LR35902 Documentation

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1 LEC 1: High-Level Details

1. **Name**: LR35902 (official manufacturer name) or SM83 (nickname by GBDev community)

   The CPU (Central Processing Unit) has three main jobs:

   - Fetch instructions from memory
   - Decode what those instructions mean
   - Execute them (math, moving, logic)

   The GB CPU is composed of essential subsystems:

   - **Registers:** They are "ultra-fast" storage cells built right into the CPU used to hold temporary/intermediate data. They are essential because they allow quick access and storage (due to their small sizes) as opposed to relying on a slower (due to its enormous size) main memory. There are five types of registers.
     - *General-Purpose*: The purpose is to hold numbers that the processor is currently working with. In the GB, there are 5 labeled B,C,D,E,H,L, each of which is an 8-bit (byte) register. Which means they can store a number from $0 - 2^8$. But sometimes the CPU needs to work with bigger numbers or memory addresses, so in the GB we can pair registers and treat them like a 16-bit unit. What happens in these cases is that the data stored is connected end-to-end where one register represents the high byte and the other the lower byte. The GB only allows 4 register pairs: AF, BC, DE, HL. They serve as the destinations for most operations. The collection of general purpose registers is also known as the register file.
     - *Accumulator (A)*: Special-purpose register used to hold one of the operands for arithmetic/logical operations and store the results of those operations.
     - *Flag Register (F)*: A register whose bits record the status of the last ALU operation. It essentially tells the CPU what happened in the last calculation. We label its bits from 0-7, and each bit except the 3-0 stores meaningful information. The first three are always 0. Here I list the bit number, its name, and its meaning:
       - **bit name meaning**
         - 7 Z-Zero 1 if the result was 0
         - 6 N-Subtract 1 if the operation was subtraction
         - 5 H-Half-carry 1 if a carry happend from bit 3→4
         - 7 C-Carry 1 if there was an overflow beyond 8 bits
     - *Program Counter (PC)*: A 16-bit register that holds the address of the next instruction to execute in memory.
     - *Stack Pointer (SP)*: A 16-bit register that points to the top of the stack in RAM (Random Access Memory).
   - **Arithmetic Logic Unit (ALU)**: The ALU performs the math and logic operations: +, -, AND, OR, XOR, comparison, bit shifts, and etc. Not much to say at the high level.
   - **Control Unit (CU)**: This entity decides what happens when. It takes an instruction and generates the control signals that make all the other parts cooperate in the right order.

- **Main Memory Interface**:
- **Buses**: The CPU communicated with memory and peripherals through parallel electrical paths, which transfer a fixed number of bits at a time. These pathways are called buses. And there are three types:
  - Address Bus: CPU's way of telling memory which memory location to access.
  - Data Bus: carries the data from to/from memory.
  - Control Bus: signals the type of operation

2. **Data Width**: Arithemtic Logic Unit (ALU) 8-bit and Address Bus 16-bit

3. **Clock**: DMG Clock 4.194304 MHz; CPU runs at 1/4 master per machine cycle (M-cycle = 4 T-cycles)

   Explanation: In a chip, there is a multitude of operations occurring at the same time. Whether it is a simple transistor or some circuitry, its signals need to be coordinated because practical operations are order/time-dependent. If hardware ran as fast as electrons can move, then it would be impossible to coordinate anything. Therefore, we need a clock to set a pace (a speed) and synchronize (make sure things happen in order or at the same time) for related hardware components. It is implemented with a repeating electrical signal (up and down wave) caused by a crystal oscillator due to its voltage properties. You should think about it as creating this time unit for which everything else will be based on. How many times per second this wave goes up and down would be the frequency of the clock, measured in Hertz (Hz $\equiv \frac{1cycle}{1second}$). For the GB, the crystal vibrates at 4.194304 MHz. Recall that M (Mega) is 10^6. The timekeeper is the crystal as it sends out perfectly spaced "ticks" (another word for cycle) to set a pace.

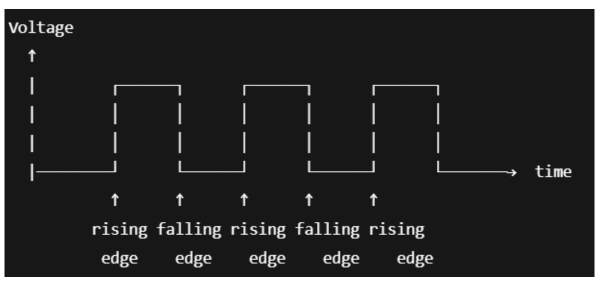

Figure 1: Clock Wave

The chip's logical units need to react in accordance with these pulses. The circuitry should update discretely, only when a specified clock edge arrives (usually the rising edge). Every subsystem on a motherboard ultimately divides or counts these pulses. Every tick can trigger:

- CPU to fetch/execute a micro-operation
- Memory read/write a byte
- graphics hardware to draw a pixel
- audit unit to move to the next waveform

In the GB, a cycle is called a T-cycle, and it is the smallest unit of time for which it operates. This is produced by the crystal, and it is referred to as the master clock. The CPU uses the pace unit of an M-cycle, which is 4 T-cycles. Each instruction takes a fixed number of M-cycles, and within it, each micro-operation consumes some T-cycles. Internally, the CPU's control unit counts those ticks so it knows exactly when it latches new data or signals "done."

Implementation: TO BE IMPLEMENTED ...