Einheitlicher Zusammenstand Elektronischen Rechengeräte

Specification

Foreword

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Contents

I Access 3

1 Primary Memory 5
- Bitstrings 5
  - 8-String 5
  - 16-String 5
  - 32-String 5
  - 64-String 5
  - 128-String 6
  - 256-String 6
- Addresses 6
  - Physical Address 6
  - Virtual Address 6
    - 1st Order Format 6
    - 2nd Order Format 7

2 Units 9
- Physical Address 9
  - Transfer 9
    - Read 9
    - Write 9
  - Order of Accesses 9
- Virtual Address 9
  - Frame Table 9
    - Root Table 9
    - 2nd Order Frame Gate 10
    - 1st Order Frame Table 10
    - 1st Order Frame Gate 11
  - Procedure 11
    - Frame Table Walk 11
    - *n*th Order Frame Access 11

II Interruptions 13

3 Structures 15
- Target 15
- Gate 15
- Entry 15
- Source 15

4 Operation 17

III Execution 19

5 Operation 21
- Instruction Cycle 21
- Conditions 21

6 Processing Units **23**
Register File . . . 23
0-15 – Data . . . 23
IP – Instruction Pointer . . . 23
SR – Status Register . . . 24
Data . . . 24
Fixed Point Numbers . . . 24
U/Z1 . . . 24
U/Z2 . . . 24
U/Z4 . . . 24
Floating Point Numbers . . . 24
X4 . . . 24
X8 . . . 24
X16 . . . 25
X32 . . . 25
Instructions . . . 25
Control Instruction . . . 25
SCI – Skip . . . 26
JMP – Jump . . . 26
Move Instruction . . . 26
STR – Move . . . 26
USS – Atomic Move . . . 27
BRS – Context Switch . . . 27
UDB – Interruption . . . 28
Bitwise Instruction . . . 28
LSH – Left Shift . . . 28
RNS – Logical Right Shift . . . 29
RFS – Arithmetic Right Shift . . . 29
THR – Rotate . . . 29
AND – Conjunction . . . 29
OR – Union . . . 29
NOT – Complement . . . 29
SSW – Sign Swap . . . 30
Arithmetic Instruction . . . 30
GIV – Add . . . 31
TAC – Subtract . . . 31
FLD – Multiply . . . 31
CUT – Divide . . . 31

7 Channel Units **33**
Register File . . . 33
IP – Instruction Pointer . . . 33
IGP – Interrupt Gate Pointer . . . 33
IEP – Interrupt Entry Pointer . . . 33
SR – Status Register . . . 33
Instructions . . . 34
Control Instruction . . . 34
Transfer Instruction . . . 34
Read . . . 35
Write . . . 35
Operation . . . 35
Programs . . . 35
Traps . . . 35

Introduction

The OSER is an architecture for systems designed to facilitate data processing and exchange. An OSER system instance is made up of **primary memory**, one or more **processing units** and naught or more **channel units**.

In the OSER, data processing and exchange occurs in **programs**. When a program is run, three main processes happen:

- access;
- interruption; and
- execution.

Access

In an access, a **datum** is transferred between a unit and primary memory.

Interruption

In an interruption, a unit causes a processing unit to run a new program.

Execution

In execution, a processing unit runs a program.

Part I

Access

Chapter 1

Primary Memory

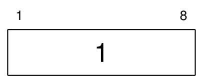
Primary memory is made of **cells**.

Bitstrings

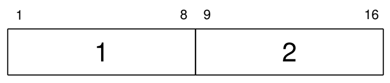
The cells hold **bitstrings**. In a bitstring, the bits are numbered from 1 and may take either 0 or 1 as values. A string of *n* bits is called an ***n*-string**.

Each cell in primary memory holds a single 8-string. A string longer than 8 bits is held by cutting it into 8-strings and holding the 8-strings in consecutive cells.

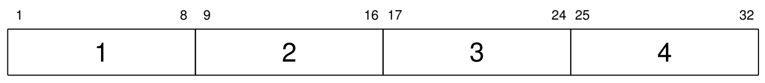
8-String



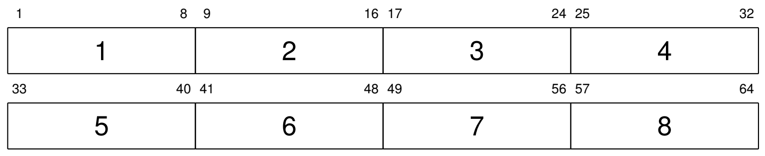
16-String



32-String



64-String



128-String

1 8	9 16	17 24	25 32
1	2	3	4
33 40	41 48	49 56	57 64
5	6	7	8
65 72	73 80	81 88	89 96
9	10	11	12
97 104	105 112	113 120	121 128
13	14	15	16

256-String

1 8	9 16	17 24	25 32
1	2	3	4
33 40	41 48	49 56	57 64
5	6	7	8
65 72	73 80	81 88	89 96
9	10	11	12
97 104	105 112	113 120	121 128
13	14	15	16
129 136	137 144	145 152	153 160
17	18	19	20
161 168	169 176	177 184	185 192
21	22	23	24
193 200	201 208	209 216	217 224
25	26	27	28
225 232	233 240	241 248	249 256
29	30	31	32

Addresses

Each cell is designated by a natural number called an **address**. A bitstring longer than 8 bits is designated by the address of its first 8-string.

Each address is a **physical address** or a **virtual address**.

Physical Address

A physical address designates a single cell in primary memory. Address 0 designates the first cell, and consecutive addresses designate consecutive cells.

Virtual Address

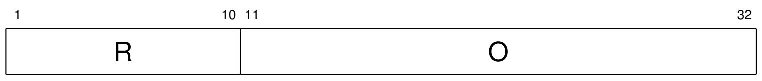
A virtual address has two formats.

1st Order Format

1 10	11 20	21 32
R	1-T	O

R	Root Index
1-T	1st Order Key Index
O	Offset

2nd Order Format



R Root Index

O Offset

Chapter 2

Units

A unit accesses the primary memory when a bitstring is transferred between this unit and designated cells.

1. The unit generates the physical address designating the first cell in primary memory.
2. The bitstring is transferred between the unit and the designated cells in primary memory.

Physical Address

When a bitstring in primary memory is addressed, all of its constituant 8-strings are also designated.

Transfer

The access is either a **read** or a **write**, depending on the direction of transfer.

Read

The access is a read when the string is sent from the unit to primary memory.

Write

The access is a write when the string is sent from primary memory to the unit.

Order of Accesses

For every unit and for every primary memory cell, a read from the cell by the unit will yield the value written by the last write to that same cell by that same unit.

Virtual Address

A virtual address is translated into a physical address.

Frame Table

The **frame table** holds the data for address translation.

Root Table

A root table holds 2nd order frame descriptors, 2nd order frame keys or 1st order frame table descriptors.

2nd Order Frame Descriptor

1 10	11 26	27	28	29	30	31	32
T	1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	M	S	W	R	X	0

T	Frame Base
M	Modified
S	Swapped
W	Write Permission
R	Read Permission
X	Execute Permission

2nd Order Frame Key

1 28	29	30	31	32
T	W	R	X	1

T	Gate Pointer
W	Write Permission
R	Read Permission
X	Execute Permission

1st Order Frame Table Descriptor

1 20	21 32
T	1 0 0 0 0 0 0 0 0 0 0 0

T	Table Base

2nd Order Frame Gate

A 2nd order frame gate is pointed to by a 2nd order frame key.

1 10	11 26	27	28	29 32
T	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	M	S	0 0 0 0

T	Frame Base
M	Modified
S	Swapped

1st Order Frame Table

A 1st order frame table holds 1st order frame descriptors or 1st order frame keys.

1st Order Frame Descriptor

1 20	21 26	27	28	29	30	31	32
T	1 0 0 0 0 0	M	S	W	R	X	0

T	Frame Base
M	Modified
S	Swapped
W	Write Permission
R	Read Permission
X	Execute Permission

1st Order Frame Key

1 28	29	30	31	32
T	W	R	X	1

T	Gate Pointer
W	Write Permission
R	Read Permission
X	Execute Permission

1st Order Frame Gate

A 1st order frame gate is pointed to by a 1st order frame key.

1 20	21 26	27	28	29 32
T	0 0 0 0 0 0	M	S	0 0 0 0

T	Frame Pointer
M	Modified
S	Swapped

Procedure

The translation runs in two phases.

Frame Table Walk

The frame table walk yields either a frame key or a frame descriptor from a virtual address.

1. The unit reads from the root table the entry which the root index designates.
2. If the entry has none of the aforementioned formats, then condition **ZEE** happens.

   Otherwise, if the entry is either a 2nd order frame key or a 2nd order frame bewrit, then the unit performs the 2nd order frame access with the entry.

   Otherwise, the unit reads from the 1st order frame table the entry which the 1st order index designates.
3. If the entry has none of the forbewritten formats, then condition **ZEE** happens.

   Otherwise, the unit undertaces the 1st order frame grasp with the entry.

*n*th Order Frame Access

The *n*th order frame access gives a physical address needed in step 1 of primary memory access from an *n*th order frame key or an *n*th order frame descriptor.

1. If the entry does not allow the access, then condition **ZEE** happens.

   The entry allows the access if one and only one of the following conditions are met.

   - The access is a write and the W-bit is 1.
   - The access is a read and the R-bit is 1.
   - The access is a read of a instruction (as described in step (1) of the instruction cycle) and the X-bit is 1.
   - The access is a read of a root table descriptor (as described with instruction BRS) and all 3 bits are 0.
2. If the entry is a key, then the unit reads the gate to which the key's gate pointer points.
3. If the S-bit is 1, then condition **ZSW** happens.
4. If the access is a write, then the unit sets the E-bit of the entry in memory to 1.
5. The unit adds the offset to the frame pointer to give the physical address.

Part II

Interruptions

Chapter 3

Structures

In an interruption, data is exchanged between units.

Target

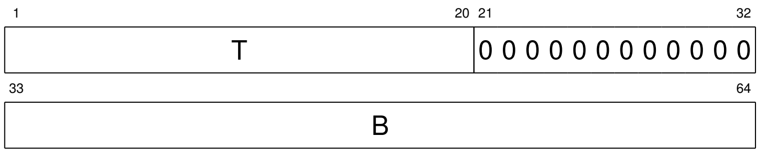
A target is a processing unit.

Gate

An interrupt gate is a cell in primary memory which is bound to a target.

Entry

An interrupt entry holds a virtual address to data and a pointer to the root table with which the address must be translated.



T	Root Table Pointer
B	Data Virtual Address

Source

A source is a unit which initiates an interruption.

Chapter 4

Operation

An interruption happens when the source writes an interrupt entry to the interrupt gate of the target.

1. The source writes the entry to the target's gate.
2. The target translates the entry's virtual address with the root table pointed to by the entry's root table pointer.
3. The target process the data pointed to by the aforegiven physical address.

The target must start the instruction cycle after having processed the interrupt entry.

Part III

Execution

Chapter 5

Operation

In the OSER, processing units follow a fixed operation.

Instruction Cycle

A processing unit follows the *instruction cycle*.

1. The unit reads an instruction.
2. If the instruction is not recognized, then condition **AEA** happens.
3. The unit performs all accesses which must happen before the instruction.
4. The unit executes the instruction.
5. The unit performs all accesses which must happen after the instruction.

Conditions

When a condition happens, the unit executes a **trap**.

A trap is a special program which gets the unit’s state at the time of the condition as input.

Chapter 6

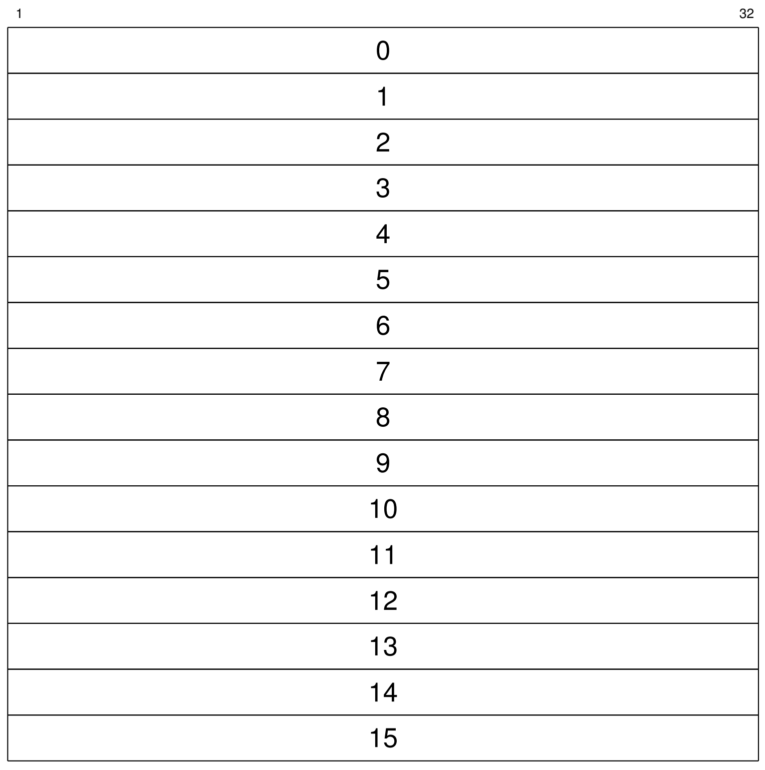
Processing Units

In the OSER, the processing units are built to a particular architecture.

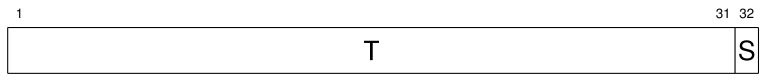
Register File

The register file does not depend on primary memory.

0-15 – Data



IP – Instruction Pointer



T	Pointer
S	State

0	Running
1	Stopped

SR – Status Register

1–20	21–29	30–31	32
R	0 0 0 0 0 0 0 0 0	C	0

33–64
IP

R	Root Table Pointer
C	Condition code
IP	Instruction Pointer

Data

Data can be either a fixed point number or a floating point number.

Fixed Point Numbers

Let $Z_U(S, M)$ be the number expressed by a bitstring S with lowest power M in an unsigned interpretation.

$$Z_U(S, M) = 2^M \sum_{i=1}^{|S|} 2^{|S|-i} S_i$$

Let $Z_Z(S, M)$ be the number expressed by a bitstring S with lowest power M in a signed interpretation.

$$Z_Z(S, M) = 2^M \left(-2^{|S|-1} S_1 + \sum_{i=2}^{|S|} 2^{|S|-i} S_i \right)$$

U/Z1

1–8
S

U/Z2

1–16
S

U/Z4

1–32
S

Floating Point Numbers

Let $X(V, M, B)$ be the number expressed by a sign bit V, an exponent bitstring M and a fraction bitstring B.

$$X(V, M, B) = (-1)^V 2^{Z_U(M,0)-2^{|M|-1}} Z_U(B, -1-|B|)$$

X4

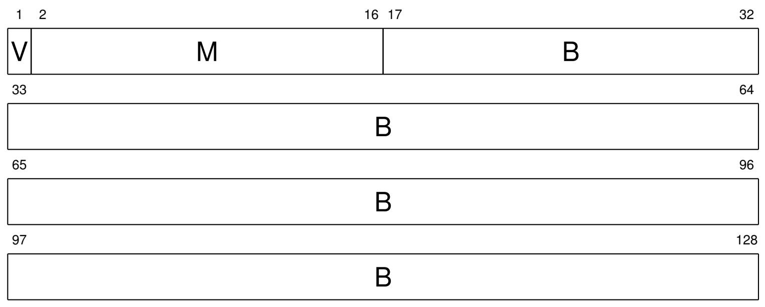
1	2–9	10–32
V	M	B

X8

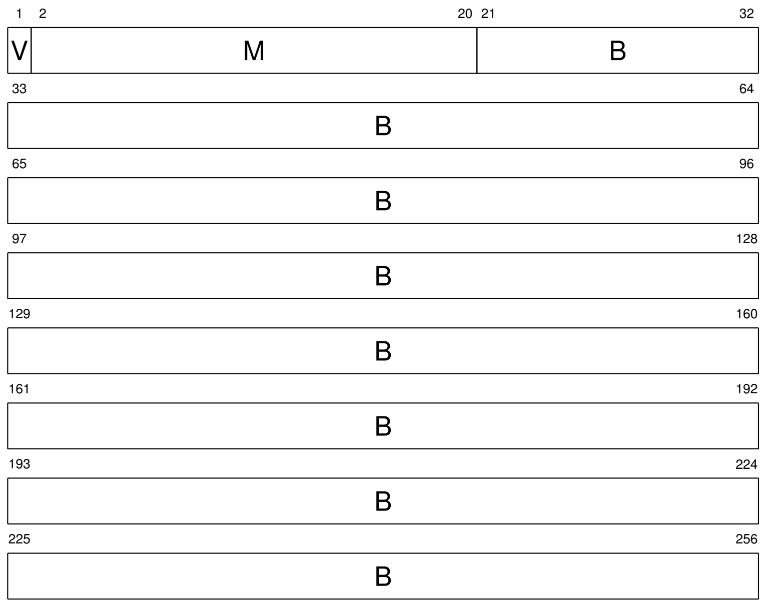
1	2–12	13–32
V	M	B

33–64
B

X16



X32



Instructions

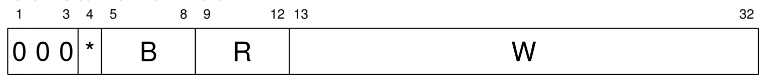
A instruction decribes a change in the program's state. Each instruction has various **formats**.

Control Instruction

A control instruction changes the run of the program when its condition is fulfilled. Each bit of the instruction condition designates a value of the SR-condition field, and the instruction condition is fulfilled if the SR-condition has a value whose bit in the instruction's condition is 1.

A control instruction has three formats.

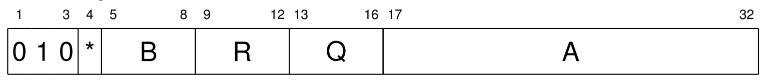
Constant Format



In this format:

- the target is register *R*;
- the source is *W*.

Memory Format



In this format:

- the target is register *R*;

- the source is the primary memory at the address given by the sum of *A* and register *Q*.

Register Format

1 3	4	5 8	9 12	13 16
1 1 0	*	B	R	Q

In this format, the target and source are registers *R* and *Q*.

SCI – Skip

After this instruction:

- *IP* is set to the sum of *IP* and the source;
- the target is set to *IP* before the instruction.

1 3	4	5 32
* * *	0	* *

1 3	4	5 16
* * *	0	* * * * * * * * * * * *

JMP – Jump

After this instruction:

- *IP* is set to the source;
- the target is set to *IP* before the instruction.

1 3	4	5 32
* * *	1	* *

1 3	4	5 16
* * *	1	* * * * * * * * * * * *

Move Instruction

A move instruction describes a movement of data between primary memory and the register file.

STR – Move

After this instruction, the target is set to the source.

This instruction has four formats.

Constant Format

1 8	9 12	13 32
0 0 1 1 0 0 0 0	Z	W

In this format:

- the target is register *Z*;
- the source is *W*.

Memory Format

1 8	9 12	13 16	17	18 20	21 32
0 1 1 1 0 0 0 0	Z	Q	Ä	G	A

In this format:

- the target is register *Z*;
- if the Ä-bit is 0, then the source is the primary memory at the address given by the sum of *A* and register *Q*; otherwise:
  - the source is the primary memory cell which register *Q* designates;

  - *A* is added to register *Q* after the instruction.

1 8	9 12	13 16	17	18 20	21 32
1 0 1 1 0 0 0 0	Z	Q	Ä	G	A

In this format:

- if the Ä-bit is 0, then the target is the primary memory at the address given by the sum of *A* and register *Z*; otherwise:
  - *A* is added to register *Z* before the instruction;
  - the target is the primary memory at the address in register *Z*;
- the source is register *Q*.

Near hold format

1 8	9 12	13 16
1 1 1 1 0 0 0 0	Z	Q

In this format, the target and source are registers *Z* and *Q*.

USS – Atomic Move

This instruction's execution depends on its format.

This instruction has two formats.

1 8	9 12	13 16	17	18 20	21 32
0 1 1 1 0 0 0 1	Z	Q	0	G	A

In this format:

- the target is register *Z*;
- the source is the primary memory at the address given by the sum of *A* and register *Q*.

1 8	9 12	13 16	17	18 20	21 32
1 0 1 1 0 0 0 1	Z	Q	0	G	A

In this format:

- the target is the primary memory at the address given by the sum of *A* and register *Z*;
- the source is register *Q*.

In particular, this instruction will trap if a write to the target has happened after the last **USS** thereto.

BRS – Context Switch

This instruction's execution depends on its format.

This instruction has two formats.

1 8	9 12	13 16	17 32
0 1 1 1 0 0 1 0	R	Q	A

In this format:

- *SR* is written to primary memory at the address in register *R*;
- a new status register is read from primary memory at the address given by the sum of *A* and register *Q*.

1 8	9 12	13 16
1 1 1 1 0 0 1 0	R	Q

In this format:

- *SR* is written to primary memory at the address in register *R*;
- a new status register is read from primary memory at the address given by the sum of *A* and register *Q*.

UDB – Interruption

1 8	9 12	13 15	16	17 32
1 0 1 1 0 0 1 0	Z	Q	0	A

In this instruction:

- the source is the register pair $(Q, Q+1)$;
- the target is the primary memory at the address given by the sum of *A* and register *Z*.

Bitwise Instruction

A bitwise instruction describes a calculation over individual bits.

Each bitwise instruction has four formats.

Constant Format

1 4	5 8	9 12	13 32
0 0 1 0	* * * *	Z	W

In this format:

- the target is register *Z*;
- the source is *W*.

Memory Format

1 4	5 8	9 12	13 16	17	18 20	21 32
0 1 1 0	* * * *	Z	Q	Ä	G	A

In this format:

- the target is register *Z*;
- if the Ä-bit is 0, then the source is the primary memory whose address is given by the sum of *A* and register *Q*;

  otherwise:

  - the source is the primary memory at the address in register *Q*;
  - *A* is added to register *Q* after the instruction.

1 4	5 8	9 12	13 16	17	18 20	21 32
1 0 1 0	* * * *	Z	Q	Ä	G	A

In this format:

- if the Ä-bit is 0, then the target is the primary memory at the address given by the sum of *A* and register *Z*;

  otherwise:

  - *A* is added to register *Z* before the instruction;
  - the target is the primary memory at the address in register *Z*;
- the source is register *Q*.

Register Format

1 4	5 8	9 12	13 16
1 1 1 0	* * * *	Z	Q

In this format, the target and source are registers *Z* and *Q*.

LSH – Left Shift

After this instruction, the target is shifted to the left by the number of bits given by the source.

1 4	5 8	9 32
* * * *	0 0 0 0	* *

1 4	5 8	9 16
* * * *	0 0 0 0	* * * * * * * *

RNS – Logical Right Shift

After this instruction, the target is shifted to the right by the number of bits given by the source. The leftmost bits are set to 0.

1 4	5 8	9 32
* * * *	0 0 0 1	* *

1 4	5 8	9 16
* * * *	0 0 0 1	* * * * * * * *

RFS – Arithmetic Right Shift

After this instruction, the target is shifted to the right by the number of bits given by the source. The leftmost bits are set to the target's first bit before the instruction.

1 4	5 8	9 32
* * * *	0 0 1 0	* *

1 4	5 8	9 16
* * * *	0 0 1 0	* * * * * * * *

THR – Rotate

After this instruction, the target is rotated to the right by the number of bits given by the source.

1 4	5 8	9 32
* * * *	0 0 1 1	* *

1 4	5 8	9 16
* * * *	0 0 1 1	* * * * * * * *

AND – Conjunction

After this instruction, each of the target's bits will be set to the conjunction of the matching bits of the target and the source.

1 4	5 8	9 32
* * * *	0 1 0 0	* *

1 4	5 8	9 16
* * * *	0 1 0 0	* * * * * * * *

OR – Union

After this instruction, each of the target's bits will be set to the union of the matching bits of the target and the source.

1 4	5 8	9 32
* * * *	0 1 0 1	* *

1 4	5 8	9 16
* * * *	0 1 0 1	* * * * * * * *

NOT – Complement

After this instruction, each of the target's bits will be set to the complement of the matching bits of the source.

1 4	5 8	9 32
* * * *	0 1 1 0	* *

1 4	5 8	9 16
* * * *	0 1 1 0	* * * * * * * *

SSW – Sign Swap

After this instruction, the target will be set to the negative of the source.

In the costant format, the source is zero-extended.

1 4	5 8	9 32
* * * *	0 1 1 1	* *

1 4	5 8	9 16
* * * *	0 1 1 1	* * * * * * * *

Arithmetic Instruction

An arithmetic instruction describes an arithmetic calculation.

All arithmetic instructions calculate over fixed point numbers.

Each arithmetic instruction has four formats.

Constant Format

1 4	5 8	9 12	13 32
0 0 1 0	* * * *	Z	W

In this format:

- the target is register *Z*;
- the source is *W*.

Main hold format

1 4	5 8	9 12	13 16	17	18 20	21 32
0 1 1 0	* * * *	Z	Q	Ä	G	A

In this format:

- the target is register *Z*;
- if the Ä-bit is 0, then the source is the primary memory at the address given by the sum of *A* and register *Q*; otherwise:
  - the source is the primary memory at the address in *Q*;
  - *A* is added to register *Q* after the instruction.

1 4	5 8	9 12	13 16	17	18 20	21 32
1 0 1 0	* * * *	Z	Q	Ä	G	A

In this format:

- if the Ä-bit is 0, then the target is the primary memory at the address given by the summ of *A* and register *Z*; otherwise:
  - *A* is added to register*Z* before the instruction;
  - the target is the primary memory at the address in register *Z*;
- the source is register *Q*.

Near hold format

1 4	5 8	9 12	13 16
1 1 1 0	* * * *	Z	Q

In this format, the target and source are registers *Z* and *Q*.

GIV – Add

After this instruction, the source is added to the target.

In the constant format, the source is sign-extended.

1 4	5 8	9 32
* * * *	1 0 0 0	* *

1 4	5 8	9 16
* * * *	1 0 0 0	* * * * * * * *

TAC – Subtract

After this instruction, the source is subtracted from the target.

In the constant format, the source is sign-extended.

1 4	5 8	9 32
* * * *	1 0 0 1	* *

1 4	5 8	9 16
* * * *	1 0 0 1	* * * * * * * *

FLD – Multiply

After this instruction, the source is multiplied by the target.

In the constant format, the source is sign-extended.

1 4	5 8	9 32
* * * *	1 0 1 0	* *

1 4	5 8	9 16
* * * *	1 0 1 0	* * * * * * * *

CUT – Divide

After this instruction, the source is divided by the target.

In the constant format, the source is sign-extended.

1 4	5 8	9 32
* * * *	1 0 1 1	* *

1 4	5 8	9 16
* * * *	1 0 1 1	* * * * * * * *

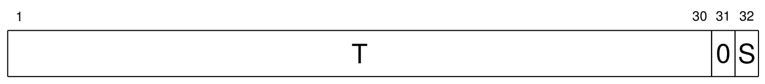
Chapter 7

Channel Units

The channel units facilitate data transfer into and out of primary memory. Each channel unit is made up of a *device* and a *execution unit*. Here will be described the execution unit's architecture.

Register File

IP – Instruction Pointer

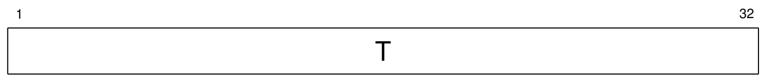


T Pointer

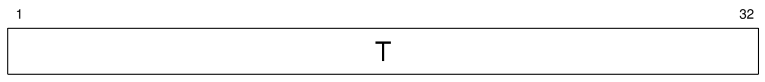
S State

- 0 Running
- 1 Stopped

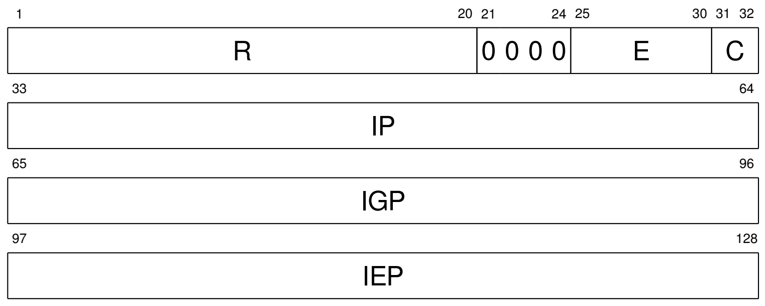
IGP – Interrupt Gate Pointer



IEP – Interrupt Entry Pointer



SR – Status Register



R Root Table Pointer

E Exception Code

C Condition Code

IP	Instruction Pointer
IGP	Interrupt Gate Pointer
IEP	Interrupt Entry Pointer

Instructions

Each instruction determines the unit's state.

1	2	3 … 32
Z	U	* *

Z	State
	0 Running
	1 Stopped
U	Interrupt

After each instruction:

- *S* in *IP* is set to *Z* of the instruction;
- if the U-bit is 1, then the unit writes the interrupt entry at *IEP* to *IGP*.

Control Instruction

A control instruction changes the run of the program.

A control instruction has two formats.

Memory Format

In this format, *IP* is set to the value in the primary memory whose address is the sum of *IP* and *A*.

1	2	3	4	5 … 10	11 … 32
*	*	0	0	0 0 0 0 0 0	A

Constant Format

In this format, *IP* is set to the sum of *IP* und *A*.

1	2	3	4	5 … 10	11 … 32
*	*	0	1	0 0 0 0 0 0	A

Transfer Instruction

A transfer instruction describes a data transfer between primary memory and the device.

A transfer instruction has two formats.

Memory Format

1	2	3	4	5 … 10	11 … 32
*	*	1	0	0 0 0 0 0 *	A

In this format, *A* points to a transfer descriptor.

1 … 32
A

33 … 64
L

A	Anschrift
L	Lange

Immediate Format

1	2	3	4	5 … 10	11 … 32
*	*	1	1	0 0 0 0 0 *	L

33 … 64
A

In this format:

- *L* is the number of 8-strings to transfer;
- *A* is the address to which the data will be transferred.

Read

After this instruction, the specified number of 8-strings will be transferred from primary memory to the device.

1	2	3	4	5 … 10	11 … 32
*	*	*	0	0 0 0 0 0 0	A

1	2	3	4	5 … 10	11 … 32
*	*	*	1	0 0 0 0 0 0	L

33 … 64
A

Write

After this instruction, the specified number of 8-strings will be transferred from the device to primary memory.

1	2	3	4	5 … 10	11 … 32
*	*	*	0	0 0 0 0 0 1	A

1	2	3	4	5 … 10	11 … 32
*	*	*	1	0 0 0 0 0 1	L

33 … 64
A

Operation

Programs

The channel unit starts a program when it is interrupted with a status register entry in which *S* in *IP* is **Running**.

Traps

The channel unit writes *IP* to the primary memory following *IGP* + 4.

The channel then executes a program consisting of a single control instruction with the following fields:

- *Z* set to 1;
- *U* set to 1;
- *A* set to 0.