Math Co-Processor 8087

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INTRODUCTION

- 8087 was the first math coprocessor for 16-bit processors designed by Intel.
- It was built to pair with 8086 and 8088.
- The purpose of 8087 was to speed up the computations involving floating point calculations.
- Addition, subtraction, multiplication and division of simple numbers is not the coprocessor's job.
- It does all the calculations involving floating point numbers like scientific calculations and algebraic functions.

INTRODUCTION

- By having a coprocessor, which performs all the calculations, it can free up a lot of CPU's time.
- This would allow the CPU to focus all of its resources on the other functions it has to perform.
- This increases the overall speed and performance of the entire system.
- This coprocessor introduced about 60 new instructions available to the programmer.
- All the mnemonics begin with "F" to differentiate them from the standard 8086 instructions.
- For e.g.: in contrast to ADD/MUL, 8087 provide FADD/FMUL.

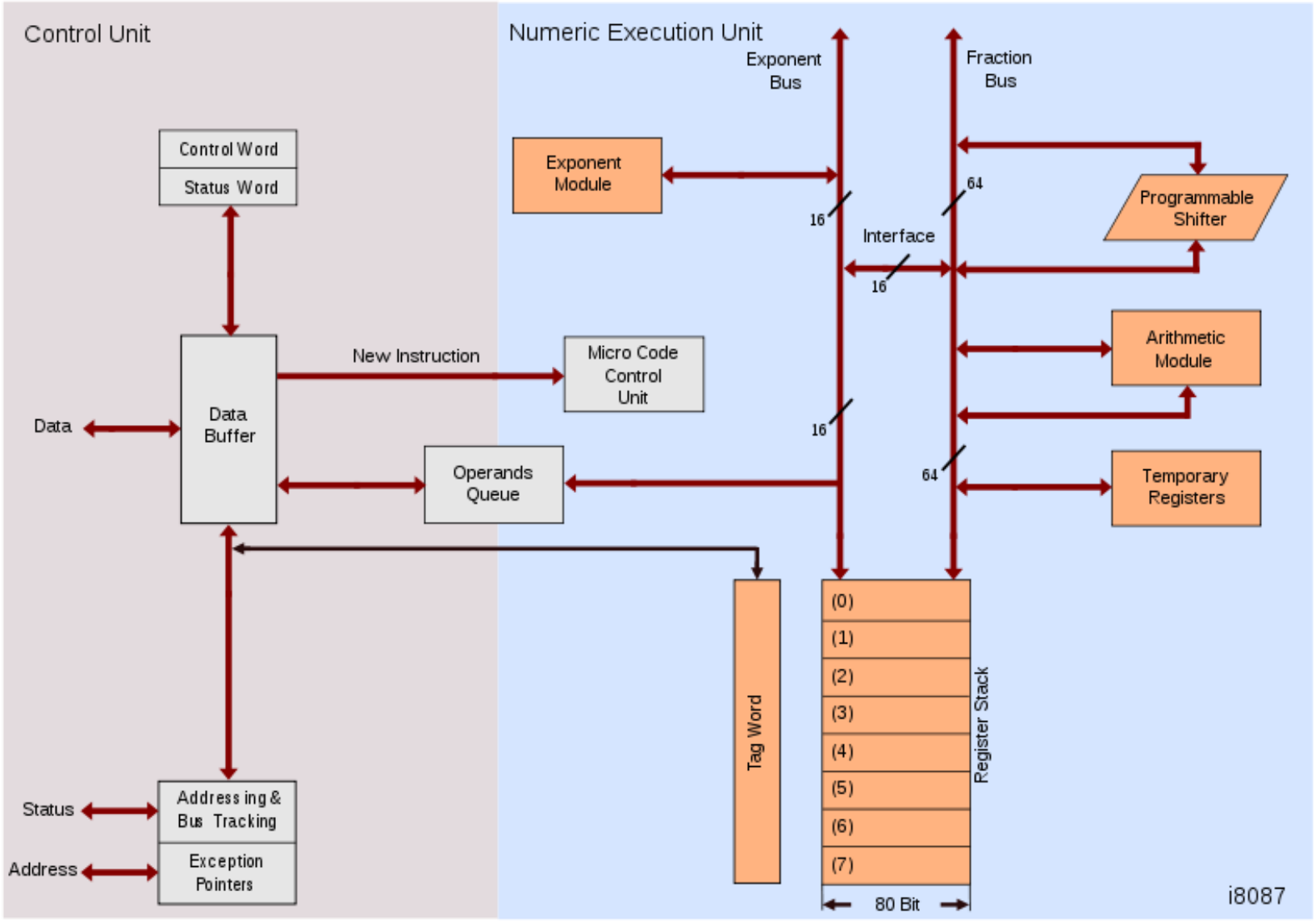
INTRODUCTION

- Math coprocessor is also called as:
  - Numeric Processor Extension (NPX)
  - Numeric Data Processor (NDP)
  - Floating Point Unit (FPU)

Architecture of 8087

- 8087 coprocessor is designed to operate with 8086 microprocessor.
- The microprocessor and coprocessor can execute their respective instructions simultaneously.
- Microprocessor interprets and executes the normal instruction set and the coprocessor interprets and executes only the coprocessor instructions.
- All the coprocessor instructions are ESC instructions, i.e. they start with “F”.

ARCHITECTURE OF 8087



Architecture of 8087

- The internal structure of 8087 coprocessor is divided into two major sections:
  - Control Unit (CU)
  - Numerical Execution Unit (NEU)

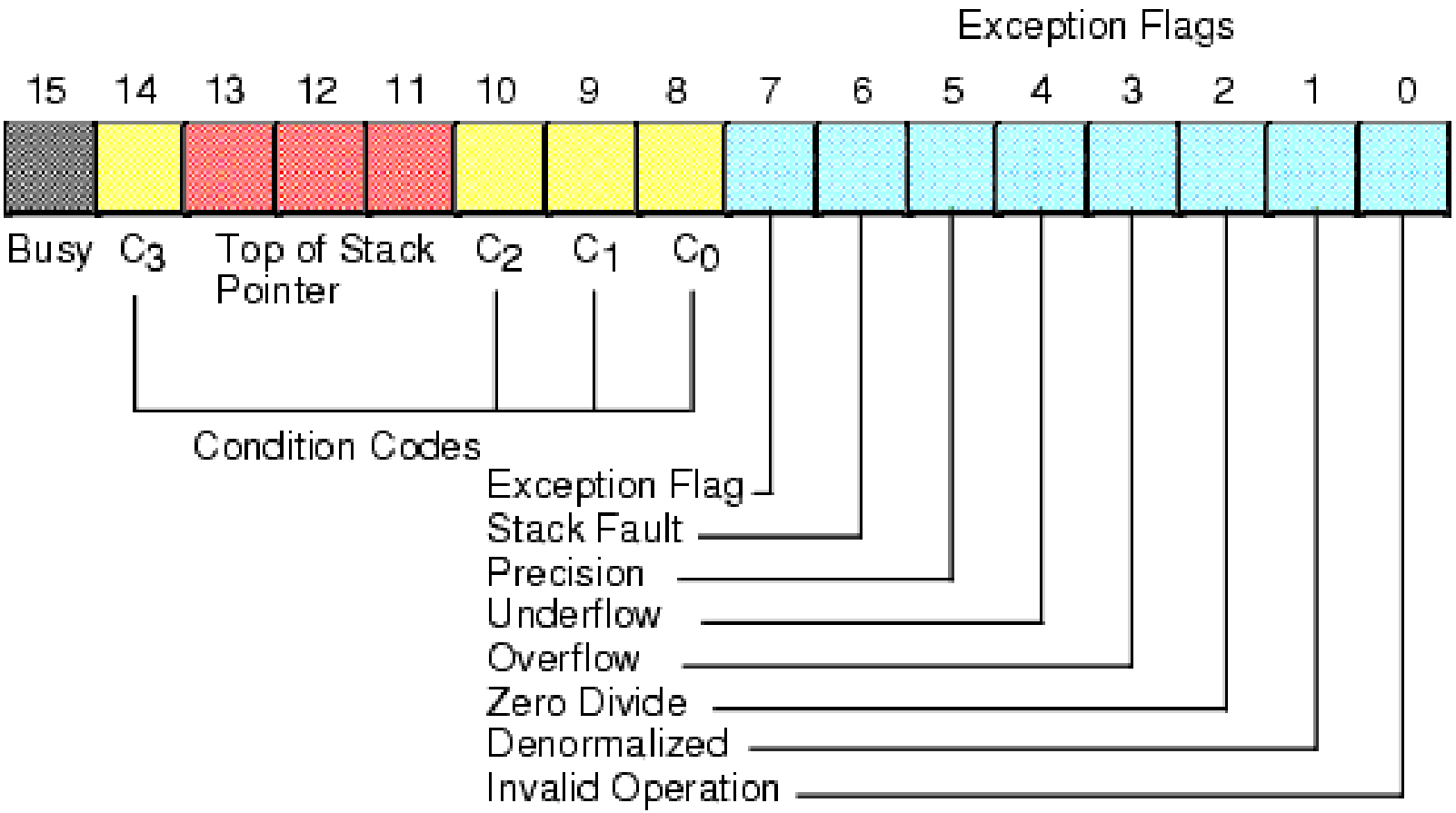
Control Unit (CU)

- It interfaces coprocessor to the microprocessor system bus.
- It also synchronize the operation of the coprocessor and the microprocessor.
- This unit has a Control Word, Status Word and Data Buffer.
- If an instruction is ESC instruction, then coprocessor executes it.
- If not, then microprocessor executes.

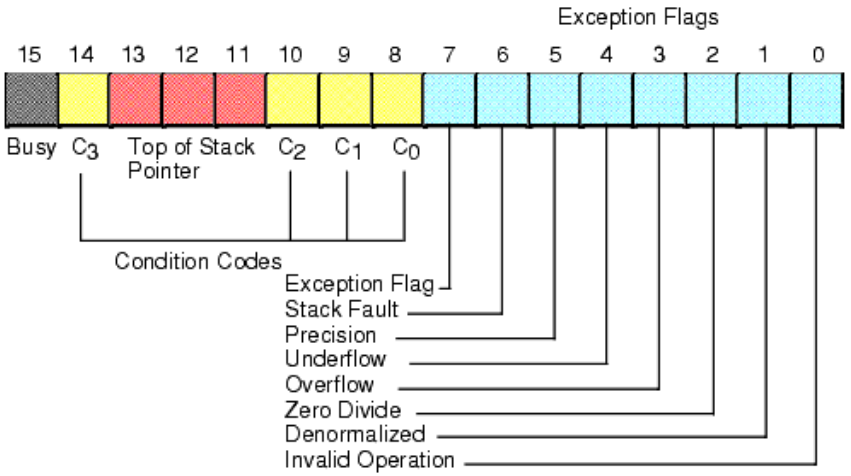
Numeric Execution Unit (NEU)

- This unit is responsible for executing all coprocessor instructions.
- It has an 8 register stack that holds the operands for instructions and result of instructions.
- The stack contains 8 registers that are 80-bits wide.
- Numeric data is transferred inside the coprocessor in two parts:
  - 64-bit mantissa bus
  - 16-bit exponent bus

STATUS REGISTER

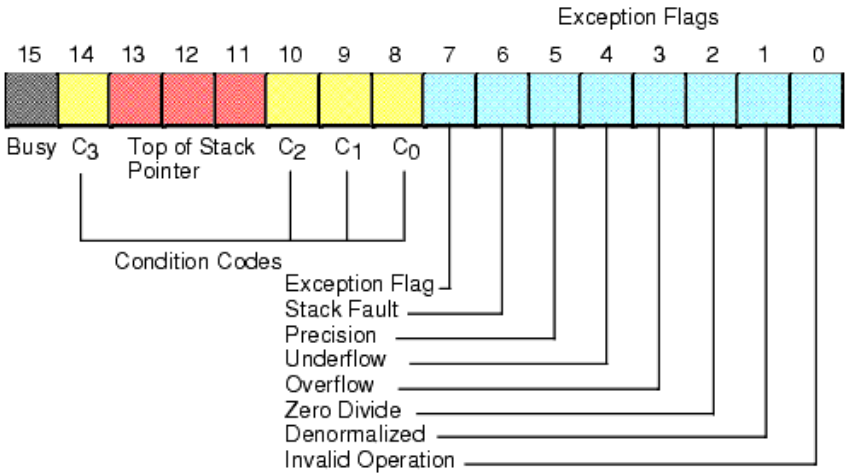


STATUS REGISTER



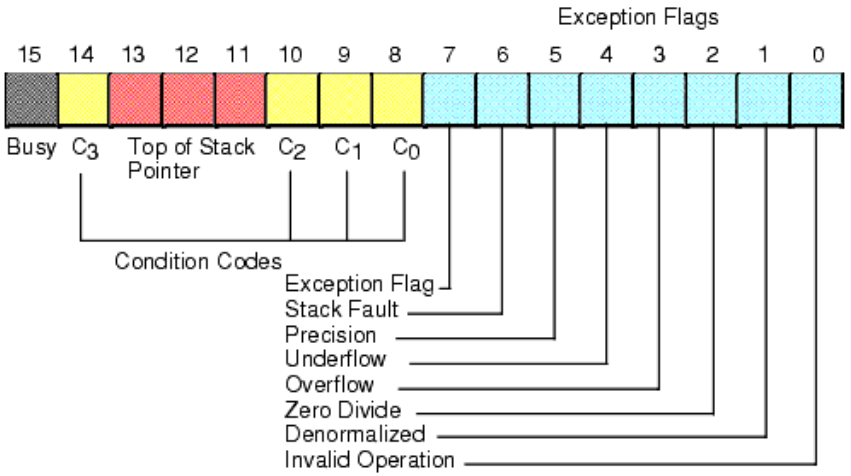
- Status Register tells the overall status of 8087 coprocessor.
- It is a 16-bit register.
- It is accessed by executing the FSTSW instruction.
- This instruction stores the contents of status register into memory.
- Once the status is stored in memory, the bit positions of the status register can be examined.

STATUS REGISTER



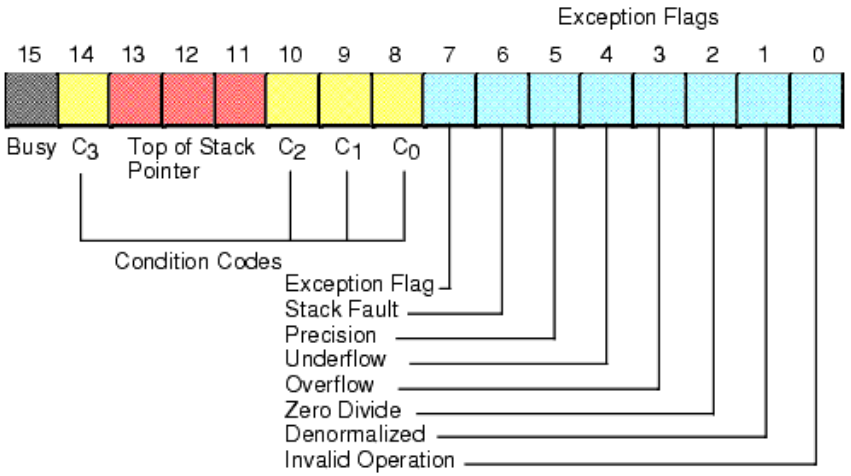
- **Busy:** It indicates that the coprocessor is busy executing the task.
- **Condition Codes (C_0-C_3):** They indicate various conditions about the coprocessor.
- **Top of Stack:** It indicates a register as top of stack register, out of the eight stack registers.
- **Exception Flag:** It is set if any of the exception flag bits (SF, PR, UF, OF, ZD, DN, IO) are set.

STATUS REGISTER



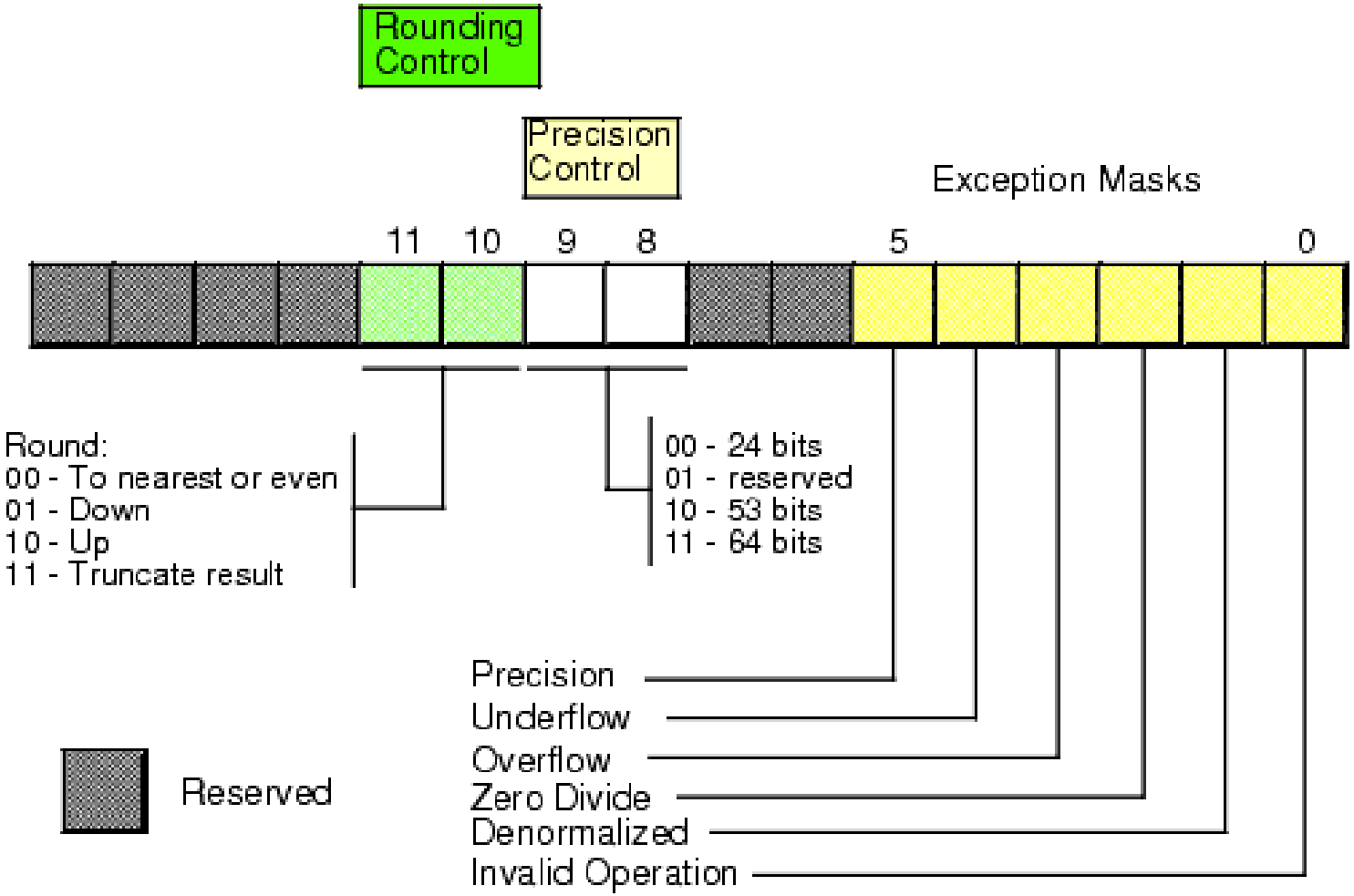
- **Stack Fault:** It is not available in 8087. It is active only in 80387 and above.
- **Precision:** It indicates that the result has exceeded the selected precision.
- **Underflow:** It tells if the result is too small to fit in a register.
- **Overflow:** It tells if the result is too large to fit in a register.

STATUS REGISTER

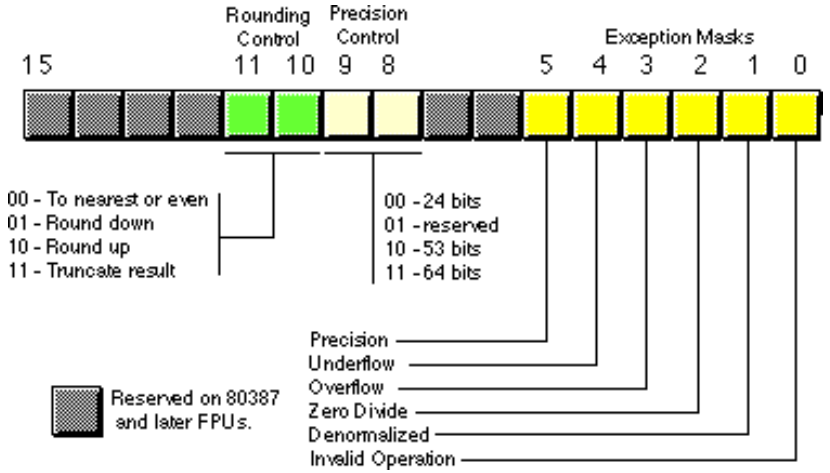


- **Zero Divide:** It indicates that you try to divide a non-zero value by zero.
- **Denormalized:** It indicates that at least one of the operand is de-normalized.
- **Invalid Operation:** It indicates an invalid operation. For e.g.: pushing more than eight items onto the stack, attempting to pop an item off an empty stack or taking the square root of a negative number.

CONTROL REGISTER

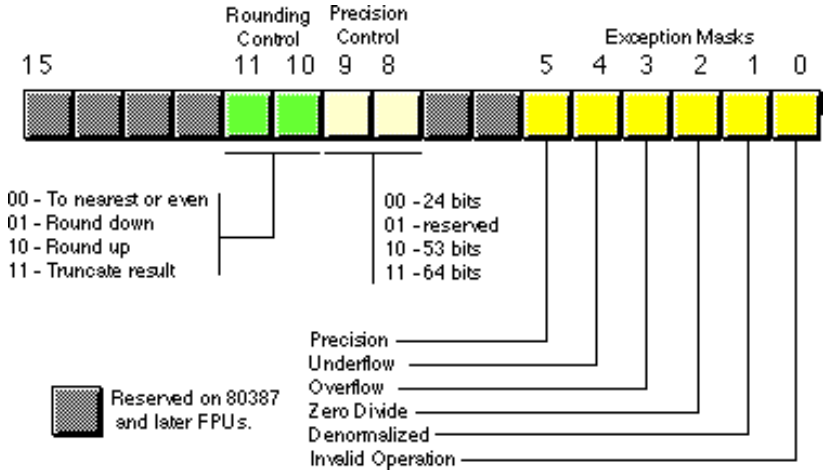


CONTROL REGISTER



- Control Register controls the operating modes of 8087.
- It is also a 16-bit register.
- It performs rounding control and precision control.
- It is also used to do masking and unmasking of the exception bits that correspond to the rightmost six bits of the status register.
- FLDCW instruction is used to load the value into control register.

CONTROL REGISTER



- **Rounding Control:** It determines the type of rounding or truncating to be done.
- **Precision Control:** It sets the precision of the result.
- **Exception Masks:** It determines that whether an error effects the exception bits in the status register.
  - If it is one, then the corresponding error is ignored.
  - If it is zero and the corresponding error occurs, then it generates an interrupt, and the corresponding bit in status register is set.

TAG REGISTER

TAG 7	TAG 6	TAG 5	TAG 4	TAG 3	TAG 2	TAG 1	TAG 0

Tag Values:
00 = Valid
01 = Zero
10 = Invalid
11 = Empty

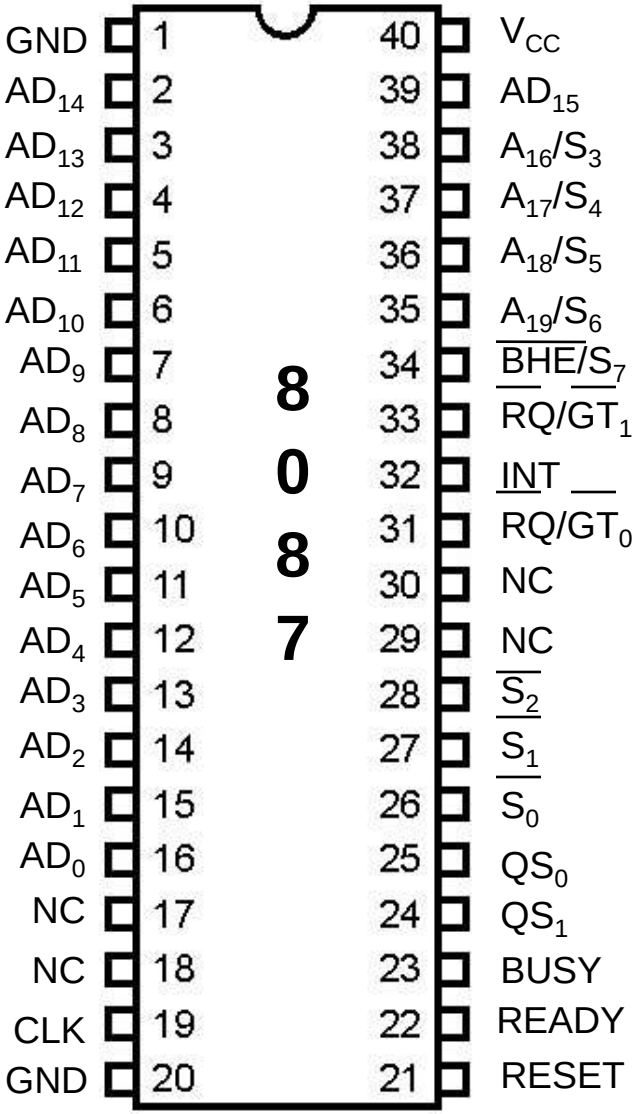
TAG 7	TAG 6	TAG 5	TAG 4	TAG 3	TAG 2	TAG 1	TAG 0

TAG REGISTER

Tag Values:
00 = Valid
01 = Zero
10 = Invalid
11 = Empty

- Tag Register is used to indicate the contents of each register in the stack.
- There are total 8 tags (Tag 0 to Tag 7) in this register and each tag uses 2 bits to represent a value.
- Therefore, it is a 16-bit register.

PIN DIAGRAM OF 8087



INTERFACING OF 8086 AND 8087

- Multiplexed address-data bus lines are connected directly from 8086 to 8087.
- The status lines and the queue status lines are connected directly from 8086 to 8087.
- The Request/Grant (RQ/GT_0 and RQ/GT_1) signals of 8087 are connected to RQ/GT_0 and RQ/GT_1 of 8086.
- BUSY signal of 8087 is connected to TEST pin of 8086.

Thank You

Have a Nice Day