



INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
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H4.SMR. 403/5

**FIFTH COLLEGE ON MICROPROCESSORS: TECHNOLOGY AND APPLICATIONS
IN PHYSICS**

2- 27 October 1989

Course Overview

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These notes are intended for internal distribution only.

WELCOME

TO THE

FIFTH INTERNATIONAL COLLEGE
ON MICROPROCESSORS.

TRIESTE

OCTOBER 2 - 27, 1989

THE MICROPROCESSOR IS STILL
RELATIVELY YOUNG: 18 YEARS OLD.

EVEN NOVEMBER 15, 1971. IN SANTA CLARA
CALIFORNIA, THE BABY, BAPTIZED INTEL 4004
GREW VERY FAST, AND THE FAMILY BECAME
VERY PROSPEROUS.

THE 4004 STARTED WITH THE DESIGN
- AT INTEL - OF A HIGH-PERFORMANCE POCKET
CALCULATOR FOR BUSICOM IN JAPAN.

VERY RAPID DEVELOPMENT:

1972 : 8008

1974 : 8080 AND 6800

ALSO: PACE

1976 : 8048

1978/79 : 8086, 9900, 28000

1979 : 8088, 6809, 68000

1981 : iAPX432

1983 : HP9000, BELLMAC, 68020

1984 : 32016

1985 : μ VAX, 32032, 80386, RISC-II

IN 1979 75M MICROPROCESSORS WERE SOLD
BY THE END OF 1979 TOTAL NUMBER SOLD: 110M
SALES IN 1985: BILLIONS

EVEN IBM BUYS THEM!

WHERE DID ALL THOSE MICROS GO?

- A FEW : REPLACEMENT OF MINICOMPUTERS
- MANY : REPLACEMENT OF RANDOM LOGIC
- THE LOT : UNEXPECTED, NEW APPLICATIONS.

IN MANY APPLICATIONS, THE MICRO IS NOT SEEN BY THE USER ("EMBEDDED" IN SOMETHING)

- HOME APPLIANCES (DISH WASHER, REFRIGERATOR)
- AUTOMOBILES (IN THE CAR, IN THE GARAGE)
- TV AND ARCADE GAMES
- TRAFFIC LIGHTS, LIFTS
- INDUSTRIAL CONTROLS

MANY APPLICATIONS WHERE THE USER CAN MAKE AN INTELLIGENT USE OF THE MICRO:

NOT USER-PROGRAMMABLE:

- INDUSTRIAL CONTROLS (ROBOTS, MACHINE TOOLS)
- OFFICE AUTOMATION
- COMPUTER PERIPHERALS (DISCS, TERMINALS)
- INSTRUMENTS (CHEMICAL, MEDICAL, PHYSICAL)

USER PROGRAMMABLE:

- PERSONAL COMPUTERS
- PROFESSIONAL WORKSTATIONS
- SCIENTIFIC INSTRUMENTS AND EXPERIMENTS.
 - MONITORING
 - CONTROL
 - DATA ACQUISITION AND RECORDING
 - DATA ANALYSIS (REAL-TIME OR OTHER)

THIS ALL-PERVASIVE USE OF MICRO-S
WAS MADE POSSIBLE BY THEIR LOW COST:
ROUGHLY 10 X THE POWER OF CERN'S FIRST
COMPUTER (1958), FOR 10^{-4} X THE COST!
TODAY YOU BUY "MAINFRAME CAPACITY" FOR
15-20 K\$.

EVERYBODY, IN ALL COUNTRIES, WILL BE MORE
AND MORE CONFRONTED WITH MICROPROCESSORS.

EXPERTISE IS NEEDED TO KNOW HOW TO USE
THEM, HOW TO ADAPT THEM TO SPECIFIC NEEDS,
HOW TO MAINTAIN AND REPAIR THEM.

IT IS IMPORTANT TO TRAIN PEOPLE WHO
CAN MAKE INTELLIGENT USE OF MICRO-
PROCESSORS. AND WHO CAN TRANSMIT THE
ACQUIRED KNOWLEDGE TO OTHERS.

IT IS ALSO IMPORTANT FOR PHYSICISTS,
TO LEARN TO USE THEM IN EXPERIMENTS.

In 1980 ICTP decided to organize a course on Microprocessors. CERN collaborated and the result was:

A COURSE FOR PHYSICISTS BY PHYSICISTS

THE GOAL OF THE COURSE:

TO PROVIDE SUFFICIENT KNOWLEDGE OF MICROPROCESSOR HARDWARE AND SOFTWARE TO ENABLE THE PARTICIPANTS TO WORK EFFECTIVELY WITH MICROS IN THEIR LABORATORY.

THUS:

- PLAN
- DESIGN
- BUILD
- INTEGRATE

A MICROPROCESSOR SYSTEM

THE COURSE THEREFORE HAS:

- INTEGRATED HARDWARE/SOFTWARE APPROACH.
- PRACTICAL HANDS-ON EXPERIENCE IN ADDITION TO THEORY.
- EXAMPLES OF APPLICATIONS IN DIFFERENT FIELDS OF PHYSICS.
- SOME ADDITIONAL COMPUTER "CULTURE".

SEVERAL COURSES HAVE TAKEN PLACE:

1.	TRIESTE	SEPTEMBER 1981	140
2.	TRIESTE	APRIL/MAY 1983	90
3.	COLOMBO, SRI LANKA	JUNE 1984	60
4.	BOGOTA - COLOMBIA	JUNE 1985	80
5.	TRIESTE	OCTOBER 1985	80
6.	HEFEI, PEOPLE'S REPUBLIC OF CHINA,	SEPT. 1986	80
7.	TRIESTE	OCTOBER 1987	110
8.	TRIESTE	OCTOBER 1989	96

IN ADDITION, SEVERAL LOCAL COLLEGES WERE ORGANIZED:

- LISBOA, PORTUGAL	APRIL '85	50
- COLIMA, MEXICO	MAY '86	50
- SAN LUIS, ARGENTINA	APRIL '88	50
- BOGOTA, COLOMBIA	MAY-JUNE '88	~50
- ACCRA, GHANA	JANUARY '89	50

I SHOULD MENTION TWO PEOPLE WHO CONTRIBUTED GREATLY:

WOLFGANG VON RÜDEN
ALESSANDRO MARCHIORO

THE COLLEGES EVOLVED AND SEVERAL THINGS WERE IMPROVED:

- THE EQUIPMENT IS FASTER, MORE MODERN AND EASIER TO USE (6809, FLOPPY DISK)
- PRACTICAL SESSIONS ARE LONGER;
TOTAL TIME FOR EXERCISES INCREASED FROM 30 TO 75 HOURS.
- BETTER RATIO INSTRUCTORS/STUDENTS
- MORE PROJECT ORIENTED (COLOMBO '84)

THE MAJORITY OF OUR PRESENT INSTRUCTORS WERE PARTICIPANTS AT PREVIOUS COLLEGES. THEY RECEIVED ADDITIONAL TRAINING IN "INSTRUCTORS WEEKS": 1983, 1984, 1985. SEVERAL EX-PARTICIPANTS ORGANIZED COURSES IN THEIR HOME COUNTRY.

THE COURSE IS BASED ON THE MOTOROLA 6809

THIS IS A MODERN 8-BIT PROCESSOR,
WHICH HAS MANY OF THE CHARACTERISTICS
NORMALLY FOUND IN 16-BIT MACHINES.

IT IS IDEALLY SUITED FOR TEACHING
BASIC CONCEPTS, WITHOUT THE GREATER
COMPLEXITY OF THE 16-BIT PROCESSORS.

THE EXERCISES WILL BE DONE ON
DEVELOPMENT STATIONS, CONSISTING OF:

MICROCOMPUTER:

- 6809 + 48 K MEMORY + PARALLEL + SERIAL I/O INTERFACES.
- TERMINAL + KEYBOARD
- 5 1/4" FLOPPY DISK
- PRINTER (1 FOR 2 STATIONS)

SOFTWARE:

- THE FLEX OPERATING SYSTEM,
INCLUDING EDITOR, ASSEMBLER, FILE
SYSTEM.

ELECTRONICS:

- COLLECTION OF "LOGIDULES", ALLOWING
TO RAPIDLY MAKE EXTERNAL HARDWARE.
- MATERIAL FOR STUDENT PROJECTS

(COLOMBO '84)

WHY TEACH AN 8-BIT MICRO IN 1989?

SEVERAL REASONS:

- INVESTMENT IN OUR EQUIPMENT.
- ADEQUATE, EVEN IDEAL, FOR TEACHING THE BASIC CONCEPTS.
- INTERFACING IS EASY AND CHEAP. CAN BE DONE BY STUDENTS DURING THE COURSE.
- 6809 IS "OVERKILL" FOR MANY APPLICATIONS.
- GOOD KNOWLEDGE OF THE 6809 ALLOWS YOU TO SWITCH EASILY TO MORE POWERFUL MACHINES.
- GOOD PRACTICE IS TO "HIDE" THE SPECIFIC HARDWARE

WE MUST ALSO TEACH YOU 6809-SPECIFIC THINGS
WE HOPE TO MAKE CLEAR WHEN WE ARE
DOING THIS.

OUTLINE OF THE COURSE.

FIRST DAY IS SPECIAL.

2.

- PARTICIPANTS WILL BE DIVIDED INTO 2 GROUPS:

GROUP 1: LECTURES IN THE MORNING

9.00-12.30

EXERCISES IN THE AFTERNOON

14.00-18.00

GROUP 2: EXERCISES IN THE MORNING

8.30-12.30

LECTURES IN THE AFTERNOON

14.00-17.30

19.00-22.00

- FOR THE EXERCISES THERE WILL BE

2 PARTICIPANTS/STATION

SOME RESHUFFLING MAY BE DONE AFTER
1ST WEEK, OTHERWISE:

SAME TEAM, SAME STATION

INSTRUCTORS WILL MOVE AROUND.

- INSTRUCTORS ARE HERE TO HELP YOU!

- FOR ADMINISTRATIVE PROBLEMS, GO AND
SEE OUR SECRETARY:

MRS. AVE LUENTI

- DOCUMENTATION WILL BE HANDED OUT WHEN NEEDED

VALID FOR 1ST WEEKS
THEN ROTATE.

EXERCISES.

- 1, 2 - LOGIC WITH LOGIDULES:
GATES, DECODER
ALU, FLIP-FLOPS, REGISTERS
- 3, 4 - DEMONSTRATION OF ROSY:
HANDS-ON; HANDCODING
- 5 - USE OF FLEX:
EDITOR, ASSEMBLER
- 6 - CONTROL OF FLOW CONSTRUCTS
- 7 - SUBROUTINES
- 8 - LOGIDULES ON ROSY
- 9, 10 - PIA PROGRAMMING (COLOMBO '84)
- 11 - INTERRUPTS WITH LOGIDULES
- 12 - DIGITAL TO ANALOG CONVERSION
- 13 - ANALOG TO DIGITAL CONVERSION
- 14 - VOLTAGE TO FREQUENCY CONVERSION (COLOMBO '84)

MANUEL GONÇALVES LEADS
THE LABORATORY.

YOU FIND THE NAMES OF ALL INSTRUCTORS
IN BULLETIN 2 AND ON THE NOTICE BOARD.

LECTURES 1ST + 2ND WEEK.

1. GENERAL INTRODUCTION TO (MICRO)PROCESSORS

RINUS VERKERK

6 HOURS

- COMPUTER, PROGRAM, CPU, MEMORY, I/O
- FROM CHIP TO SYSTEM
- ADDRESSING, INSTRUCTION EXECUTION
- BOOTING; MONITOR, EDITOR, ASSEMBLER, FILES, LOADING
- ADDRESSING MODES AND THEIR REASON
- NUMBER REPRESENTATION, ARITHMETIC
- DOUBLE PRECISION, SIGNED/UNSIGNED, BCD
- BRANCHES
- INTERRUPTS; SHARED PROGRAM, SHARED DATA.

2. DIGITAL LOGIC

SRINIVASAN. VENKATARAMAN

4 HOURS

- DEFINITIONS, BOOLEAN EXPRESSIONS, TRUTH TABLE
- MUX, ENCODER, ALU
- SEQUENTIAL CIRCUITS, FLIP-FLOPS
- REGISTERS; DESIGN OF SEQUENTIAL CIRCUITS
- PROGRAMMABLE HARDWARE

3. THE 6800

CHU SUAN ANG

7 HOURS

- CPU, REGISTER SET, INSTRUCTIONS
- ADDRESSING MODES
- HARDWARE, CONTROL SIGNALS
- MINIMAL SYSTEM, ADDRESS DECODING
- I/O AND SIMPLE INTERFACE
- USE OF 6809 IN ROSY
- INTERRUPTS, MASKING, STACKING, ETC.

4. ASSEMBLY LANGUAGE PROGRAMMING.

..... NII QUAYNOR

6 HOURS

- INSTRUCTION REPRESENTATION, FIELDS
- SYMBOLS, ASSEMBLER DIRECTIVES
- BUILDING UP A PROGRAM; TOP-DOWN
- LOOPS, BRANCHES, INDEXING, ARRAYS
- SUBROUTINES, STACKS, PARAMETER PASSING
- STRUCTURED FLOW OF CONTROL, DEVELOPMENT
- RELOCATION; POSITION INDEPENDENT CODE
- LINKING
- MACROS
- INTERRUPT HANDLING, CRITICAL SECTIONS.

5. INPUT/OUTPUT AND INTERFACING

5 HOURS

ALBERTO COLAVITA

- DEFINITIONS. HANDSHAKE
- ADDRESSING. PARALLEL I/O. PIA.
- SERIAL TRANSMISSION AND I/O. ACIA
- POLLING. INTERRUPTS.

6. FLEX OPERATING SYSTEM.

RINUS VERKERK

1 HOUR

7. HARDWARE OF COLBITZ '81,

ALBERTO COLAVITA

1. HOUR

LECTURES 3RD AND 4TH WEEK:

1. SOFTWARE TOOLS AND TECHNIQUES 7 HOURS
PAUL BARTHOLDI
2. FLOATING POINT ARITHMETIC 2 HOURS
PAUL BARTHOLDI
3. ANALOG/DIGITAL, D/A AND V/F CONVERSION 1 HOUR
MARIO TRUJILLO
4. ARRAY LOGIC 2 HOURS
ALBERTO COLAVITA
5. BUS BASICS 3 HOURS
BOB DOBINSON
6. INTRODUCTION TO THE PROJECTS 1 HOUR
GASPAR BARREIRA
7. OTHER MICROPROCESSORS 3 HOURS
DARIO CROSETTO
8. DIGITAL SIGNAL PROCESSORS 2 HOURS
DARIO CROSETTO
9. REAL-TIME SYSTEMS 3 HOURS
LUCIA ZANELLO
10. MICROS IN THE USSR 2 HOURS
VICTOR IVANOVITCH RYZHII
11. HARDWARE MAINTENANCE 1 HOUR
GASPAR BARREIRA
12. MULTICHANNEL ANALYZER 1 HOUR
GASPAR BARREIRA
13. TRANSPUTERS 1 HOUR
BOB DOBINSON

INSTRUCTORS

GROUP 1

MAHANADA BANDARA
ABHAYA INDURUWA
MANUEL GONÇALVES
WU GENG-FENG
LAMINE KONATE
AHMAD IMTIAZ

AFTERNOON
SHIFT

GROUP 2

RAVINDRA KARNAD
DRISSA SORO
MARIO TRUJILLO
JOHN TRUJILLO
XIONG XIA-ZHONG
GAO ZHONG-REN

MORNING
SHIFT

IN THE LAB.

DIRECTORS:

GASPAR BARREIRA
RINUS VERKERK