An Introduction to Lab3

Lecture 4 for Information Processing

Aaron Zhao, Imperial College London, a.zhao@imperial.ac.uk

What is in this lab?

- Design a NIOS II system that interfaces with the accelerometer on DE10-lite board.
- Understand the SPI interface.
- Learn how to read the acceleration value provided by the accelerometer.
- Design a low-pass FIR filter to process the readings.
- Investigate the impact of using low arithmetic precision to the quality of the results and the performance of your system.

Accelerometer

- Analog Devices' ADXL345 chip
- 3-axis accelerometer, it measures acceleration in three directions, which are referred to as x-axis, y-axis and z-axis.
- Serial Peripheral Interface (SPI) / I2C
- 16-bit digital output

How does NIOS interact with the accelerometer

- Add accelerometer_spi IP
  - IP controls the accelerometer and provides an SPI interface to NIOS
  - 58 internal registers
  - Memory mapped through two 8-bit registers: Address and Data
  - Memory mapped means they are mapped to specific memory addresses at the time the core is instantiated in a Qsys-developed system.

Address	7 · · · 6	5 · · · 0	
0x10004020	0	Addr	Address register
0x10004021	Data		Data register

Address	Register Name	Description
0x32	*DATAX0*	Low-order byte of *x*-axis acceleration.
0x33	*DATAX1*	High-order byte of *x*-axis acceleration.
0x34	*DATAY0*	Low-order byte of *y*-axis acceleration.
0x35	*DATAY1*	High-order byte of *y*-axis acceleration.
0x36	*DATAZ0*	Low-order byte of *z*-axis acceleration.
0x37	*DATAZ1*	High-order byte of *z*-axis acceleration.

Serial Peripheral Interface (SPI)

- Synchronous Serial Communication
- Short distances
- Embedded systems
- Duplex communication and a Master-Slave architecture

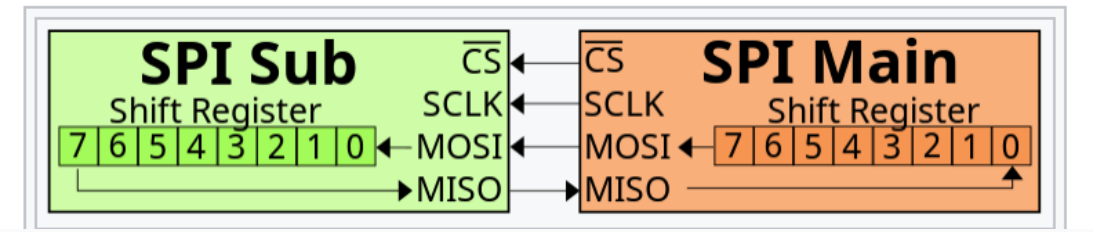
Serial Peripheral Interface (SPI)

SPI has four logic signals (which go by alternative namings):

- SCLK : Serial Clock (clock signal from main)
- MOSI : Main Out Sub In (data output from main)
- MISO : Main In Sub Out (data output from sub)
- CS : Chip Select

SPI communication

- Chip Select (CS) first, it is possible to have multiple slaves.
- Slave does not have the clock, you must provide one.
- Duplex communication, you are transferring and receiving at the same time.



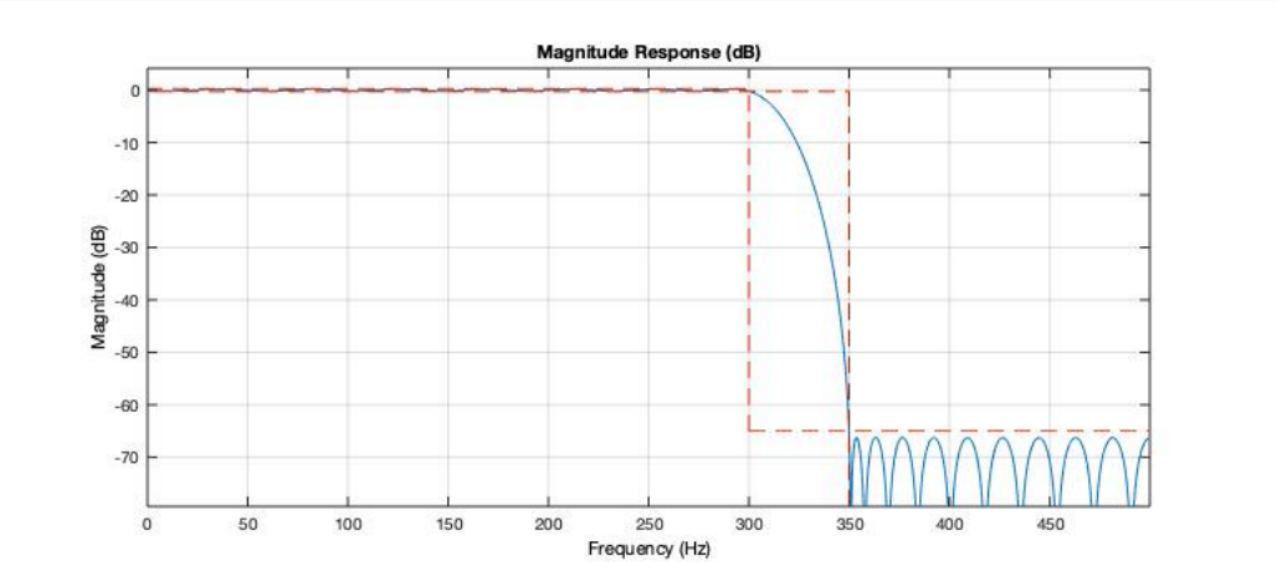
Program NIOS to read accelerometer values

- Understand code to interface with accelerometer
- Drive the LEDs with the accelerometer value

```
int main() {

    alt_32 x_read;
    alt_up_accelerometer_spi_dev * acc_dev;
    acc_dev = alt_up_accelerometer_spi_open_dev("/dev/accelerometer_spi");
    if (acc_dev == NULL) { // if return 1, check if the spi ip name is "accelerometer_spi"
        return 1;
    }

    timer_init(sys_timer_isr);
    while (1) {

        alt_up_accelerometer_spi_read_x_axis(acc_dev, & x_read);
        // alt_printf("raw data: %x\n", x_read);
        convert_read(x_read, & level, & led);

    }

    return 0;
}
```

FIR filter implementation and optimisation

- Moving average with a 5-tap filter
- Extend this to a low-pass N-tap filter
  - Use Matlab to design your filter
- Optimise you program
  - Convert floats to fixed-point values
  - Observe the impact on performance and results



Questions?

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