fig. 5 The attenuation coefficient, μ, depends on the frequency

DOPPLER EFFECT

If an ultrasound beam of incident frequency, f_i, is directed towards a stationary object the frequency of the reflected beam, f_r, has the same frequency as f_i.

$$f_i = f_r$$

But the ultrasound beam is directed towards a moving object, (even towards the blood flowing in a blood vessel or the moving structures of the heart say), then the reflected beam frequency will be different to the incident beam frequency such that:

If the boundary is moving towards the source,

$$f_i < f_r.$$

If the boundary is moving away from the source

$$f_i > f_r.$$

If the incident frequency beam hits the moving boundary at right angles the total frequency shift or Doppler Shift Frequency will be:

$$f_d = \frac{2fiu}{c}$$

Assuming the ultrasound incident beam makes an angle A with the boundary then the Doppler Shift Frequency, fd,, will be:

$$f_d = \frac{2fiu \cos A}{c}$$

where u=velocity of the moving object, (blood say), and

c=speed of propagation of the beam in the medium.

It will be noted that the greater the velocity of the moving object the greater will be the doppler shift frequency and it is on this principle on which doppler systems are based.

The doppler effect finds applications in blood flow measurements and generally in cardiovascular examinations. A block diagram of a basic doppler ultrasound system is shown in Fig.6.

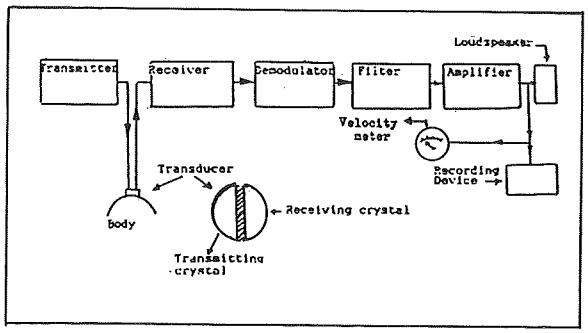

Fig. 6 A block diagram of a basic doppler ultrasound system

The picture in Fig. 7 shows peripheral blood flow measurements and traces of arterial blood flow as may be displayed by a doppler ultrasound system.

There are Continuous Wave (CW) doppler ultrasound systems and Pulsed Wave (PW) doppler systems.

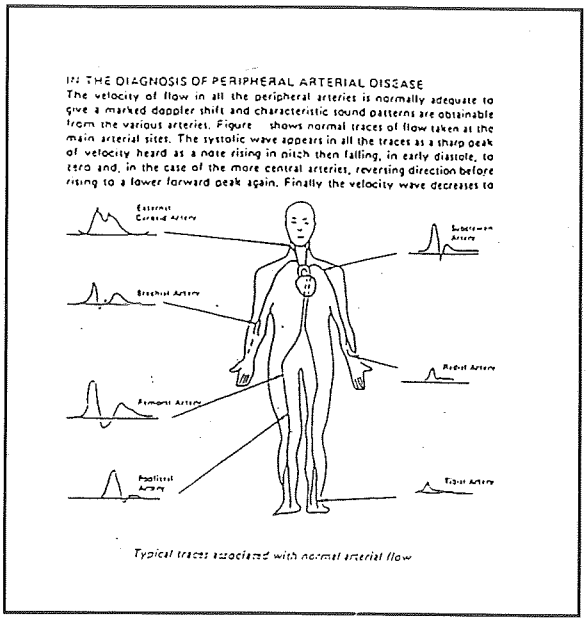

Fig. 7 Typical traces associated with normal arterial flow

The CW system, which employs a transducer with one trnasmitting and one receiving piezoelectric crystals (Fig.8), has the advantage that it can mesure high velocity blood flow, but is not depth selective, that is it cannot discriminate between various sources at different depths.

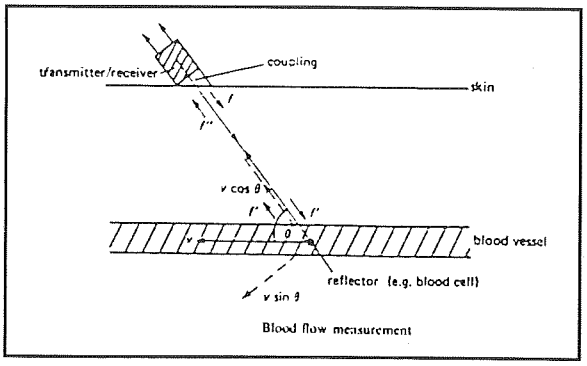

Fig. 8 Blood flow measurement

The Pulsed Wave doppler system uses one transducer acting alternatively as a transmitting and as a receiving element with a co-ordinating time-gating mechanism.

With such a system the depth at which the blood flow is examined can be selected, but measurement of high velocity blood flow is rather limited.

ULTRASONIC TRANSDUCERS

The piezoelectric crystal element, usually Lead Zirconate Titanate, is the major component of the ultrasound transducer. The piezoelectric crystal is capable of converting electrical energy into mechanical acoustic vibrations and vice versa. Different transducer probes are used for continuous wave than for pulsed wave operation.

The thickness, d, of the transducer crystal plays an important part on the frequency of excitation.

The thickness, d, determines the resonant frequency, f_o, at which maximum stresses are set up.

$$f_o = \frac{c}{2d}$$

$$\text{But } c = \lambda f_o$$

$$f_o = \frac{\lambda f_o}{2d}$$

$$d = \frac{\lambda}{2} \text{ for resonance}$$

In order to transfer the ultrasonic energy with minimum losses, the transducer casing is backed with air and also a matching layer of jelly must be used of thickness $t_n = \lambda/4$

ULTRASOUND FIELDS AND FOCUSSING

When a circular disc transducer is excited it will produce an ultrasound beam which is divided into two regions.

These are the Near Field (also called Fresnel Zone), and the Far Field, (also called Fraunhofer Zone), as shown in Fig. 9.

The length of the Near Field, L_{nf}, is given by the relationship:

$$\text{Ln f} = \frac{r^2 f}{c} - \frac{c}{4f} = \frac{r^2}{\lambda} - \frac{\lambda}{4}$$

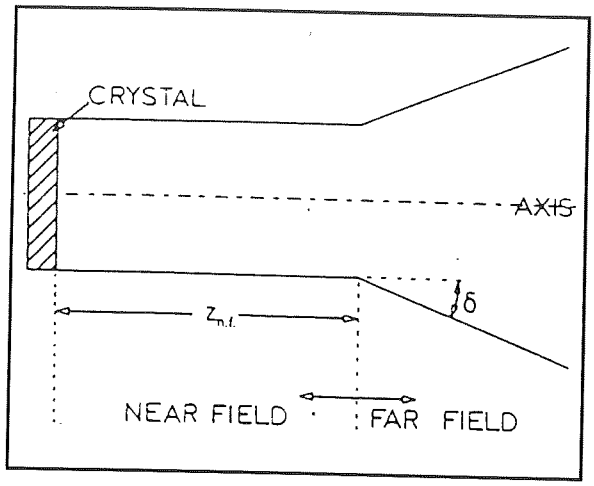

Fig. 9 Near Field and Far Field Zones

Within the Near Field region a series of maximum and null pressures exist.

The length of the Near Field gives an indication fo how far the efficient part of the beam propagates into the body.

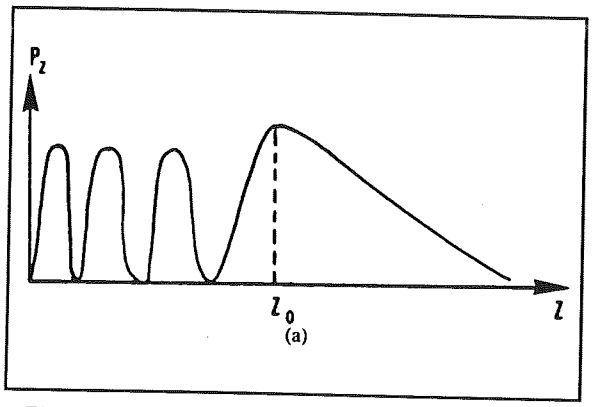

Fig. 10 Propagation of the beam into the body

After the Near Field region of length Lnf, the beam diverges and the pressure variations become very complicated.

The angle of divergence, δ, is given by the relationship:

$$\delta = \sin^{-x} \qquad \text{where } x = \frac{0.61c}{fr}$$

FOCUSSING

By using various focussing techniques such as placing an acoustic lens in close contact with the crystal or by constructing the piezoelectric crystal to be curved or by using a reflecting mirror, the ultrasound beams can be made to become narrowed and therefore more intensified, as shown in Fig. 11.

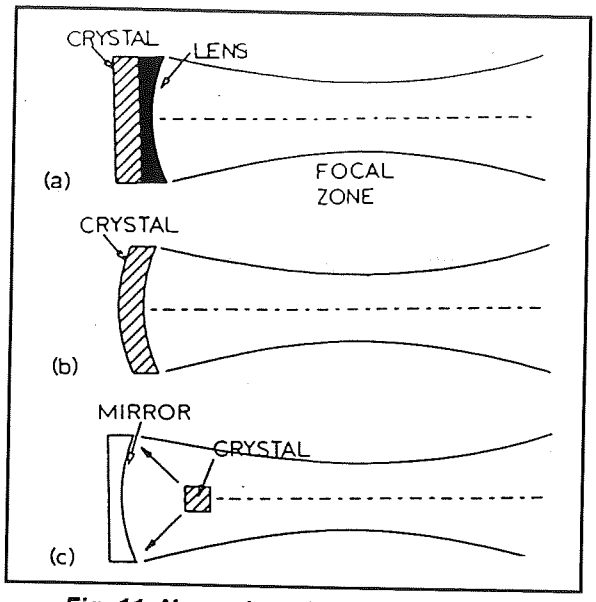

Fig. 11 Narrowing of ultrasound beams

IMAGING TECHNIQUES

Several methods are used to obtain images of the reflections or echo signals from internal organs of the body and display them in medical ultrasound examinations. Some of these methods are:

A- Mode

B - Mode:

a) M-Mode Time positioning

b) Static

c) Real Time with mechanically or electronically driven transducers.

The block diagrams of a basic A- Mode and the B-Mode Time/Position system will be given with a brief explanation.

BRIEF EXPLANATION OF THE A-SCAN SYSTEM

The A-Scan system is a range-measuring system, since it displays the time taken by the pulses to travel to an interface in the body and back.

Refering to the block diagram of the A-Scan system the explanation is as follows.

The timer is a pulse repetition frequency device which sends out clock or timing pulses to the pulse generator, the Time Gain Control Amplifier and to the delay unit.

This timer in effect starts ultrasound transmission and the display is synchronised accordingly. The pulse repetition frequency

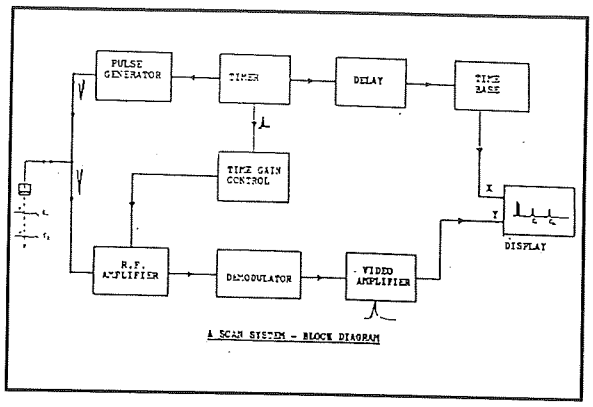

Fig. 12 A block diagram of a scan system

depends on the depth of the structure to be examined.

The depth, L, of the structure under examination is given by the depth-echo equation namely:

$$L = \frac{C_{av} \times \Delta t}{2}, \text{ where:}$$

$$C_{av} = \frac{L_1 + L_2}{\frac{L_1}{C_1} + \frac{L_2}{C_2}}$$

$$\text{and } \Delta t = \Delta t_1 + \Delta t_2$$

$$= \frac{2L_1}{C_1} + \frac{2L_2}{C_2}$$

$$= \frac{2(L_1 + L_2)}{C_{av}}$$

= time taken to travel twice across both layers

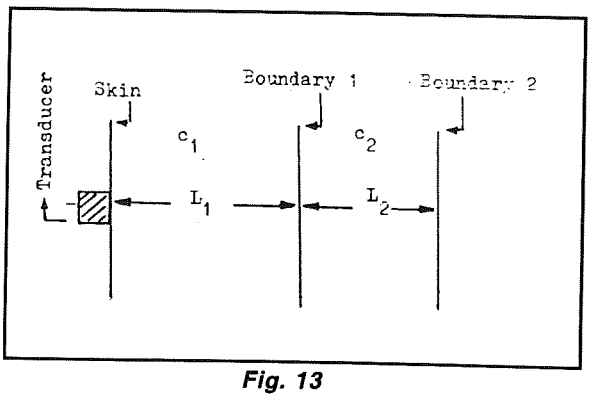

Fig. 13

The reflected waves or echoes coming from the body structure under examination are applied to the R.F. Amplifier.

Together with the Time Gain Control unit the R.F. Amplifier will amplify more the echoes coming from the inner interfaces of the body because the deeper the interfaces the weaker the signals will be. See Fig. 14.

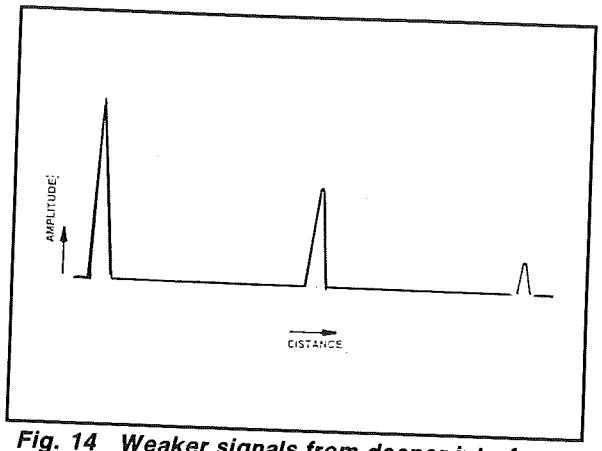

Fig. 14 Weaker signals from deeper interfaces of the body

The A-Scan system is employed, usually, in encephalography. A typical result would be as shown in Fig. 15.

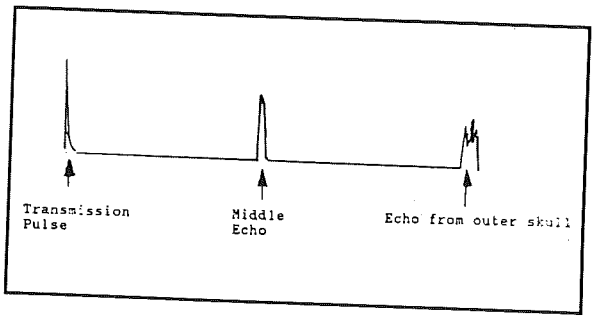

Fig. 15

If the Middle Echo is not half way, it suggests abnormality.

The disadvantage of the A-Scan system is that it is not possible to study motion of structures such as the heart.

B-MODE SCANNING

B-Mode stands for Brighness Modulation. This is because the reflected or echo signals from the body are processed in such a way so as to display dots the brightness of which is proportional to the strength of the echoes as shown in Fig. 16.

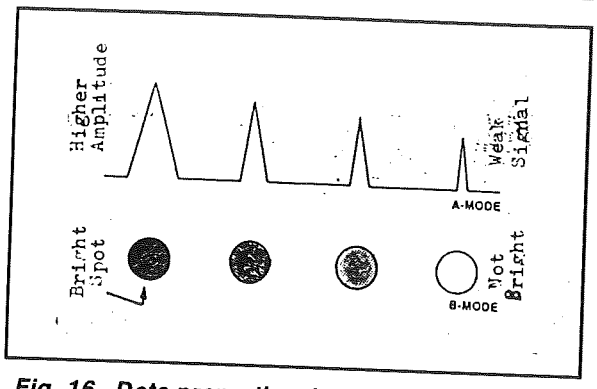

Fig. 16 Dots proportional to the strength of the echoes

The Time-Position or Motion Mode Scanning System.

(T.P/M-Mode System)

This is based on the B-Mode scanning system.

In the T.P./M-Mode scanning system stationary reflectors exist which produce straight vertical lines and also moving reflectors which produce position-time curve characteristics of the motion of the reflectors.

A picture as may be obtained from this system of scanning is shown in Fig. 17.

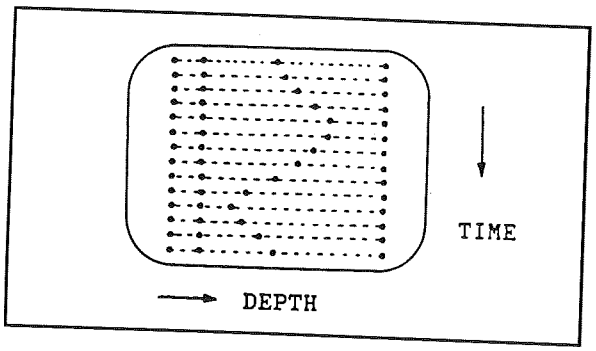

Fig. 17 Picture of T.P./M-Mode scanning system

Thus with this system we can study movements of structures in the body such as the heart as shown in Fig.18.

A block diagram of the T.P. / M-mode scanning system is shown below in Fig.19.

It will be noted that a second (slow) time base is employed. This supplies a ramp voltage to the Y plates of the CRT. This very much slower time base produces the effect of moving the baseline which carries the bright spots either up or down the screen.

Although now shown on the block diagram,

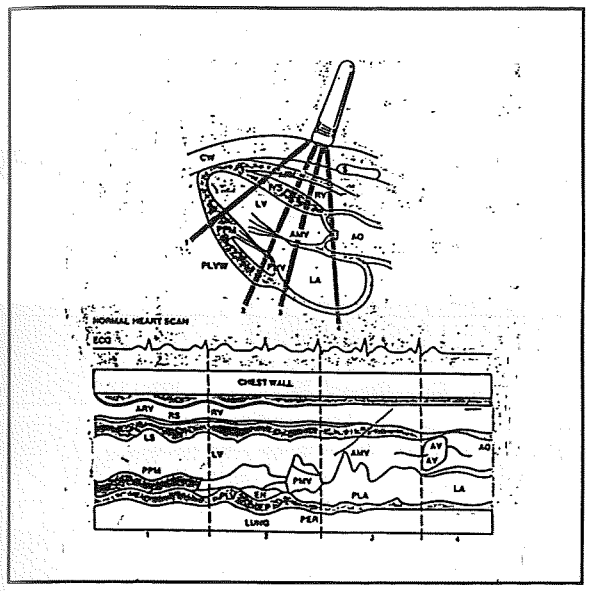

Fig. 18 Movements of the heart observed by scanning

FUTURE TRENDS

Generallly the method of ultrasound is a non-invasive, safe and very useful medical diagnostic tool.

As the system in further developed with computerised and high/Sophisticated Technologies it is expected that such systems will not only show the image of internal organs and structures but their functions as well, which will prove a very useful tool for the promotion of health care in the world.

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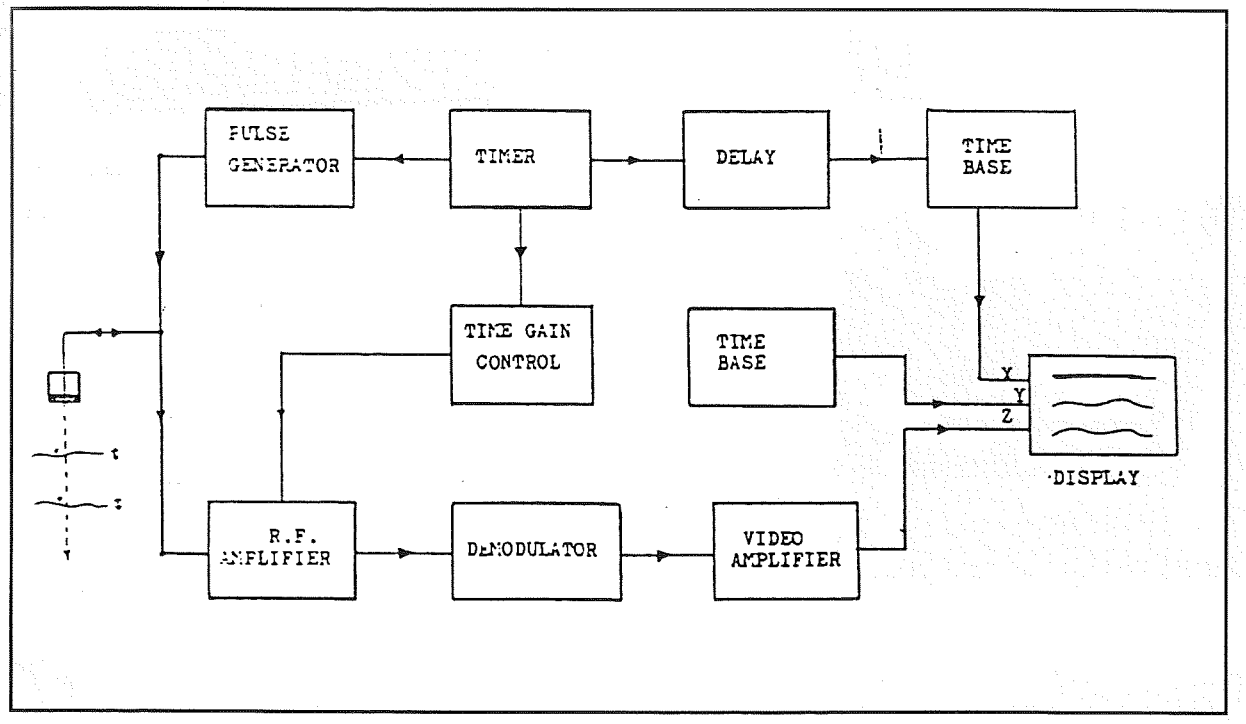
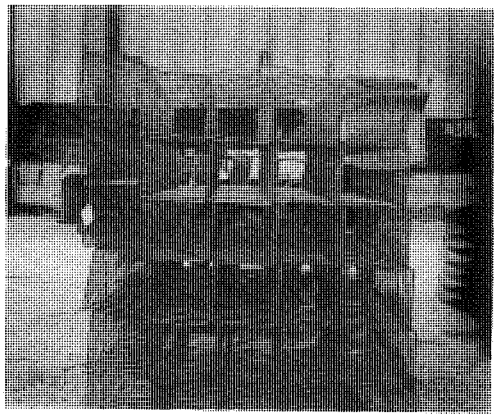
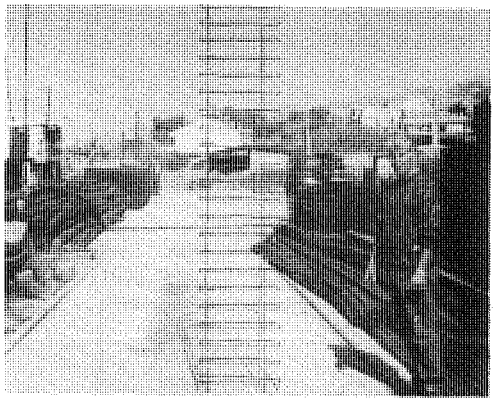
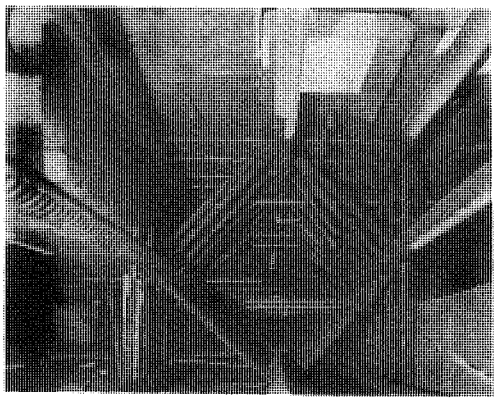


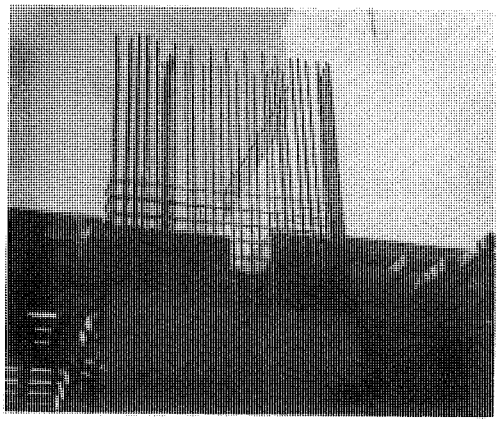
Fig. 19 T.P. / M - Mode scanning system

there are of course other differences between this sytem and the A-Mode system. The difference is in the signal processing after the demodulator which is not shown.



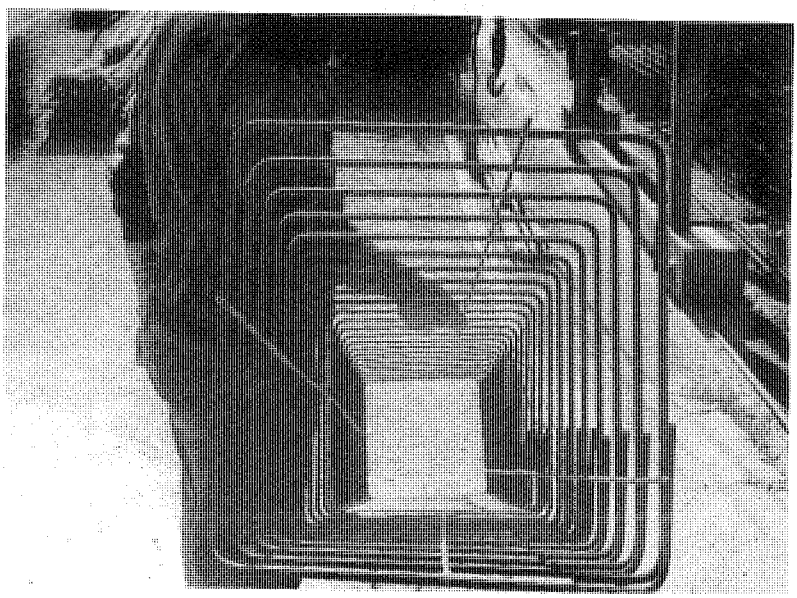






ΜΑΝΔΥΑΣ

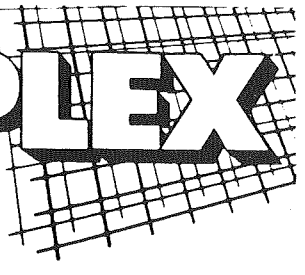
ΣΥΓΚΟΛΛΗΜΕΝΟΣ ΚΛΩΒΟΣ ΣΥΝΔΕΤΗΡΩΝ ΓΙΑ ΚΟΛΩΝΕΣ & ΔΟΚΟΥΣ



- Ομοιομορφία και ακρίβεια στον οπλισμό συνδετήρων.
- Λειτουργία «μανδύα» - αύξηση της θλιπτικής αντοχής και πλαστιμότητας.
- Οικονομία χρόνου, εργατικών και υλικών.
- Ευκολία ελέγχου και επίβλεψης.
- Αποφυγή του κινδύνου μετατόπισης των συνδετήρων κολώνων.
- Εξασφαλισμένη πύκνωση συνδετήρων στους κόμβους - αντισεισμικότητα της κατασκευής.
- Ευκολία, ταχύτητα και οικονομία.

Η τρίτη διάσταση στο συγκολλημένο πλέγμα

DOMOPLEX



- για λιγότερο κόπο, χρόνο και χρήμα
- για καλύτερη κατασκευή

ΒΙΟΜΗΧΑΝΙΚΗ ΠΕΡΙΟΧΗ ΑΓ. ΑΘΑΝΑΣΙΟΥ. ΛΕΜΕΣΟΣ. Τ.Κ. 4185. ΤΗΛ. 05-323862. ΤΕΛΕΦΑΞ: 05-323715

Artificial Neural Networks

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ABSTRACT

A chronological exposition of the developments on Artificial Neural Networks (ANNs) is presented. Current work at H.T.I. is then detailed. Briefly, a computer program on ANN, using the Microsoft EXCEL (V.4) macro-language has been developed. The program utilizes the standard backpropagation algorithm. There are 10 neurodes in the input layer, 21 in the hidden and 10 in the output layer. The user has the option to control the value of the learning coefficient, the initial (random) connection weights and their range, the number of iterations required, and the maximum value of the Pattern Sums of Squares (PSS). The effect of these changes can be seen in animated graphs. Commentary and voice annotation has been included in order to improve the user-friendliness of the program.

INTRODUCTION

The study of **Artificial Neural Networks (ANNs)** is one of the two major branches of Artificial Intelligence, the other one being "Expert Systems". Recently, there has been interest in merging the two fields in the so called **"Expert Networks".**

During the last ten years there has been a substantial increase in the interest on artificial neural networks. The field of study is alternatively known as *Parallel Distribution Processing Systems, Connectionist Systems, Artificial Neural Systems, Neurocomputers, Adaptive Networks* or even *Neuromorphic Systems.*

The ANNs are good at some tasks while lacking in some others. More specifically, they are good for tasks involving incomplete data sets, fuzzy or incomplete information and for highly complex decisions where humans usually decide on an intuitional basis. The tasks that ANNs cannot handle effectively are those requiring high accuracy and precision as in logic and arithmetic. Furthermore they exhibit **robustness, fault-tolerance, and graceful degradability.** A number of running applications have been developed both in research and in applications. Some of these are briefly stated here:

(i) Classification

In pattern recognition, sound and speech recognition, analysis of electroencephalograms, electromyographs and other medical signatures, identification of explosives in passenger suitcases, and identification of military targets.

(ii) Data Clustering and Compression

In signal transmission e.g. in telephones and modems.

(iii) Forecasting

For weather and market trends and predicting potential mineral exploration sites.

(iv) Control Systems

In adaptive and robotic control.

(v) Optimization and Decision-Making

Both in engineering and management.

Furthermore there has been some fundamental research in using ANNs concepts to model and understand the human capacity for associative memory.

In this introduction, the ANNs are briefly defined and explained.

The building block of ANNs are the artificial neurons (ANs). The artificial neurons are themselves models of the biological neurons (BNs). The BN and the AN are shown as simple models in Fig. 1 and 2.

In this neuron, there is a flow of coded information (using electrochemical media -the so called neurotransmitters-) from the synapses towards the axon. The axon of each neuron transmits information to a number of other neurons. The neuron receives information at the synapses from a large number of other neurons. It is estimated that each neuron may receive stimuli from as many as 10,000 other neurons. Groups of neurons are organized into subsystems and the integration of the subsystems forms the **brain**. It is estimated that the human brain has around 100 billion interconnected neurons. The quality and the amount of information which is transmitted from an axon to a **dendrite** at a synapse, depends

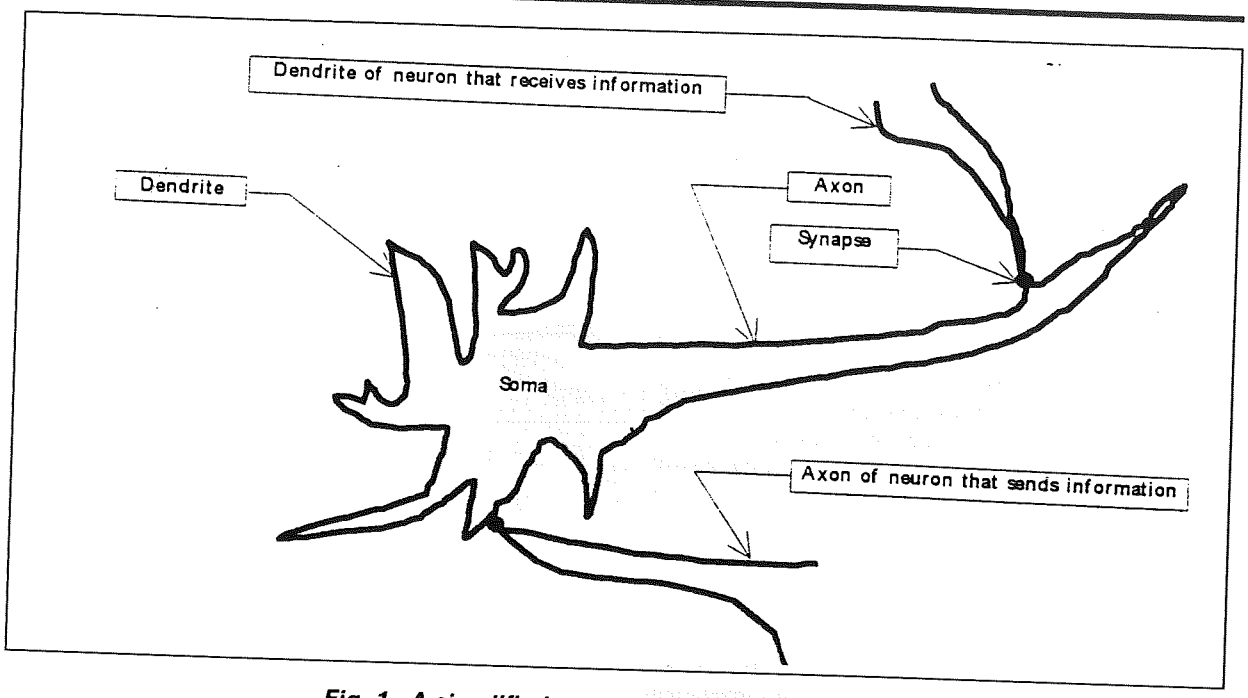

Fig. 1 A simplified model of a Biological Neuron

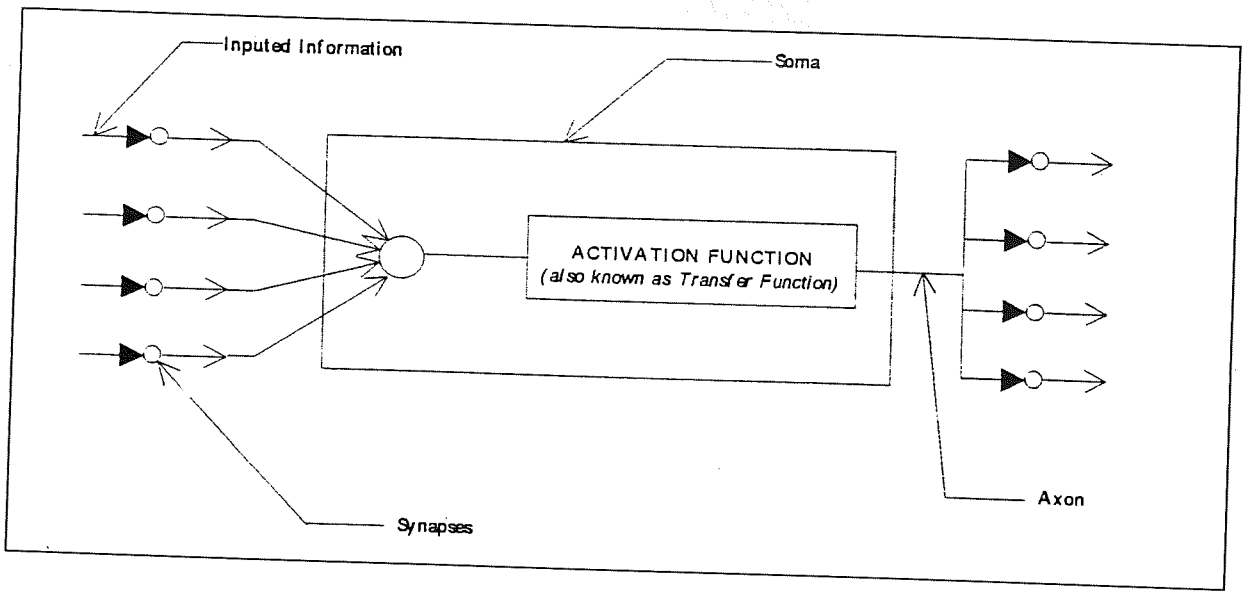

Fig. 2 An Artificial Neuron model

on a number of factors. Presently, more than 45 such factors have been identified. In fact, it has been observed that even the shape of the dendrite can influence drastically the time constant and the electrical potential at the synapse (Stevens, 1985).

Figure 2 shows a highly simplified model of an Artificial Neuron which may be used to simulate some important aspects of the real biological neuron.

An ANN is a group of interconnected ANs (network), interacting with one another in a concerted manner. In such a system, excitation is applied to the input of the network (possibly from a suitable sensor). Following some suitable operation, it results in a desired output. At the synapses, there is an accumulation of some potential, which in the case of the ANs is modeled as a **connection weight W_{ij}** from neuron j to neuron i. These weights are continuously modified, based on a suitably chosen **Learning Rule.**

Because each neuron is the node of the resulting interconnection graph, the term **Neurode** has been suggested by some

investigators as an appropriate one.

Activation State, $A_i(t)$:

This is a function of time and represents the state of the receiving neurode, after it has been stimulated by the sending group of neurodes. This activation state, is usually a summation operation on all incoming stimuli, multiplied by the corresponding weight coefficients i.e.

$$A_j(t) = \sum_{k=1}^{i} W_{jk}\, O_k(t) + \Theta j \qquad (1)$$

where,

j = Subscript signifying jth neurode unit, u_j

k = 1,2, .., i = Number of neurodes sending information to neurode unit, u_j

Other functional relationships have been tried by various investigators.

Activation Function (or Transfer Function), F

This is a function that transforms the activation state. The output of this transformation is the output of the neurode.

e.g. for a neurode j:

$$O_j(t) = F_j\, A_j(t) \qquad (2)$$

The various ANs are connected together in an interactive manner to form an Artificial Neural Network. Many different **network topologies** (architectures) have been proposed. Two well known architectures are shown in Fig. 3.

During the training of a network, the Weights W_{ji} are continuously updated according to a predefined manner. This manner is known as the **Learning Rule.**

If a weight which is originally zero assumes, a finite value, the effect in the network is the same as if a new neuronal connection has been created. Similarly, in the reverse case, a connection has been deleted, or a neuron has died.

Some learning rules that have been applied by various investigators are: Hebbian, Delta and its variations (perceptron, adaline, backpropagation), Hopfield, Kohonen, ART. It appears that the most popular learning rule is the **BACKPROPAGATION.** The algorithm of this rule, is described in Fig. 4.

STATE OF THE ART

A. Internationally

In this section a brief historical exposition of the most important quantum advancements in the development of ANN systems is presented.

HISTORICAL DEVELOPMENT:

James W. (1890)

He was one of the most influential psychologists/researchers who studied in detail the biological neurons and the functioning of the brain.

McCulloch W.S. and Pitts W. (1943)

They have studied the biological neurons and proposed a discrete/mathematical model of artificial neurons. This has been known ever since as the M-P Neuron. This neuron was able to perform simple logical operations such as OR and AND.

Hebb D.O. (1949)

He proposed a general learning process which is presently known as the **"Hebbian Rule".** This rule is very important because it was the first rule that explicitly stated that physiological learning may be thought of as synaptic modification, and thus correlates physiology and psychology. It is also the basis of many rules that were proposed in later years. The rule says:

"When a neuron is stimulated by another neuron, the relationship of their connection is strengthened".

Another important idea that was propagated by Hebb was that Knowledge is distributed over assemblies of neurons.

Rosenblatt F. (1958)

He developed a well known ANN known as the **Perceptron**. This is essentially a generalization of the M-P model with the inclusion of learning. He developed the **Perceptron Convergence Theorem,** which is valid for the two-layer network.

Widrow B. and Hoff M. E. (1960)

They have developed an ANN system which they called **ADALINE** (From **ADA**ptive **LINE**ar). Their system was similar to the perceptron. This system has been implemented and used in adaptive signal processing and in control systems. They have used a learning

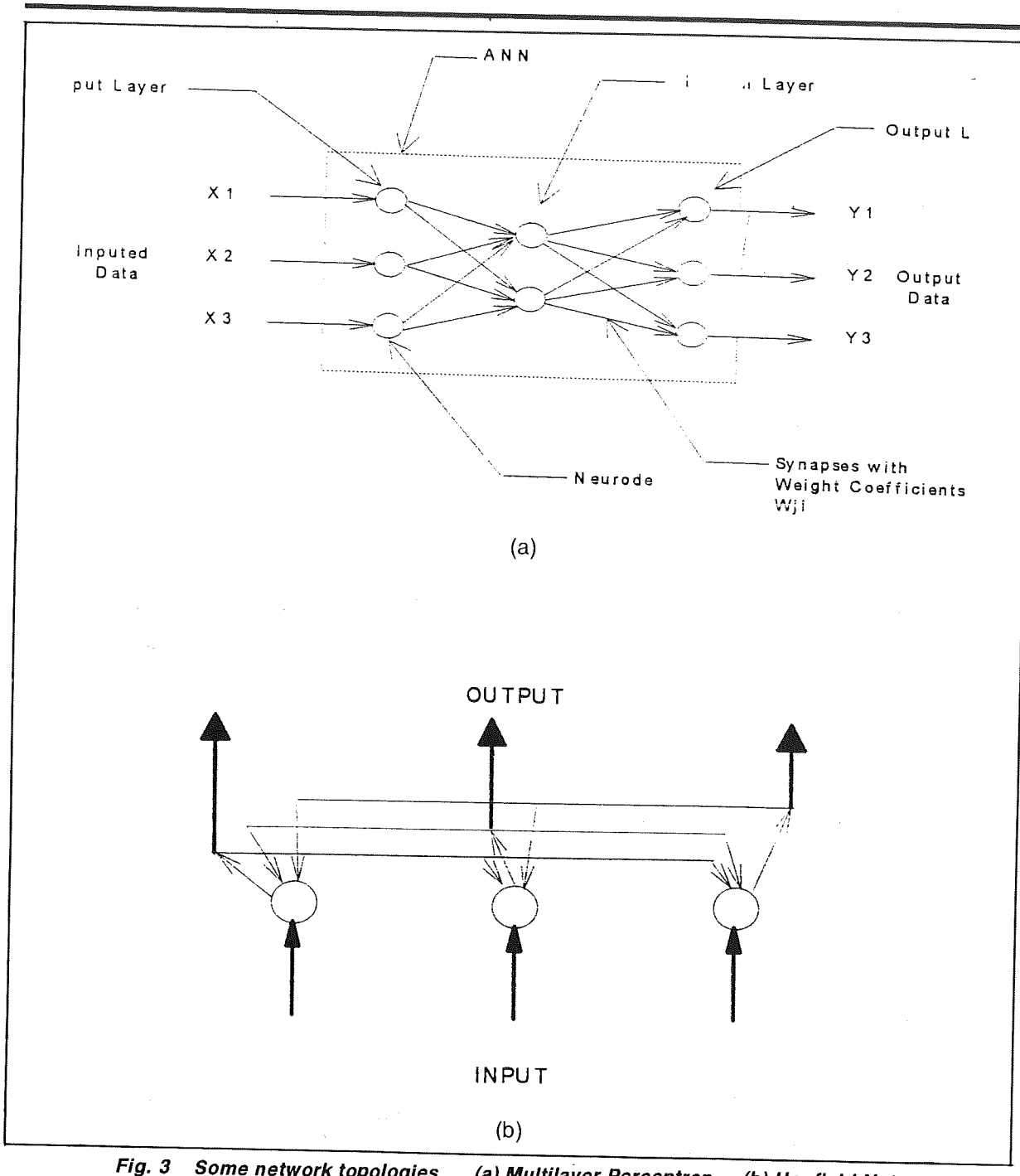

Fig. 3 Some network topologies. (a) Multilayer Perceptron (b) Hopfield Net

paradigm which has been the basis for the very popular backpropagation learning algorithm.

Grossberg (1964)

He studied both the psychological and the biological processes (body and mind) of human information processing, and tried to tie the two. He formed the Center of Adaptive Systems, which is a research group at Boston University. This group contributed a vast number of papers in human information processing, in the areas of vision, speech, memory, conditioning, arm movement among others. His approach to human information processing is holistic in the sense that he considers the human as a complex system that has many subsystems working in an orchestra-like manner.

Minsky M. and Papert S. (1969)

They have published a book titled "Perceptrons". In this, they discredited the perceptron approach as incapable of executing

Initialize W_{ji}

Enter one input pattern Xi from the set of training patterns.

Normalize as I_i^o

$O_i^o = I_i^o$ where $i = 1,2,\ldots,N_o$ *(after normalization)*

Forward Calculations

$$A_i^l = \sum_{j=1}^{N_0} W_{ij}^l O_j^0 + \Theta_i^l \quad \text{and} \quad O_i^l = f_i^l(A_i^l) \quad \text{where } i = 1,2,\ldots,N_l$$

Similarly, in general:

$$A_i^l = \sum_{j=1}^{N_{l-1}} W_{ij}^l O_j^{l-1} + \Theta_i^l \quad \text{and} \quad O_i^l = f_i^l(A_i^l) \quad \text{where } i = 1,2,\ldots,N_l$$

Learning

Apply desired output D_i^p $\quad i=1,2,\ldots,N_L$

corresponding to input X_i^p $\quad i=1,2,\ldots,N_o$

where $p = 1,2,\ldots,m$ $\quad$ m= set of training patterns.

Normalize the desired output of D_i^p into T_i^p (target) for each applied pattern p

$$\delta_i^L = (T_i^p - O_i^L) f_i'(A_i^L)$$

where

$i = 1,2,\ldots,N_L$

$p = 1,2,\ldots,m$

and

$$\delta_i^l = f_i'(A_i^L) \sum_j \delta_j^{l+1} W_{ji}^{l+1}$$

where

$l = 0,1,\ldots,L-1$

$j = 1,\ldots$ up to W_{ji} values

$$W_{ij}^l{}_{new} = W_{ij}^l{}_{old} + \eta \delta_i^l O_j^{l-1} \qquad i=1,2,\ldots,N_l \; ; \; j=1,2,\ldots,N_{l-1}$$

and

$$\Theta_i^l{}_{new} = \Theta_i^l{}_{old} + \eta o_i^l$$

Fig. 4 BP Algorithm

even the simple XOR logic. Their work was of major influence in discrediting the ANN approach in general. As a result there had been a major setback in the research and development of ANNs following the publication of their work.

Kohonen T. (1972)

He initiated impressive work, initially in the area of associative memories, and later on pattern recognition/classification using ANN systems. He introduced the Self-organizing feature maps.

Anderson J.A. (1972)

He developed the **Adaptive Resonance Theory (ART)** model in his attempts to study the short-term memory (STM) and the long-term memory (LTM). He introduced the sigmoidal activation function. He developed the **Brain State in the Box** (BSB) model, which has been used to explain the concept formation, categorization and knowledge processing.

Fukushima K. (1975, 1983)

He developed the **cognitron** (1975) and later the **neocognitron** (1983) model. This is a highly successful system that may be used to recognize hand written characters even if they are distorted, shifted, and rotated. It is a multilayer (as many as nine) cascaded perceptron-like system.

Hopfield J.J. (1982)

He introduced the concepts of **Network Energy, Network Entropy, Stochastic Unit Excitation and Hopfield Nets.**

Sejnowski T.J. (1986)

He co-discovered (with G. Hinton) the so called **Boltzman Machine** algorithm. They have developed the **NETtalk** ANN system which is an impressive system for converting text to speech. He also did work in the area of sonar signal identification

PDP Group (McClelland et. al.) (1986)

They have formed a research team, known as the **Parallel Distribution Processing (PDP)** Research Group. Their primary aim was to study the microstructure of cognition. They have done extensive work in both fundamental research as well as in ANN applications in the general area of using ANNs to model aspects of human psychology. Basing their work on previous studies by Werbos and Widrow, they have developed the highly popular backpropagation learning algorithm.

Mahowald M., Douglas R. (1991)

They proposed the so called **silicon neuron.**

RECENT ADVANCEMENTS:

There have been significant advancements (especially in the domain of applied research) in the fields of: Speech Processing, Signal Processing, Image Processing, Pattern Classification and Control, Data Compression, Medical (and other) Diagnostics, Control Systems, Design, Knowledge Processing and Management. Some important implementations of ANNs, mainly in the areas of Engineering and Management, are:

(a) Control Systems:

(i) Guez A., Eilbert J. and Kam M. (1988)

(ii) Pourboghrat F and Sayeh M. (1988): *On robot manipulators.*

(iii) Eberlein S. (1988): *On the Control of autonomous vehicles.*

(iv) Psaltis D., Sideris A and Yamamura A (1988): *On an ANN System Controller.*

(v) Barnes C., Brown S., Flake G., Jones R., O' Rourke M. and Lee Y.C. (1991):*On process modelling and control.*

(b) Classification

(i) Pattichis C. (1992): *On Electromyograph classification*

(ii) Schizas Chr. et. al. (1990): *On Electromyograph classification*

(iii) "SNOOPE" system by SAIC Corp.: *A system for detecting potential plastic explosives in luggage and cargo.*

(c) Engineering Design

(i) Tsutsumi K., Katayama K. and Matsumoto H. (1988)

(ii) Hung S.L. and Adel: H. (1991) *On the design of structures.*

(d) Management

(i) Noetzel A and Grazini M. (1988):

On global optimization

(ii) Fort J (1988): *On combinatorial optimization*

(iii) Werbos P. (1988): *Backpropagation applied to a specific market.*

(e) Manufacturing

(i) Nadi F. (1989): *On modelling of manufacturing processes.*

(f) Forecasting

Mainly on market trends and weather forecasting.

HARDWARE IMPLEMENTATIONS
(Neurocomputer coprocessors)

"ANZA" Plus by HNC Corporation.

"Odyssey" by Texas Instruments.

"Network Emulation Processor" by IBM.

"Neuro-engine" by NEC Corporation.

"Δ-1" by SAIC.

"BALBOA" by HNC Corporation.

NEURAL NETWORK PROGRAMMING LANGUAGES AND BUILDING SHELLS (netware)

(a) Neurosoftware Languages:

P3

Panspec

AnSpec

AXON

MIND

(b) Building Shells:

"Explore Net" by HNC Corp.

"N-Train" by Scientific Consultants Services

"Genesis" by Neural Systems Inc.

"Neural Works" by Neural Wave Inc.

"Neuroshell" by Ward Systems Group Inc.

"Braincell" based on Microsoft EXCEL.

B. Work Done in Cyprus

Extensive work has been done in Cyprus. A group of researchers at the University of Cyprus, are working, mainly, in the general area of classification. Their major work has been done on medical signature classification. They are currently extending the domain of their work in the areas of Weather Forecasting, Computer Aided Instruction and in Engineering Design. The principal researchers in ANN Systems are:

Dr Christos Schizas of the University of Cyprus who studied EMG and MUAP classification as well as Medical Diagnosis.

Dr Costas Pattichis of the University of Cyprus who studied EMG classification and Medical Diagnosis. The above work was done with collaborators of the Institute of Neurology and Genetics.

Dr Chris Charalambous of the University of Cyprus who applied established optimization techniques to the standard backpropagation rule, aiming at improving the learning process. This algorithm has been given the name **"CGBP"** from **C**onjugate **G**radient **B**ack **P**ropagation.

Dr Sylas Michaelides, who in collaboration with Schizas and Pattichis, studied the possibility of Weather Forecasting using ANNs.

CURRENT WORK AT HTI
(up to May 1993)

Objective:

The primary objective of this first phase of research is to employ various ANN topologies and Learning Rules in order to design a system, that may be used by College/University students, as a Computer Aided Instruction tool on ANN. This tool should also be able to handle real-life applications. User friendliness, and use of easily available (in Cyprus) hardware and software is a necessary constraint.

Tools:

The tools employed in this research are:

Hardware:

80486/50MHz/SVGA 32 bit computer.

Software:

Microsoft Excel V.4

Justification for using EXCEL

This is probably one of the most powerful, general-purpose spreadsheets available. It offers extensive engineering, statistical, and graphical capabilities. The excel-macro language is an extremely powerful high-level language, offering great flexibility, resembling BASIC and somewhat the FORTRAN.

Topology:

In this first phase, a perceptron-like system has been used. An input layer of 10 neurodes, a hidden layer of 21 neurodes, based on the theoretical investigations of Kolmogorov on mappings, and an output of 10 neurodes. The system is fully connected and the activation function used is the sigmoidal. Normalization has

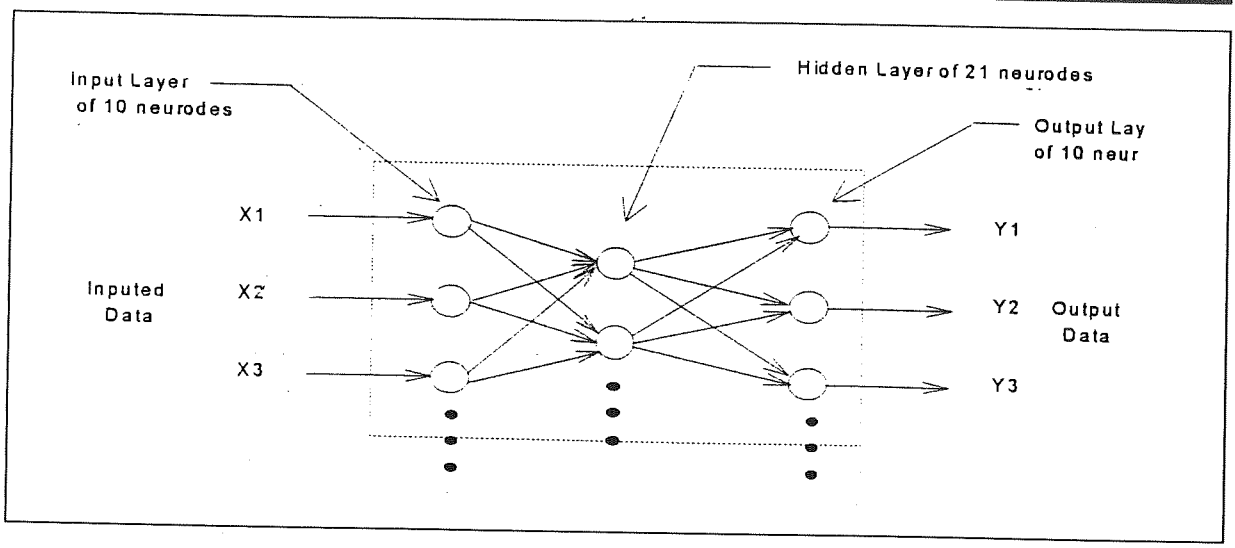

Fig. 5 The topology of the network used

been employed so that practically any kind of input may be used. The topology used is shown in Fig. 5.

Learning Rule:

The basic Learning Rule that has been employed is the simple, standard, back propagation of Fig. 4.

The user has the option to enter an operating rate of learning (the gain), the desired number of iterations and the desired maximum Pattern Sums of Squares (PSS). See Fig. 6.

LEARNING COEFFICIENT,	eta =	3
NUMBER OF ITERATIONS,	iter =	20
PSS Desired	=	0.01

Fig. 6 Input Window

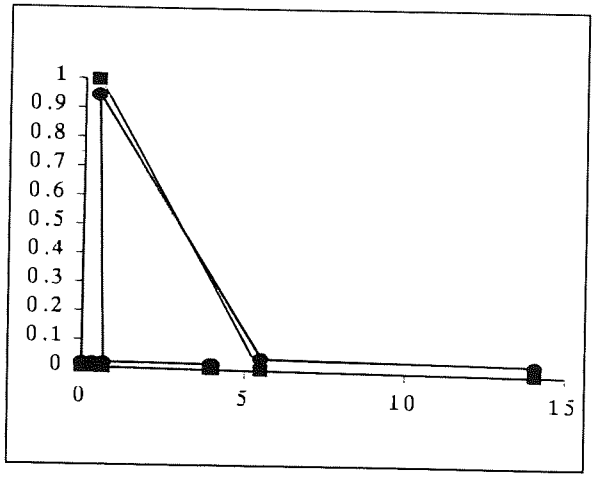

Fig. 7 Outputs(desired and actual) Vs Input

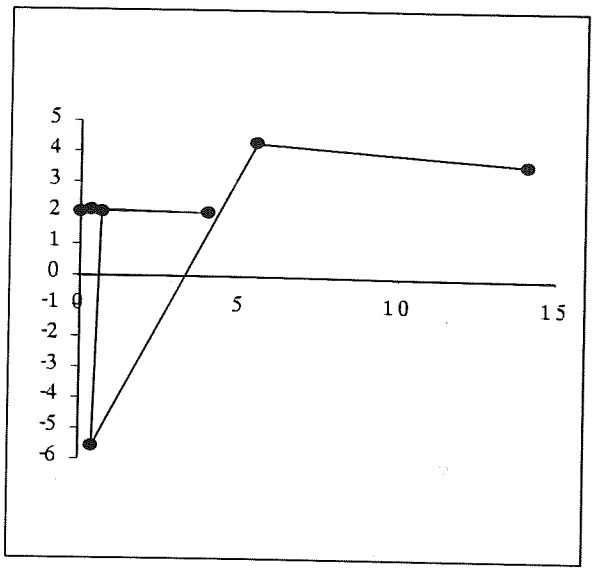

Fig. 8 Percentage Error Vs. Input

The arrangement of the screen is set in the usual manner of arranging matrices for multiplication. The learning progress of the network can be represented in an animated form, in adjustable graphs of Outputs (desired and actual) Vs Input, % Error Vs. Input, PSS Vs Iteration cycle and TSS Vs Iteration cycle (Fig. 7,8,9,10).

The trained model is saved as a feedforward ANN system.

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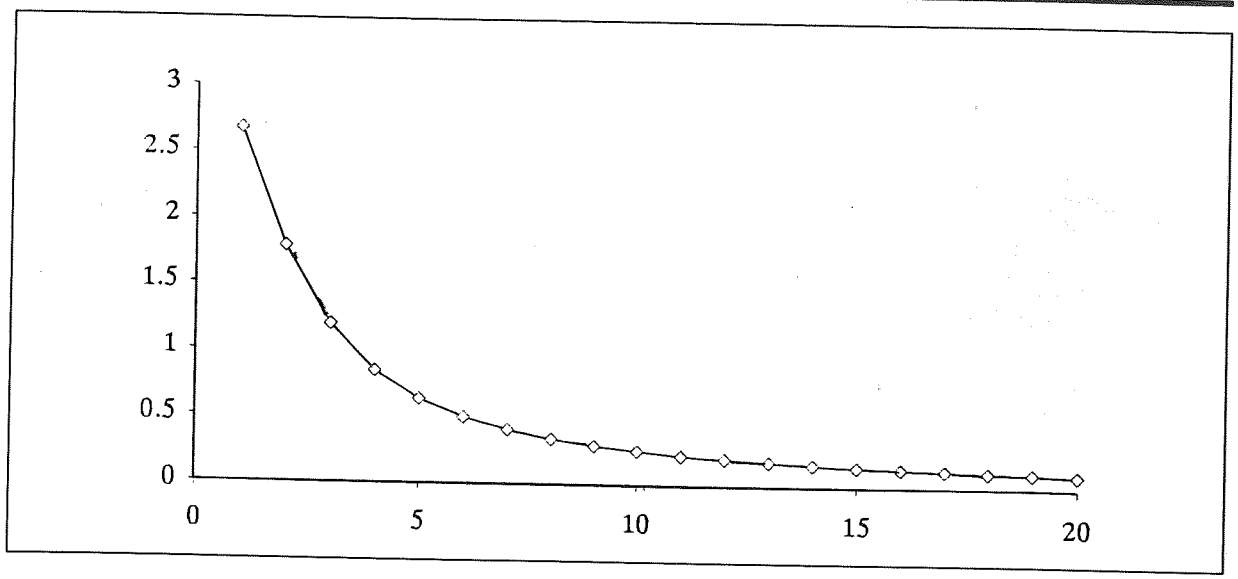

Fig. 9 PSS Vs Iteration cycle

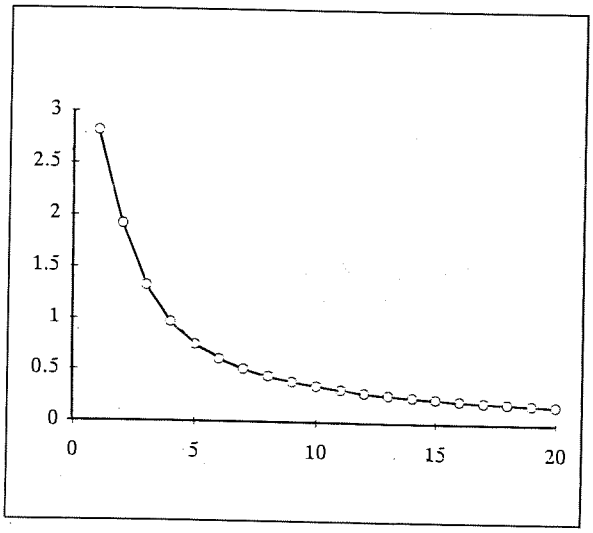

Fig. 10 TSS Vs Iteration cycle

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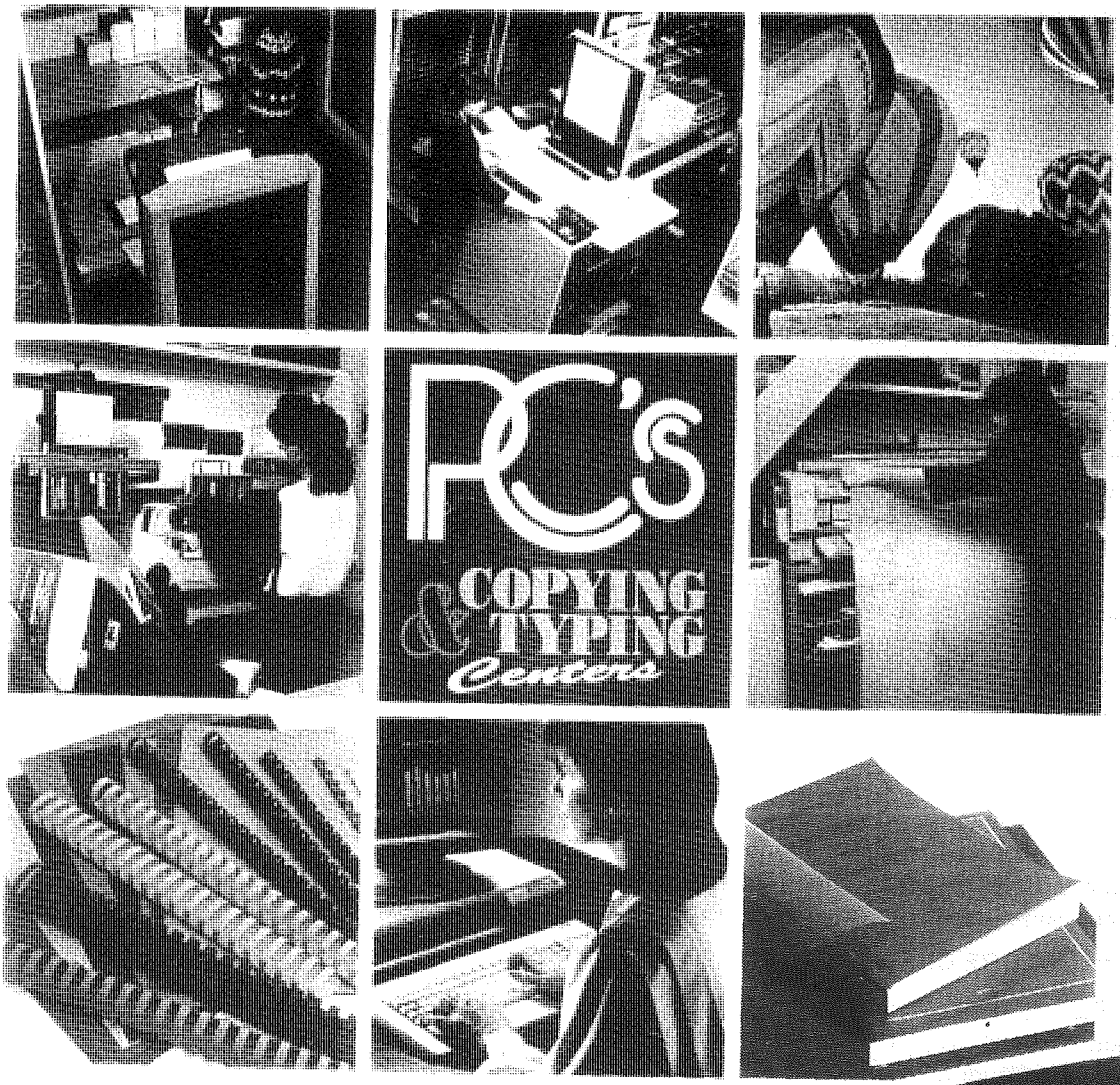
ABBREVIATIONS:

AN	=	Artificial Neuron
ANN	=	Artificial Neural Networks
BN	=	Biological Neuron
EMG	=	Electromyograph
MUAP	=	Motor Unit Action Potential
PSS	=	Pattern Sums of Squares
TSS	=	Total Sums of Squares



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Introduction to the "IEE Wiring Regulations 16th Edition"

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ABSTRACT

The 16th Edition of the IEE Wiring Regulations has been issued on May 1991 and has superseded the previous edition as from 1st January 1993. This is the latest edition of a continually updated and improved series of Wiring Regulations which began in 1882 and reflects the development of materials, technology and utilisation of the electrical energy. It incorporates also the international consensus of opinion reached towards the harmonisation of the European and the International Regulations concerning the electrical installations.

This presentation aims at the introduction of this new edition and the identification of the new approaches as compared to the 15th edition of the Regulations.

THE STRUCTURE OF THE 16TH EDITION

The IEE Wiring Regulations follow the international consensus and agreement reached by the International Electrotechnical Committee (IEC) which in Europe is realised by the work of the European Electrotechnical Standards Committee (CENELEC) which produces Harmonisation Documents to harmonise the National Standards of the member countries. In UK the British Standards Institution participates in the drafting of the IEE Wiring Regulations and the Regulations are now registered with a BS Number.

This process is a continuing one as technology changes and there is a need for new regulations to meet the new applications. This is particularly important for Cyprus to up-date the existing Regulations to follow the International and European requirements so that the utilisation of electricity is safeguarded according to the present conditions.

Structure

The Regulations are now divided into 7 parts as compared to 6 parts of the previous edition outlined below:

Part 1 : Scope, object and fundamental requirements for safety
2 : Definitions
3 : Assessment of general characteristics
4 : Protection for safety
5 : Selection and erection of equipment
6 : Special installations or locations - particular requirements
7 : Inspection and testing
Appendices 1 - 6

Parts 1 to 5 are similar to the previous edition while Part 6 is a new part which brings together regulations referring to baths, sauna rooms and similar condition. Part 7 is the last part of the previous edition which has been renumbered and stays the last part to preserve the logic that Inspection and Testing should follow the design, selection and erection requirements.

The Appendices have been limited to a minimum and some of the information now excluded has been absorbed by the following supporting guidance documents:

- "On Site Guide" giving guidance to the competent electrician to construct an installation
- Protection against electric shock
- Protection againt overcurrent
- Protection against fire
- Isolation and switching
- Selection and erection of equipment

Numbering System

The numbering is an all-number identification system which follows the IEC Publication 364 and the CENELEC Harmonisation Documents. It consists of a three-part number as follows:

412 - 04 - 02

This is read as: (Four One Two, 0o Four, 0o Two)

The first three digits identify in turn the Part, the Chapter and the Section of the Regulations. The two digits that follow identify a Regulation group which represents a number of regulations under the same group. The last part of the number identifies the regulation number.

Thus the system employed simplifies indexing and cross - referencing and facilitates future insertion or deletion of regulations.

Notes

All notes incorporated in the 15th edition have been included in the regulations themselves or transferred to the supporting documents.

SCOPE OBJECT AND FUNDAMENTAL REQUIREMENTS FOR SAFETY (PART 1)

This part is similar to the previous edition and is divided in three Chapters as before. It identifies the areas where the regulations are applicable as well as the necessary requirements to produce a safe, functioning and economical electrical installation. The main requirements of the three chapters are outlined below.

Scope

The regulations now refer to electrical installations generally and therefore do not restrict only to the electrical wiring in buildings. Thus the highway installations are now included in the regulations and furthermore other installations are partly controlled together with other British Standards (e.g. High Voltage discharge lighting, potentially explosive atmospheres etc).

Object and Effects

The regulations are now aiming not only to protect persons and livestock but also property from damage or destruction by fire. Although the IEE Wiring Regulations in UK are not statutory they may be used in evidence in a court to justify the level of safety provided by an electrical installation.

Fundamental requirements for safety

These requirements remain almost unchanged from the 15th edition and mainly require good workmanship and use of proper materials, overcurrent and earth fault current protection and Inspection and Testing. It is however specifically required by the designer to inform the owner of the installation for the need of periodic re-inspection.

ASSESSMENT OF GENERAL CHARACTERISTICS (PART 3)

This part requires an initial assessment of the requirements of the installation to match the available supply and the environment where it is going to be used. Issues like maximum demand, earthing arrangements, circuit divisions, external influences, compatibility and maintenability are dealt with in a similar way as in the 15th edition of the regulations.

Chapter 35 of the 15th edition has disappeared and the relevant requirements for safety services and supplies are now incorporated in other regulations.

PROTECTION FOR SAFETY (PART 4)

This is the most important part of the regulations and its structure remains the same as in the previous edition. Each of the six chapters deal with a specific safety aspect such as electric shock, thermal effects, overcurrent, undervoltage and isolation and switching. Chapter 47 then provides further requirements to be met when applying these six safety measures and identifies any specific limitations to their use in a particular location or installation.

Protection against electric shock (Chapter 41)

This group of regulations contains vital requirements for protection of persons and livestock from electric shock. The shock can be due to direct or indirect contact and measures against these dangers are set down. Thus one approach is the use of the "Safety Extra Low Voltage" (SELV) to provide protection against both direct and indirect contact in a very similar way as on the previous edition.

Protection against direct contact is provided as before by:

- protection by insulation of live parts
- protection by barriers or enclosures
- protection by obstacles
- protection by placing out of reach
- supplementary protection by residual current devices 30mA

Protection against indirect contact (Section 413)

is provided as in the 15th edition with the following five methods:-

- protection by earthed equipotential bonding and automatic disconnection of supply (EEDADOS)
- protection by Class II equipment
- protection by non-conducting location
- protection by earth-free local equipotential bonding
- protection by electrical separation.

Among these five approaches the EEBADOS is usually employed by the designer while the remaining four are restricted to particular applications or parts of the installation.

The EEBADOS method requires **earthing** of exposed conductive parts, **bonding** of extraneous conductive parts and **rapid** interruption of the earth fault currents. In the 16th Edition of the Regulations many changes have been incorporated mainly with the introduction of various tables which optimise the use of fuses and mcb ' s for earth leakage protection.

Thus tables for 0. 4s and 5s disconnection times are provided as in the previous edition. The alternative method for socket outlets is, also, now incorporated in the regulations with a specific table for maximum impedances:

When using the Residual Current Device (RCD) for earth leakage protection again the following must be satisfied:

$$Z_s \, I_{\Delta N} < 50V$$

For a TT system this equation is restated as
$R_A \, I_a < 50$ V where R_A = earth electrode and protective cond. resistance
I_a = The current causing the automatic operation of the protective device within 5 s.

When using RCD $I_a = I_{\Delta N}$ (The tripping current of the RCD).

The bonding requirements have been refined and there is no need for supplementary bonding when RCD is used except where is specifically required by the regulations (bathroom).

Protection against Thermal effects, Ovecurrent, Undervoltage and Isolation and Switching

There are no significant changes from the previous edition but the supporting documents for Time/Current characteristics of the protective devices contain in the form of Table the current required for disconnection times 0. 4 s and 5s.

SELECTION AND ERECTION OF EQUIPMENT (PART 5)

The structure of Part 5 is similar to that of Part 5 of the 15th Edition and contains the following chapters:

- Common Rules
- Wiring Systems
- Switchgear
- Earthing Arrangements
- Other Equipment
- Safety Services

Common Rules

It is required as before that all equipment and materials to comply to British Standards or to the Harmonised European Standard. Other standards providing equal degree of safety are acceptable.

In the colour coding the functional earthing for telecommunication purposes is cream BS6701.

Wiring Systems

This chapter has been retitled and brought into line with the appropriate Harmonisation Documents. The external influences are taken into consideration and the effects of thermal insulation on cables is more clearly defined by Table 52A. Table 52C describes minimum cable sizes for various circuits such as $1mm^2$ for lighting circuits.

The voltage drop must be such as not to impose the safe functioning of an equipment. It has been agreed internationally that a 4% voltage drop from the origin to the final circuit satisfies these requirements.

Remaining Chapters

The cartridge fuses are preferred to be used for protection instead of the rewireable which have an inheret low breaking capacity.

Table 54G provides data for the selection of an earthing conductor other than copper which enables the calculations for the use of steel conduit and metal sheaths as protective conductors.

Minimum supplementary bonding conductor is $2.5 \, mm^2$ if mechanical protection is provided

otherwise 4 mm^2.

Sizes of main bonding conductor according to Table 54H.

The other two chapters relating to other equipment and safety services are the same as in the 15th edition.

SPECIAL INSTALLATIONS OR LOCATIONS - PARTICULAR REQUIREMENTS (PART 6)

This is a new part in the regulations and brings together many requirements for special locations which have been agreed by the CENELEC Committee. It groups also a number of regulations which have been spread in various sections of the 15th edition.

Although Part 6 seems to the designer to be sufficient for installations in special locations it requires cross reference to the other parts as well. Thus Part 6 is logically organised as the general Regulations and for each special location the following issues are covered:

- Scope
- Assessment of general characteristics
- Protection for safety
- Selection and erection of equipment

The particular locations dealt with in this part are covering areas such as bath or shower rooms, swimming pools, hot air saunas, construction site installations, agricultural and horticultural installations, restrictive conductive locations, earthing requirements in installations with high earth leakage currents, caravans and caravan sites, and highway installations.

Locations containing a bath or shower

The body resistance under these conditions is reduced and consequently the electric shock risks are increased. The regulations are therefore more demanding and the following requirements are worth mentioning:

a. Surface wiring shall not be installed in a metal conduit, metal trunking or exposed metal sheath.

b. Every switch to be inaccessible to a person taking a bath except cord operated switches.

c. No socket outlets allowed except the shaver unit to BS 3535.

d. Shrouded luminaires are required for luminaires within 2.5 meters from the bath.

e. Floor electric heating shall be in an earth metallic grid which must be connected by supplementary bonding.

Swimming pools

The area of the swimming pools is divided into three zones which are clearly defined by two typical drawings. Important requirements are:

a. Local supplementary bonding shall be provided to every extraneous conductive parts.

b. In the swimming pool area voltages not exceeding 12V must be used.

c. The enclosures must have minimum degrees of protection of

IPx8 (Zone A in the pool)

IPx5 where water jets are existing

IPx4 (Zone B)

IPx2 (Zone C Indoor pools)

(Zone C Outdoor pools)

Hot Air Saunas

The various areas indicating temperature variations are classified by a typical diagram. It is required that:

a. All equipment to have a degree of protection IP 24

b. Only flexible cables with 150 ^{o}C rubber must be used.

c. Only a thermostat or a thermal cut-out can be installed in the sauna room.

Construction site installations

Maximum operating voltages are specified for the various areas such as damp locations (25V), portable hand-held lamps and tools (110V 3-phase) fixed floodlighting (240V), fixed and movable equipment above 3.75 KW (415V, 3 phase).

Disconnection time for earth leakage currents is specified to be 0.2s and corresponding EFLI values are provided by suitable tables.

For TT systems R_a I_a < 25V

Plugs and socket outlets to BS 4343.

Agricultural and Horticultural Installations

The upper limits of Safety Extra Low Voltage (50V) are reduced according to the livestock kept in the installation. Also disconnection times 0.2s are required for shock protection and appropriate tables for maximum EFLI are provided for this disconnection time.

For TT system R_a I_a < 25V

Wiring systems to be inaccessible to livestock. Fence controllers shall comply with BS 2632 or BS 6369.

Earthing requirements for installation of equipment having high earth leakage current

This section refers to equipment with high leakage currents usually exeeding 3.5 mA like information technology equipment to BS 7002 and industrial control equipment.

If the leakage current is less than 3.5 mA no precautions are needed.

The total leakage current in an installation should not exceed 25% of the tripping current of any RCD.

If the leakage current is 3.5 - 10 mA the equipment should be permanently connected or through a socket outlet to BS 4343

If the leakage current is above 10 mA the equipment should be permanenty connected and a supplementary cpc cable of $4mm^2$ is needed.

For TT system $2 R_a I_{leakage} < 50V$

Electrical Installations in Caravans and Motor Caravans

The two divisions of this section lay down the Regulations one for the caravan itself and the other for the caravan parks.

Reserved section for marinas

Highway Power supplies and street furniture

These regulations are included in the IEE Regulations for the first time as the 16th edition has expanded its role for Electrical installations in general and not only for buildings.

INSPECTION AND TESTING

This part is very similar to part 6 of the previous edition with minor changes as follows:-

- Initial verification may be carried even during erection if appropriate as well as on completion of an installation
- Testing is required to be completed before the installation is put into service implying that certain tests may be carried out after the installation is energised (RCD Testing)
- Inspection is now required and not Visual Inspection meaning the use of other senses like touch. Inspection precedes Testing.

Table 71A describes the voltages for testing the Insulation Resistance for all voltage ratings.

Methods of testing are now included in the Guidance Notes.

CONCLUSIONS

The wiring regulations are becoming internationally uniform and the IEE Wiring Regulations 16th Edition incorporates the philosophy of the international consensus of opinion regarding the electricity regulations. The current edition is similar in structure with the previous edition while the differences observed represent some rearrangement of material between the appendices and the various parts and also the creation of a new chapter incoporating the regulations for particular locations. The major difference, however, is that a lot of material has been gathered in the supporting documents which thus become a vital part of the whole document.

The above changes are the result of technological development which give rise to the need for continuous modifications of the regulations governing the electricity utilisation. For the Cyprus conditions this need to upgrade the local regulations is of upmost importance in order to keep safety and reliablity of the supply within proper levels.

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The IEE Wiring Regulations 16th Edition

Report of the HTI Research Committee

E. Michael , BSc, MSc, MIEE, CEng
Secretary Research Committee, HTI

ABSTRACT

The research work at the HTI is an integral part of the activities of the Institute and its function is monitored by the HTI Research Committee. The aim is to promote applied research work related to the available resources in an effort to achieve better utilization of staff expertise and the infrastructure of the Institute.

The present article describes the research work undertaken during the past academic year and outlines the research areas for which there is currently interest among the HTI staff. It is believed that this will encourage the local industry to seek participation in these projects and thus exploit the HTI facilities in solving technical problems.

THE HTI RESEARCH COMMITTEE

The management of the HTI has long ago recognized the capabilities of the Institute to engage its staff in applied research work and has consequently established the mechanisms to promote such activity. The Research Committee was set up to monitor such work and distribute the available resources for this purpose.

The budget allocates a sum of £10.000 for research work which is utilized about equally for the acquisition of necessary equipment and the partial replacement of staff involved in research projects. In addition, in many cases the staff is engaged in research work out of their own time or utilizing free time resulting from the time table. Furthermore a number of staff is registered for higher MPhil/PhD degrees and consequently the research work is carried out in collaboration with foreign Universities.

CURRENT RESEARCH PROJECTS

During the outgoing Academic Year the HTI staff of the various Departments have been involved with the research projects which are outlined below:

Civil Engineering Department

a) "Zero Energy House for Cyprus" by D Serghides

Optimization of the regulatory systems inherent in domestic architecture through choice of orientation, building materials and the use of natural resources of energy, to achieve comfort conditions without the need for mechanical heating and cooling for the Cypriot climate.

b) "Deterioration of Reinforced Concrete Repair Techniques and Materials" by K Anastasiades

Investigation of problematic materials and workmanship during the last few years in Cyprus which way lead to serious problems in reinforced concrete structures.

c) "Hydrological Resources in the Mediterranean Area" by N Kathijotes

Investigation through scientific, formative, technical and infrastructural objectives. Lycimeters were applied and a monitoring station is set up.

d) "Durability of Coarse Crushed Aggregates" by N Hadjgeorgiou

Assessment of the durability of aggregates through current testing methods specially selected and corrected with soundness test results. Verification of acceptance and non acceptance of materials used in concrete and road construction.

e) "Graphical Presentation of Bituminous Mixes Specifications" by I Economides

To develop a single chart representing most or all of the parameters on which specifications for bituminous mixes are given in order to facilitate the correct selection of these specifications.

f) "Seismic Response of Steel Infilled Frames"
by Chr Chrysostomou

Analysis of infilled structures under various earthquakes to understand the effect of infilled walls on the force distribution of the frame members.

Electrical Engineering Department

a) "Total Frequency Spectrum"
by C Marouchos

Data acquisition systems and organization of procedures for sound acquisition and recognition analysis.

b) "Signature Analysis in Circuit Emulation"
by S Hadjioannou

Development of Microcontroller troubleshooting methods.

c) "Digital Signal Processing"
by D Lambrianides

Investigation of the current applications of digital signal processing. Set up a colour image processing system and testing algorithms.

d) "Computational Linguistics"
by M Kassinopoullos

Development of a dictionary model for translation between English and Greek.

Mechanical Engineering Department

a) " Evaluation of Total Quality Management in the Cyprus Manufacturing Industry"
by I Angeli

Improvement of the Cyprus Manufacturing Industry by the introduction of modern concepts of TQM based on the findings of a scientific survey. Data has been collected, processed, analyzed and the relevant conclusions have been reached.

b) "Solar Cooling"
by Ch Kalogirou

A solar refrigerator using zeolite 13X as absorpant and various low boiling temperature liquids as refrigerants have been developed and tested.

c) " Modelling and Simulation of Solar Systems"
by I Michaelides

A computer simulation model for solar systems has been developed and validated

d) "Artificial Neural Network"
by C Neocleous

Development of Computer Aided Design of mechanical systems using artificial neural networks.

General Studies Department

a) 'The English / Cavafy Comparative Studies"
by D Solomi-Charalambidou

Comparative study of the poetry of Cavafy and the English poets.

Workshops Section

a) "Wåter Purification with Solar Desalination in Cyprus
by S Kalogirou

Development of a solar desalination system and evaluation of its reliability.

b) "Cypriot Women in Civil Engineering"
by Chr Antoniou

Participation and Status of the Cypriot women in the Civil Engineering profession.

RESEARCH PAPERS/ ANNOUNCEMENTS/PUBLICATIONS

In many occasions the research work carried out at the HTI is well founded and of wider importance and is therefore presented in scientific seminars, professional periodicals and the everyday press. The following is a selected list of announcements made during the last year:

a. D. Serghides

i) "The Traditional Courtyard as a Climatic Modifier in Mediterranean Houses", Proceedings 1992 World Renewable Energy International Congress U.K. Sept. 1992.

ii) "Our Architectural Heritage is at Risk" Proceedings ASHRE - Cairo International Congress, April 1992.

iii) "Bioclimatic Architecture", Architecton, Cyprus Architects Association Periodical May 1992.

b. I. Michaelides

i) "Computer Simulation of the Performance of Thermosyphon Solar Water Heater"; Applied Energy 41, 1992.

ii) "Solar Energy in Cyprus. Facts and Prospects" Proceedings Second World Renewable Energy Congress Sept 1992, Reading, U.K.

iii) "An Investigation of some Performance Criteria in the Design of Solar Space Heating Systems" Cairo Third International Conference on Renewable Energy Sources, Dec 1992, Cairo, Egypt.

c. I. Angeli

i) "The Total Quality Management (TQM) Concept", Journal of the Cyprus Mechanical Engineers Association, June 1992.

ii) "ISO 9000 and the Philosophies of the Quality Gurus - A Quality Function Deployment" Proceedings of the Conference of the Israel Society for Quality Assurance, Jerusalem, Nov 1992.

iii) "ISO 9000? Quality Management Systems in Cyprus", Phileleftheros Newspaper, 27 June 1993.

d. S. Kalogirou

i) "Modelling of a Parabolic Trough Collector System of Hot Water Production" paper accepted for presentation in the Harmony with Nature - ISES Solar World Congress, Budapest, August 1993.

ii) "Solar Desalination: The Solution to Cyprus Water Shortage Problem" Paper accepted for presentation in the Environmental Engineering Conference, Leicester, Sept 1993.

COMPLETED HIGHER DEGREE RESEARCH THESES

During recent years three members of the HTI staff performing research work in collaboration with foreign Academic Institutions have submitted their Theses in partial fulfillment of the requirements for the award of post-graduate degrees. These cases are outlined below:-

a) "Computer Simulation and Optimization of Solar Heating Systems for Cyprus submitted by I Michaelides to the University of Westminster, UK, for which he was awarded the degree of Doctor of Philisophy (PhD) in June 1993.

b) "Water Consumption & Recycling of Grey Water in Cyprus" submitted by Chr Kampanellas to the Polytechnic of Wales for which he was awarded the degree of Doctor of Philosophy (PhD) in May 1991. This research project was carried out in collaboration with the Water Development Department.

c) "Solar Energy Utilization Using Parabolic Trough Collectors in Cyprus" submitted by S Kalogirou to the Polytechnic of Wales, UK, for which he was awarded the degree of Masters of Philosophy (MPhil) in November 1991.

d) "Evaluation of Status of Total Quality Management (TQM) in Cyprus Manufacturing Industry" submitted by I Angeli to the University of Glamorgan, UK, for which he was awarded the degree of Masters of Philosophy (MPhil) in July 1993.

CONCLUSIONS

The research work carried out at the Higher Technical Institute is considered to the be of high level and its quality is recognized by foreign Institutions. It is however believed that the HTI is capable of performing substantially more research work especially in the solution of engineering problems in the Cyprus industry arising from the need to upgrade technologically the manufacturing industry. The HTI always welcomes such activities and collaboration with industry is considered of vital importance as amongst others it contributes also towards the development of a more realistic training course suitable for the local conditions.

Power Electronics: An Alternative Approach Leads to a Solid State Reactive Power Generator

C.C. Marouchos, MSc, PhD, MIEE, C Eng
Lecturer, HTI
&
Maria Frangoudi, HTI Dipl

ABSTRACT

Power electronic circuits are usually investigated and analysed in isolation from each other and rearly outside the traditional methods of analysis: Laplace Transforms and frequency analysis. In this paper a general model for switching circuits is presented and it will be shown that some well known circuits are derived from it together with the rather new family of switched capacitor circuits. It is believed though that all known circuits in power electronics can be derived from this general model. This is achieved by imposing certain restrictions on its elements. Most of the work presented here was developed at Brunel University (UK) more than ten years ago. One circuit was recently reproduced at the HTI (Nicosia) and experimental results are presented. The general model aproach is best suited for the switching function method of analysis. This method of analysis is not presented here.

INTRODUCTION

Power electronic circuits range from the simple controlled or uncontrolled rectifier for dc loads to the more sophisticated Inverter or Cycloconverter for ac loads such as ac machines. A more general approach to power electronic circuits can lead to a new family of circuits, namely the switched capacitor circuits. It will be argued that a general model for switching circuits constructed from a basic building block- an ideal switch in series with an impedance- includes all known power electronic circuits. Further more new circuits arrangements can be derived. In this publication two well known circuits are derived together with the new type of reactive power generators. This is the single switch single capacitor reactive generator. The actual circuit was constructed (ref.1) and experemental results are presented.

The new reactive generator consists from a series arrangement of an inductor and a capacitor connected across the mains. A bidirectional solid state switch- a MOSFET in a full wave bridge in this case-is connected across the capacitor. The switching function of the switch is such as to close when the capacitor voltage is zero. Hence the switching frequency is 100Hz for a 50Hz supply. The impedance of this circuit is found to vary in accordance with the duty cycle of the switch thus giving smooth control of reactive power supply.

The switching function method of analysis gives the steady state response of a switching circuit by applying simple amplitude modulation theory. This is not presented here but more information can be found in ref. 2.

THE UNIVERSAL MODEL FOR SWITCHING CIRCUITS

In any switching arrangement three elements are identified: the source (or sources), the load and the switches. This is easily verified by considering simple circuits around us: The wiring circuit for lighting in a room, a bridge rectifier, a radar's pulse generation mechanism etc. In the first example the mechanical switch is operated at random. In the bridge rectifier, the diodes act as switches but their switching action is determined by the polarity of the supply voltage and to a smaller degree by the type of load. For the radar, the switch is independently controlled from both the load and the source. It is determined by a control circuit according to the range to be covered and immunity from electronic warfare measures.

Therefore a basic building block is identified. It consists from an ideal switch and a series impedance. The latter represents either the losses of the switch or an external electric element (L, C, R) or both (Fig.1). In this manner a three dimensional model of the switching mechanism can be constructed consisting from "XYZ" elements of the basic building block. All known circuits in power electronics can be derived from this model by connecting a source or sources at appropriate nodes and by imposing the necessary

restrictions to the switches and the impedances. The switches can be always ON, always OFF or operated according to a switching function. The impedances can take the value of a resistance, a capacitance and an inductance.

For simplicity and for the purpose of this puplication a two dimensional model is used (Fig. 2). In this case sources and loads can be connected at any node.

The operation of the switch is best described by a switching function. A switching function can be represented graphically by a train of pulses

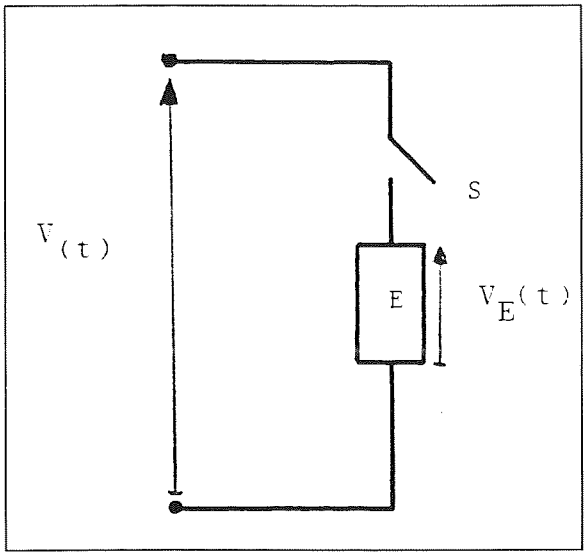

Fig.1 Model of the basic building block

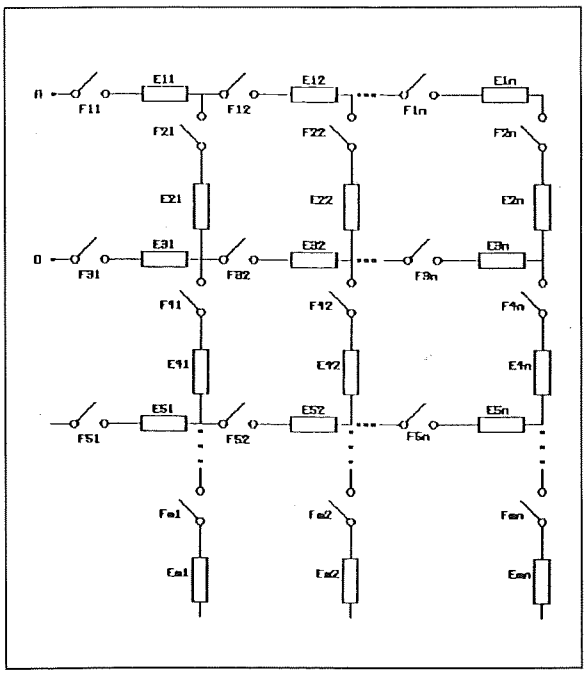

Fig.2 Two-dimensional general model

with variable pulse width and period (Fig.3) and mathematically by:

F (t) = 0 switch open

= 1 switch closed

By applying simple Fourier theory the above can be analysed into its fundamental and harmonic components.

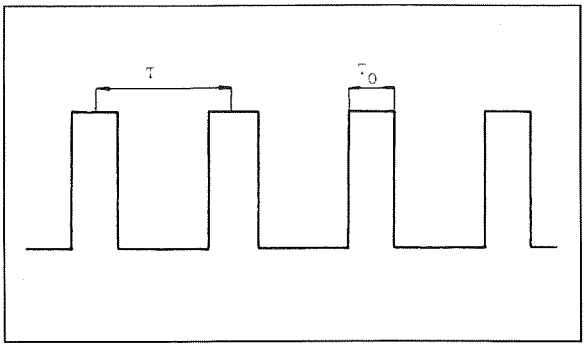

Fig. 3 The switching function, F (t)

THE GENERAL MATRIX

In applying the general model two matrix equations are identified. An equation which deals with the state of the switches and a second one which deals with the type of the impedances.

In order to derive the state of the switches the equation shown below is applied

$$\begin{bmatrix} F11 & F12 & F13 & ..F1n \\ F21 & F22 & F23 & ..F2n \\ F31 & F32 & F33 & ..F3n \\ \cdots & \cdots & \cdots & \cdots \\ Fm1 & Fm2 & Fm3 & ..Fmn \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & ..0 \\ 0 & 1 & 0 & ..0 \\ 0 & 0 & 1 & ..0 \\ \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & 0 & ..1 \end{bmatrix} \begin{bmatrix} S11 & S12 & S13 & .. & S1n \\ S21 & S22 & S23 & .. & S2n \\ S31 & S32 & S33 & .. & S3n \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ Sm1 & Sm2 & Sm3 & .. & Smn \end{bmatrix}$$

"F" represents the switching function of the appopriate switch and the elements of "S" can take the value of zero, one or a specific switching function {F(t)]} as shown in Fig. 3.

$$\begin{bmatrix} Z11 & Z12 & Z13 & ..Z1n \\ Z21 & Z22 & Z23 & ..Z2n \\ Z31 & Z32 & Z33 & ..Z3n \\ \cdots & \cdots & \cdots & \cdots \\ Zm1 & Zm2 & Zm3 & ..Zmn \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & ..0 \\ 0 & 1 & 0 & ..0 \\ 0 & 0 & 1 & ..0 \\ \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & 0 & ..1 \end{bmatrix} \begin{bmatrix} E11 & E12 & E13 & .. & E1n \\ E21 & E22 & E23 & .. & E2n \\ E31 & E32 & E33 & .. & E3n \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ Em1 & Em2 & Em3 & .. & Emn \end{bmatrix}$$

E can take the value of R, L or C.

In both cases the elements of the personality matrices, "S" & "E" (far right) determine the type of circuit.

DERIVATION OF EXISTING POWER ELECTRONIC CIRCUITS FROM THE UNIVERSAL MODEL

Two known circuits will be derived now as a demostration of the validity of the model. The two dimensional model is used (Fig.2). It must be emphasised that this approach is useful in order to derive the circuits. More research work is recommended in order to show if the switching fuction can also be derived from a unified theory. At the moment the switching function is derived by a careful study of the operation of the specific circuit.

The single diode rectifier

This simple circuit which consists from a single diode and a load (Fig.4) can be represented by a single switch and a series impedance. The switching function will be such that the switch is ON for the positive half cycle of the supply (diode forward biased) and OFF for the negative half cycle of the mains (diode reversed biased). Therefore the switches F11 and F31 must be always ON; F21 must have a switching function as described above and all other switches must be always OFF. Hence the personality matrix "S" will be of the form:

1	0	0	0
F(t)	0	0	0
1	0	0	0
0	0	0	0

The derived circuit from the general model is shown in Fig. 4(b). The switching function is of the form shown in Fig. 4(c)

In the same way the personality matrix "E" for the impedances must be such as to give zero values for E11 and E31. The value of E21 is the load and it can be represented by "R". ie

0	0	0	0
R	0	0	0
0	0	0	0
0	0	0	0

For the circuit to be completed the source must be connected across A&B in the 2-dimensional model of Fig. 2

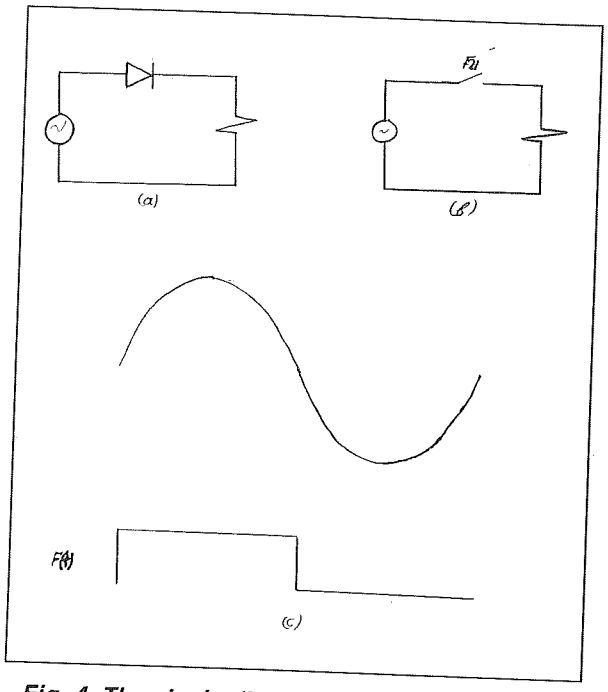

Fig. 4 The single diode bridge (a), the derived circuit (b) and the associated switching function F(t) (c)

The single phase inverter

The switching circuit of a single phase inverter (Fig.5) is derived from the general two dimensional model by imposing the following conditions to it:

Switches F11, F12, F51, F52 and F32 are always closed ie their switching function is 1. Switches F21, F22, F41 and F42 are operated by an

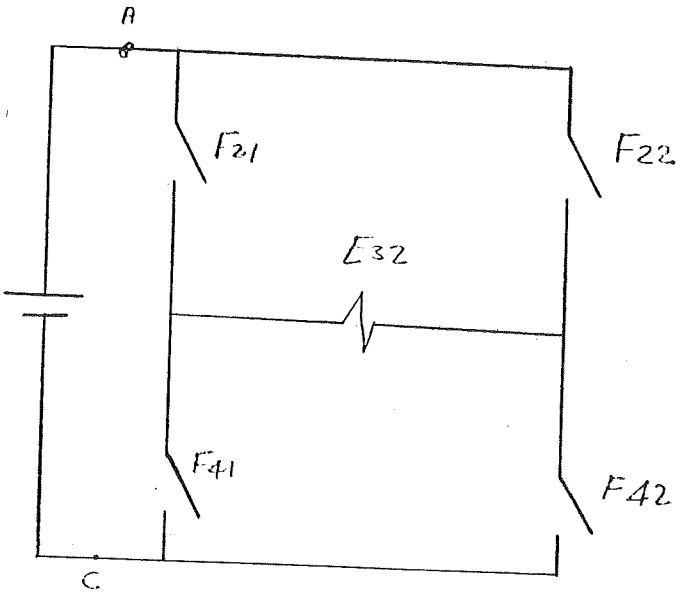

Fig. 5 The single phase inverter

appropriate switching function in order to give an alternating voltage output across E32 (Fig.2). All other switches are permanently off ie their switching function is "0". Furthermore all impedances will be zero except E32 which represents the load. The dc source will be connected across AC. If the source impedance is non-zero then E11 can represent it.

Personality matrix "S" for the switching function:

1	1	0	0	0	0
$F_{21}(t)$	$F_{22}(t)$	0	0	0	0
0	1	0	0	0	0
$F_{41}(t)$	$F_{42}(t)$	0	0	0	0
1	1	0	0	0	0
0	0	0	0	0	0

Personality matrix "E" for the impedances:

0	0	0	0
0	0	0	0
0	R	0	0
0	0	0	0

A NEW FAMILY OF POWER ELECTRONIC CIRCUITS

These new circuits consist of a series combination of a capacitor and a switch connected in parallel. The combination is connected via an inductor to the mains. This is derived from the universal model by imposing specific restrictions to the impedance and Switching Function matrix. Three circuits have been derived and investigated (ref.2). One of them was reproduced at the HTI (ref.1) and used for reactive power generation. This is the Single Switch Single Capacitor circuit (SSSC) shown in Fig. 6. The characteristic matrices for its derivation are:

Personality matrix "S" for the Switching Function:

1	1	0	0
$F_{21}(t)$	1	0	0
1	1	0	0
0	0	0	0

Personality matrix "E" for the impedances:

L	0	0	0
0	C	0	0
0	0	0	0
0	0	0	0

The steady state response of the circuit was investigated and theoretical results are reported in ref.2.

The operation of the switch is such that the current is diverted form the capacitor to the switch and vice versa. The switching function is a series of pulses, their width indicating the period the switch is on. The timing of closing the switch is chosen so that it is closed when the capacitor voltage is zero thus avoiding shorting the capacitor when it is charged.

THE SSSC AS A REACTIVE POWER GENERATOR

For the purpose of investigating the potential of this circuit as a reactive generator the circuit of Fig.6 was set up and readings of supply voltage, line current, power dissipated and voltage across the switch were taken. Fig.7 indicates experimental results (ref.1). It is demostrated that reactive power is generated and smoothly controlled from O.5KVA to 1.5 KVA by varying the ON period of the switch.

The voltage across the switch and the capacitor takes enormous values, up to six times the supply voltage. Nevertheless it is shown in ref. 2 that this overvoltage can be restricted to three times the supply for a wide range of control. This high voltage imposes severe restrictions to the capacitor and solid state switch used. The present state of solid state switches is such that this problem can be solved (ref 1) but the voltage rating of the capacitors must be considered very carefully.

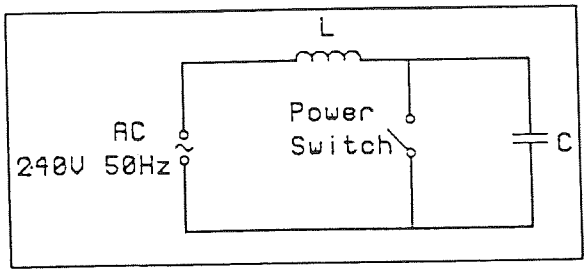

Fig. 6 The single switch single capacitor circuit

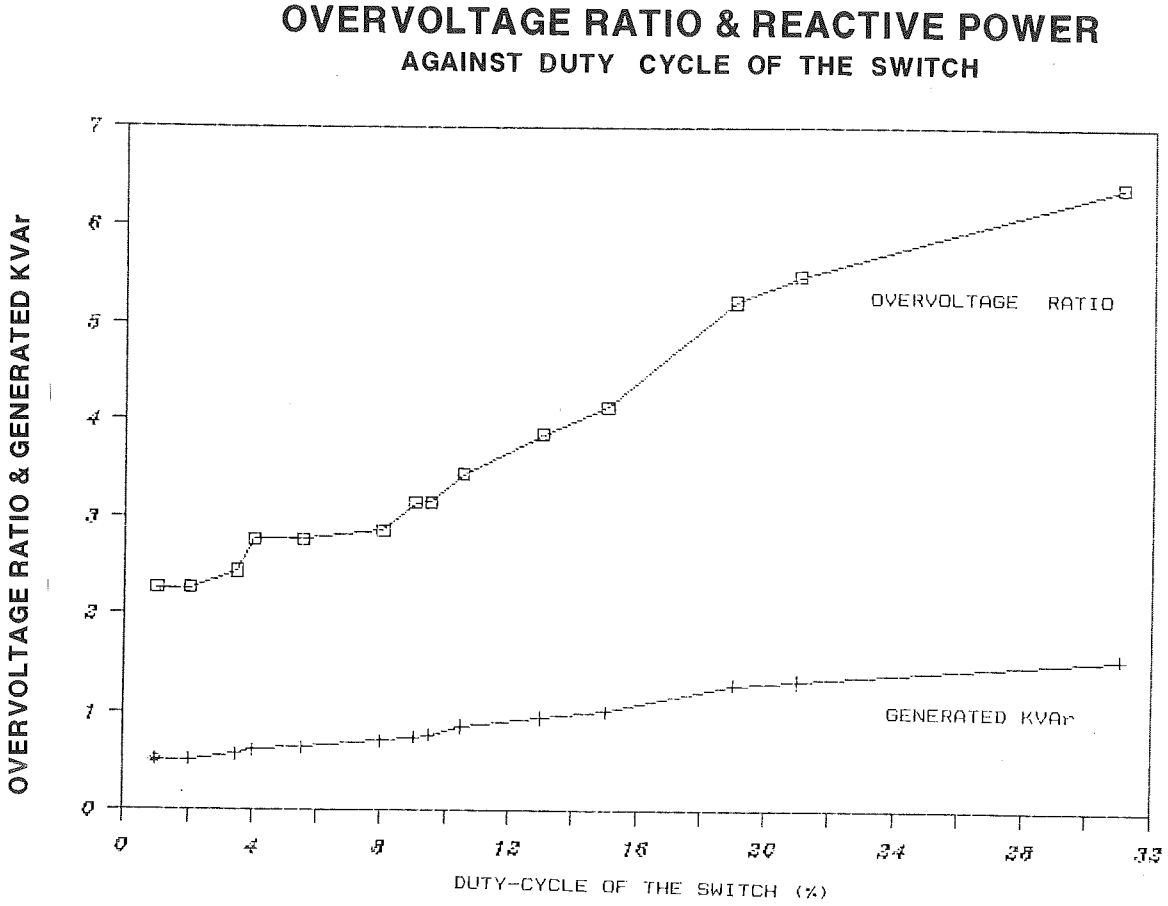

Fig. 7 Results for the SSSC reactive power generator

What is perhaps very interesting is the fact that the capacitor is "forced" to give more reactive power in this circuit than the normal direct connection to the mains. The capacitor used is 14μF which from a 240V supply would give 0.253KVA. In the SSSC connection it gives six times that. Of couse the capacitor is subjected to a much higher voltage the nominal supply. More theoretical work is still required in order to establish the relation between the generated reactive power and the energy storage capacity of the passive elements in the circuit.

Obviously this is not recommended to replace existing reactive power generations in its present form. More development work is necessary to establish the practical application of this system.

DISCUSSION AND FUTURE WORK

The general model of switching circuits gives a unified approach to power electronic circuits. It has been demostrated that existing and new circuits can be derived form the general model by imposing specific restrictions to the matrix equations. It is appreciated that more work is required to establish the full potential of this approach. More specifically it would be very interesting if the switching function could be derived as well in a similar method.

Power electronics is an exciting field for research. It is a rather new topic in electronics with many opportunities for scientific research.

REFERENCES

1. Development of a reactive power generation system HTI Diploma project by Ms M. Frangoudi.

2. Switched - capacitor circuits Brunel University, PhD Thesis by CC Marouchos

HTI Calendar of Activities for Academic Year 1992 - 1993

D. Charalambidou-Solomi, BA, MA, MEd, DES
Lecturer, HTI

SEPTEMBER

- Two hundred and twenty-five (225) new students were enrolled on the regular courses of HTI: 60 for Electrical Engineering, 59 for Civil Engineering, 57 for Mechanical Engineering, 19 for Marine Engineering and 30 for Computer Studies.

- Mr D. Roushas, Lecturer, joined a study tour in the field of "Engineering, Automation and Maintenance in the Manufacturing Industry" which was conducted in Prague and Bruno, Chechoslovakia, from 7-8 September.

- Mrs D. Serghides, Senior Lecturer, participated in the "1992 World Renewable Energy Congress" which was held in Reading, UK, between 13-18 September. Mrs Serghides, in her capacity as a guest-speaker, presented a paper based on her research project on Conservation of Energy in Cyprus and chaired a session on architectural topics.

- Mr I. Michaelides, Senior Lecturer, and Mr S. Kalogirou, Lab. Assistant, also participated in the 1992 World Renewable Energy Congress" and presented papers relating to their research work carried out at HTI in the field of Solar Energy.

- HTI in colloboration with the Industrial Training Authority organised a course on "Power Electronics". The course, which was of 36 hr duration, began on 30 September and was delivered by Mr E. Michael, Lecturer.

OCTOBER

- HTI in collaboration with IEE Cyprus Centre and the Industrial Training Authority organised a 30 hr course on "Supporting, Maintaining and Troubleshooting PCs" between 12-16 October. The course was aimed at personnel working in industry, was developed by the Euro Management and Technology Bureau, London, and was delivered by their authorised instructor, Mr. Neal Hutchinson.

- HTI organised a special ceremony on 14 October to honour Mr Michalis Agrotis, the Champion Cyclist, who by cycling collects money in aid of the fight against Leukemia and Thalassaemia.

The ceremony began with a speech by the HTI Director Mr D. Lazarides. It was followed by short address by the Hon Minister of Labour and Social Insurance, Dr I. Aristidou, the Hon. Minister of Health and Social Insurance, Dr P. Papageorgiou and the President of the Pancyprian Co-ordination Committee for Blood Donation, Mr St. Katsellis. All speakers praised Agrotis' altruistic and humanitarian efforts to raise money to support the fight against the two accursed scourges of our society: Leukemia and Thalassaemia.

Mr Agrotis was awarded a plaque by the HTI Director.The HTI students and staff donated blood for the needs of the Nicosia Blood Bank.

- HTI in collaboration with IEE Cyprus Centre and the Industrial Training Authority organised a 5 hr course on "Advanced Programming of Programmable Logic Controllers and their Applications" between 13 October - 7 November. The course was developed and presented by Mr E. Michael, Lecturer.

NOVEMBER

- HTI in collaboration with IEE Cyprus Centre organised a 20 hr course on "Troubleshooting Novel Netware" between 2-4 November. The course was developed by the Euro Management and Technology Bureau, London, and was presented by their authorised instructor, Mr Alan Freeman.

- Mr M. Poullaides, Senior Lecturer, visited the City University, U.K. within the framework of the exchange staff programme between 2-14 November.

- Mr A. Kkolos, Lecturer, visited the University of Glamorgan, U.K., between 2-14 November

within the framework of the exchange staff programme.

- The Third Year Marine students returned from their sea training and began classes on 9 November.

- The First Mid-Semester Examinations were held between 2 - 6 November.

DECEMBER

- HTI Director, Mr D. Lazarides, in his efforts to promote the image of HTI held various meetings with the Career-Advising staff of Lyceums and Technical Schools and outlined HTI objectives and study opportunities.

- UNESCO Day was celebrated on Thursday, 3 December. Students and staff visited the village of Phikardou. The visit ended with lunch at Drosoneri Restaurant at Ayia Koroni.

- HTI Director, Mr D. Lazarides, visited Thessaloniki between 5 -12 December where he attended the Conference of the Presidents of TEI. During his stay in Thessaloniki the Director visited the Aristotelian University and examined the possibility of strengthening the co-operation between HTI and the Aristotelian University within the framework of EEC financed programmes.

- Mrs D. Serghides, Senior Lecturer, and Chairman of the International Solar Energy Society, Cyprus Section, organised and addressed the International Seminar "Solar Buildings - Architectural and Mechanical Design and Applications" which was held at the Ledra Hotel on 5 December.

- Lectures stopped on 23 December for the annual two-week Christmas break.

JANUARY

- Lectures commenced on Thursday, 7 January.

- The Annual General Conference of the International Association for the Exchange of Students for Technical Experience (IAESTE) was held in Cork, Ireland between 15 - 22 January.

Sixty countries participated with 200 delegates.

HTI was represented by the HTI Director, Mr D. Lazarides, Chairman of the National Committee of IAESTE, Cyprus and Mr Ch. Chrysafiades, National Secretary of IAESTE, Cyprus.

The Cyprus delegation secured 38 places for the summer training of HTI students and offered 41 places to students from IAESTE member countries to receive training in Cyprus.

- The First Semester Examinations were held between 18 - 29 January.

- Mr E. Michael, Lecturer, as a scholar of the Cyprus Government, started attending a two-year part-time postgraduate course leading to the "Master on Public Sector Management" at the Cyprus International Institute of Management in Nicosia.

FEBRUARY

- Lectures commenced on Monday, 1 February.

- Mr M. Poullaides, Senior Lecturer, started a 36 hr training on "Computer Aided Design (CAD)" at the Cyprus Productivity Centre.

MARCH

- HTI Director, Mr D. Lazarides, participated in th "Conference of the Presidents of TEI" in Herakleion, Crete, between 4 - 5 March.

During his stay there he attended a meeting with the Executive Committee of the European Association of Institutions in Higher Education (EURASHE) on an invitation from the President of EURASHE, Professor S. Kaplanis. It was decided that all necessary efforts should be exerted so that HTI becomes a full member of EURASHE.

- HTI Sports Day was held on Thursday, 11 March.

- Mrs D. Serghides, Senior Lecturer, participated in the one-day Conference on "The Protection and Restoration of Historical and Traditional Buildings" which was held on 27 March at the International Conference Centre in Nicosia.

The Conference was organised by the Architects Association, the Architects and Civil Engineers Association and the Cyprus Organisation of Architectural Heritage.

- HTI in collaboration with IEE Cyprus Centre and the Industrial Training Authority organised a 20 hr course on "Engineer's Guide to Financial Accounting" between 29 - 31 March.

The course was aimed at engineers working in industry and was developed by Coopers and

Lybrand. The instructors were Mr N. Nicolaides and Mr D. Demetriades.

- The second Mid-Semester Examinations were held between 29 March - 5 April.

APRIL

- HTI in collaboration with IEE Cyprus Centre and the Industrial Training Authority organised 30 hr course on "Supporting, Maintaining and Troubleshooting PCs" between 5 - 9 April.

The course was aimed at personnel working in industry and was developed by Euro - Management and Technology Bureau, London. The course was presented by their authorised instructor Mr Neal Hutchinson.

- HTI students and staff donated blood for the needs of the Nicosia Blood Bank on Thursday, 8 April.

- Mr N. Kathijotis, Lecturer, participated in the "Med-Campus" Conference in Tunis which was organised by the Community of Mediterranean Universities. The Conference was held between 12 - 18 April.

- Lectures were suspended between 12 - 23 April for the annual holiday break.

MAY

- Mr I. Economides, Lecturer, completed the course on Laboratory Testing of Aggregates which began in March and was aimed at engineers and technician engineers of the Public Works Department.

- Dr Ch. Chrysostomou, Lecturer, in collaboration with other engineers delivered a series of lectures on the application of the Cyprus Code on Seismic Design on 8, 9, 15 and 16 May in Nicosia. The lectures were under the auspices of the Architects and Civil Engineers Association.

- Mr N. Kathijotis, Lecturer, participated in the "Med-Campus" Conference in Morocco which was organised by the Community of Mediterranean Universities and was held between 17 - 23 May.

- The Social Formal Dinner of the HTI third year students was held on Thursday, 20 May at the Philoxenia Hotel.

The Dinner was honoured by H.E. the Minister of Labour and Social Insurance, Mr A. Moushiouttas, the Director General of the Ministry of Labour and Social Insurance, Mr George Anastasiades, and guests from the local industry.

The Guest Speaker was Mr N. Mesaritis, President of the Cyprus Technical Chamber.

- The First Cultural Festival of HTI was held at the SKALI open theatre in Aglanja on 24 May and was organised jointly by HTI students and staff.

The programme of the Festival started with the award of prizes to all winning athletic teams included Greek dances, music, singing and a one - act play.

- On Friday, 28 May, a Rock Concert was held at the School of the Blind Amphitheatre. HTI was among the sponsors of the Concert as all proceeds were given in aid of the fight against Leukemia.

- Second Semester Examinations began 26 May and ended 15 June.

JUNE

- Diploma Project Oral Examinations were held between 8 - 11 June,

- HTI in collaboration with IEE Cyprus Centre and the Industrial Training Authority organised a 30 hr course on "Supporting, Maintaining and Troubleshooting PCs" between 8-11 June. The course, which was aimed at personnel working in industry, was developed by the Euromanagement & Technology Bureau, London and was presented by their authorised instructor, Mr Neal Hutchinson.

- Mr I. Michaelides, Senior Lecturer, has successfully completed his research project on "Computer Simulation and Optimisation of Solar Heating Systems for Cyprus" and was awarded the degree of Doctor of Philosophy by the University of Westminster U.K.

- Mrs D. Charalambidou-Solomi, Lecturer, on a partial scholarship by the Eastern Michigan University, attended postgraduate courses on the EMU Campus, Michigan, U.S.A., between 28 June - 8 August to complete her postgraduate programme leading to the award of Master in Education.

JULY

- The HTI Graduation Ceremony was held on Friday, 2 July, at the Cyprus International Conference Centre. H. E. the President of the

Republic, Mr Glafcos Clerides, attended the Ceremony and awarded the Presidential Prize for the Highest Overall Performance.

The HTI Director, Mr D. Lazarides, delivered the Graduation Speech and awarded all other prizes.

The President of the HTI Students Union, Mr Nestoras Nestoros, addressed the gathering.

The Hon. Minister of Labour and Social Insurance, Mr Andreas Moushouttas, awarded the Diplomas to the graduates of the Civil, Electrical, Mechanical and Computer Studies Specialisations while the Hon. Minister of Communications and Works, Mr Adamos Adamides, awarded the Diplomas to the graduates of the Marine Specialisation.

- Mrs D. Serghides, Senior Lecturer, participated in the International Conference on the "Environment and Sustainable Development" which was held in Spetse between 29 July - 1 August. The Conference was organised by the International Society of Ecological Sensibility.

Mrs Serghides, in her capacity as a guest speaker, delivered a lecture on "Solariums and Court-Yards as Climatic Modifiers in Mediterranean Architecture".

AMMAN
AMSTERDAM
ATHENS
BAHRAIN
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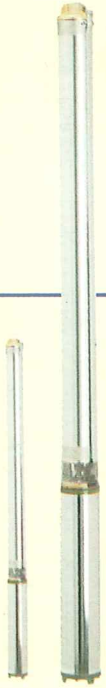

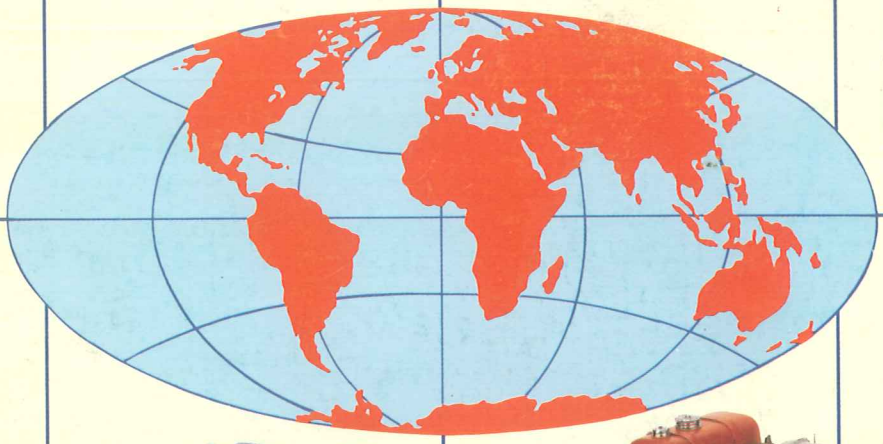

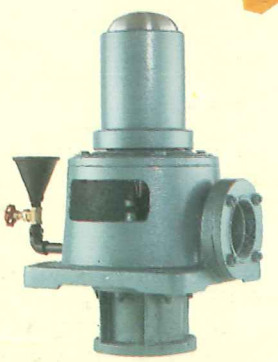

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