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Oscilloscope proposal to base Arduino DUE

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***Abstract*— The work presents measurement device-oscilloscope. The object of the investigation of my work was to design and implement this instrument. We analyze description diagram and description of the functionality of the device. The aim of the study was to Construct inexpensive, portable and user friendly oscilloscope. The work is divided into 4 chapters. It contains 1 tables and 5 images. The first chapter is devoted to the analysis of participation in other sections describing the block diagram. Finally, all parts are recovered issues and operation device.**

***Keywords:* — Oscilloscope, A/D converter, LCD display, SD card.**

I. INTRODUCTION

The period when the electrician does without measuring devices, must choose what best from a large number, yet pay attention to certain parameters like accuracy, robustness, cost and so on. Therefore, the main aim of the work is to create a two-channel oscilloscope that would be sufficiently accurate, fast and affordable. The oscilloscope will be used to display a continuous waveform on the LCD TFT screen. To address to use external converter with greater accuracy and greater speed. The main challenge lies in the involvement of individual components according to the scheme and well-written program for Arduino in C. In addition, the display will be allowed during the recording on micro SD card.

An oscilloscope is a laboratory instrument commonly used to display and analyze the waveform of electronic signals. In effect, the device draws a graph of the instantaneous signal voltage as a function of time. The device is shown in Fig. 1.

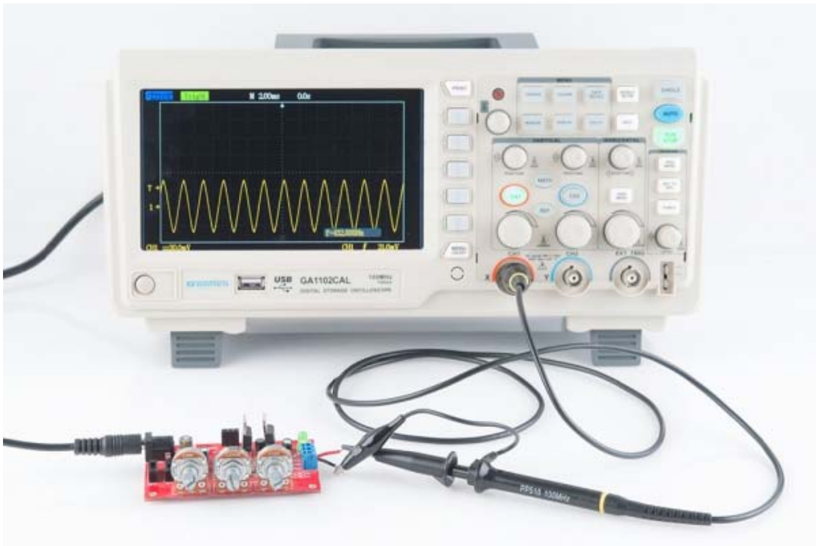

Fig. 1 Laboratory oscilloscope

A typical oscilloscope can display alternating current (AC) or pulsating direct current (DC) waveforms having a frequency as low as approximately 1 hertz (Hz) or as high as several megahertz (MHz). High-end oscilloscopes can display signals having frequencies up to several hundred gigahertz (GHz). The display is broken up into so-called horizontal divisions (hor div) and vertical divisions (vert div). Time is displayed from left to right on the horizontal scale. An instantaneous voltage appears on the vertical scale, with positive values going upward and negative values going downward. In any oscilloscope, the *horizontal sweep* is measured in seconds per division (s/div), milliseconds per division (ms/div), microseconds per division (s/div), or nanoseconds per division (ns/div). The *vertical deflection* is measured in volts per division (V/div), millivolts per division (mV/div), or microvolts per division (V/div). Virtually all oscilloscopes have adjustable horizontal sweep and vertical deflection settings.

<u>Oscilloscope divisions:</u>

According to the method of processing the input signal:

- Analog
- Digital

Based on the number of entries:

- Single channel
- Dual channel
- Multi-channel

According to the design:

- Portable
- Manually
- Connect to the PC… etc.

In the following chapters, we describe all the elements contained in the diagram, their properties, as well as ready-term involvement.

II. Analysis of Wiring

The principle of operation of the oscilloscope consists in rendering the input values (voltage) to the LCD screen display. Apart from one course we will show 2, in addition to record a course on micro SD card. Measured value enters the A/D converter, which is then converted into a digital signal that saves the Arduino and displayed on the display. The oscilloscope will contain 5 blocks that make up and it (Fig 1):

The principle of activities in the management of Arduino due. The first step is the connection of the measurement signal, which can be either AC or DC. After connecting with A / D converter, convert analog signals to digital. The signal, thus processed will be sent to the Arduino that processes it. All values are stored in the field and then drawn to the LCD screen. These values will be further processed eg. Store on external device (SD card). In addition, we will be able to measure 2 channels and plot it nicely on the display. You can also use the “print screen” button to save the shortcuts on the screen so that we can see them later.

This is how I designed it to be all-in-one. This is also a full-featured system and is especially cheap compared to commercial oscilloscopes that have a price of 300 Eur. The oscilloscope will contain 5 blocks that make up and it (Fig 2):

- Arduino DUE
- LCD display
- A/D converter (2 channel)
- SD card shield
- Measured value

In the following chapters we will describe individual blocks and also their parameters.

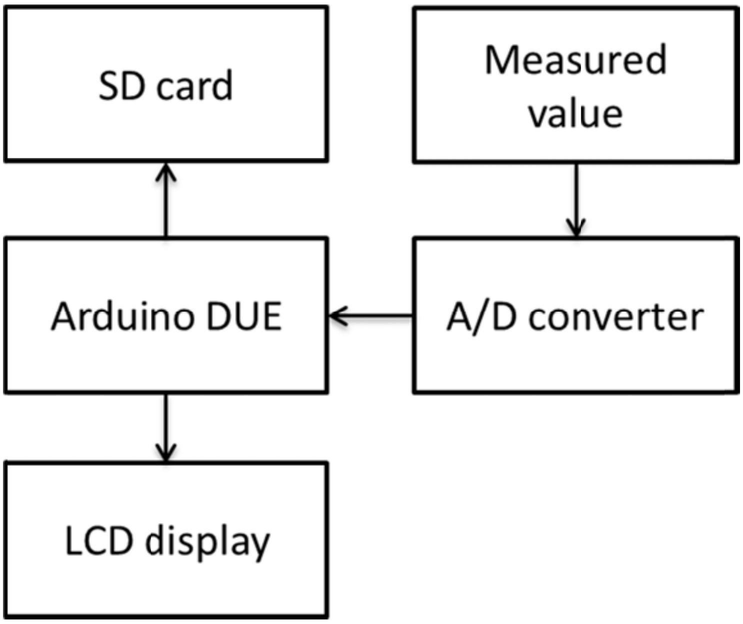

Fig. 2 Block diagram.

A. Arduino DUE

The Arduino DUE is the first Arduino board based on a 32-bit ARM core microcontroller. With 54 digital input/output pins, 12 analog inputs, it is the perfect board for powerful larger scale Arduino projects.

Fig. 3 Arduino DUE.

The Arduino DUE is a microcontroller board based on the Atmel SAM3X8E ARM Cortex-M3 CPU. It is the first Arduino board based on a 32-bit ARM core microcontroller. It has 54 digital input/output pins (of which 12 can be used as PWM outputs), 12 analog inputs, 4 UARTs (hardware serial ports), a 84 MHz clock, a USB OTG capable connection, 2 DAC (digital to analog), 2 TWI, a power jack, an SPI header, a JTAG header, a reset button and an erase button. The Arduino works with 3.3V voltage. Applying voltages higher than 3.3V to any I/O pin could damage the board.

Next Arduino consist of programming and native port. Programing port used to programming Arduino and a native port to the connect native devices (Mouse, Keyboard etc.).

Table I.
Technical specs – microcontroller.

Microcontroller	AT91SAM3X8E
Operating Voltage	3.3V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-16V
Digital I/O Pins	54 (of which 12 provide PWM output)
Analog Input Pins	12
Analog Output Pins	2 (DAC)
Total DC Output Current on all I/O lines	130 mA
DC Current for 3.3V Pin	800 mA
DC Current for 5V Pin	800 mA
Flash Memory	512 KB all available for the user applications
SRAM	96 KB (two banks: 64KB and 32KB)
Clock Speed	84 MHz
Length	101.52 mm
Width	53.3 mm
Weight	36 g

B. LCD display

3.2 Inch TFT LCD with 262K color 480x320 resolutions. The controller of this LCD module is HX8357B, it supports 16-wires Data Bus interface. Moreover, this module includes the 5V-3.3V power conversion circuit and Level conversion circuit. The displays are: touch and touch-free. We use free-touch screen.

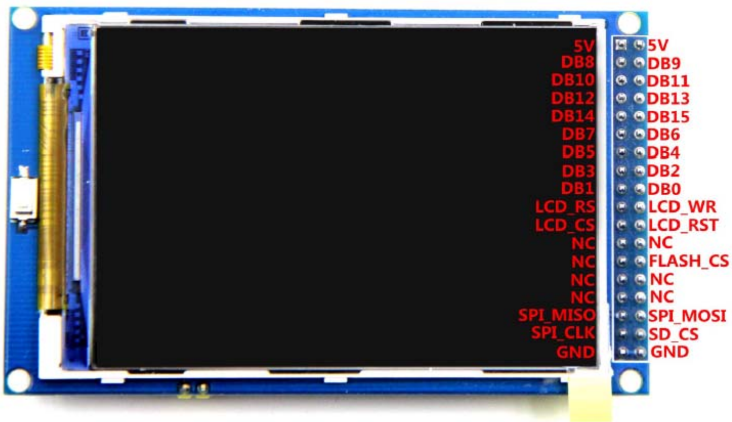

Fig. 4 LCD connection pin.

The display contains 16 data wires and 11 wires for correct viewing (Fig 4). To use anything to display or retrieve, we use the UTFT library. We can use it to list large, small letters, or to display circles, squares, points, lines, and so on.

Parameters:

- Display Type: 3.2 inch a-si TFT LCD Module
- Glass Type: TFT IPS (Full-Angle)
- Display Resolution: 480 X RGB X 320 Pixels

- Back light: 6 chip HighLight white LEDs
- Control IC: ILI9481
- Interface: 16Bit parallel interface
- PCB Module size: 89.92mm x 54.25mm
- LCD Area (WxHxT): 50.74mm x 78.35mm x 1.88mm
- Active Area (WxH): 67.68mm x 45.12mm

Fig. 5 TFT LCD display.

C. Micro SD card shield

This is the SD card shield for Arduino. It provides a storage space for your Arduino. Users can read/write SD card via the Arduino's built-in SD library. It supports SD, SDHC and Micro SD cards. It will only occupy the SPI port of your Arduino. Comparing to previous versions, it combines the standard SD slot and the Micro SD slot into a standard one, the included adaptor enables using of Micro SD cards.

Basic information:

This SD shield support Micro SD Card, Micro SDHC card (high-speed card). The level conversion circuit board that can interface level is 5V or 3.3V. We used this, because Arduino due has operation voltage 3,3V. Communication interface is a standard SPI interface. Control Interface has a total of six pins (GND, VCC, MISO, MOSI, SCK, CS) and GND to ground. VCC is the power supply, MISO, MOSI, SCK is the SPI bus, CS is the chip select signal pin. Regulator circuit 3.3V - LDO regulator output 3.3V as level converter chip, Micro SD card supply. Level conversion circuit: Micro SD card into the direction of signals into 3.3V - 5V, MicroSD card toward the direction of the control interface MISO signal is also converted to 3.3V, the general AVR microcontroller system can read the signal. The micro SD card connector has been since the bomb deck for easy card insertion and removal. Finally PCB Dimensions: 38 (L) mm * 18mm (W) * 1.6mm (thickness).

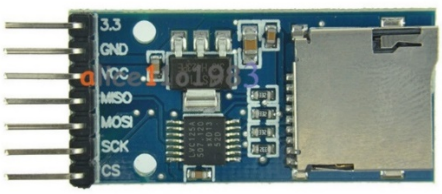

Fig. 6 Micro SD card shield.

D. A/D converter

An analog-to-digital converter, or ADC as it is more commonly called, is a device that converts analog signals into digital signals. Analog information is transmitted by modulating a continuous transmission signal by amplifying a signal's strength or varying its frequency to add or take away data. Digital information describes any system based on discontinuous data or events. This digital signal needs computer to the processing data.

We have different types of converters and that:

- 8 bits
- 16 bits
- 24bits…

For example 16 bit converter ADS1115 and 24 bit converter HX711:

The ADS1115 devices (ADS111x) are precision, low-power, 16-bit, I2C-compatible, analog-to-digital converters (ADCs) offered in an ultra-small, leadless, X2QFN-10 package, and a VSSOP-10 package. The ADS111x devices incorporate a low-drift voltage reference and an oscillator. The ADS1115 also incorporate a programmable gain amplifier (PGA) and a digital comparator. These features, along with a wide operating supply range, make the ADS111x well suited for power- and space-constrained, sensor measurement applications.

The ADS111x perform conversions at data rates up to 860 (about 3.4 MHz) samples per second (SPS). The PGA offers input ranges from ±256 mV to ±6.144 V, allowing precise large- and small-signal measurements. The ADS1115 features an input multiplexer (MUX) that allows two differentials or four single-ended input measurements. Use the digital comparator in the ADS1115 for under- and overvoltage detection.

Fig. 5 A/D converter ADS1115

Based on Avia Semiconductor's patented technology, HX711 is a precision 24-bit analog to-digital converter (ADC) designed to weigh scales and industrial control applications to interface directly with a bridge sensor. The input multiplexer selects either Channel A or B differential input to the low-noise programmable gain amplifier (PGA). Channel A can be programmed with a gain of 128 or 64, corresponding to a full-scale differential input voltage of ±20mV or ±40mV respectively, when a 5V supply is connected to AVDD analog power supply pin. Channel B has a fixed gain of 32. Onchip power supply regulator eliminates the need for an external supply regulator to provide analog power for the ADC and the sensor. Clock input is flexible. It can be from an external clock source, a crystal, or the on-chip oscillator that does not require any external component. On-chip power on-reset circuitry simplifies digital interface initialization. There is no programming needed for the internal registers. All controls to the HX711 are through the pins. It is completely accurate, but too slow (about 10 - 80 Hz)

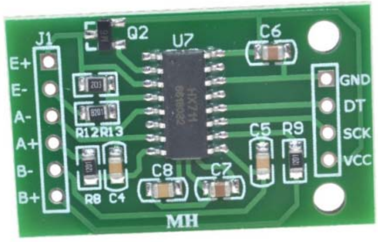

Fig. 2 A/D converter HX711

III. Operation Device

For proper operation of the device, it is necessary to correctly connect the LCD display and all external devices. After attaching the hardware, we need to load the software into the Arduino using the right library. In order to communicate with the display and other external devices (SD card, AD converter etc.). The code contains, in addition to plotting input values, the oscilloscope setting buttons: voltage (axis y), time (axis x) and trigger. The other button is for storing the image and values on the SD card. This is all we can do with 2 channels. All these parts create an overall device – oscilloscope (Fig 9,10).

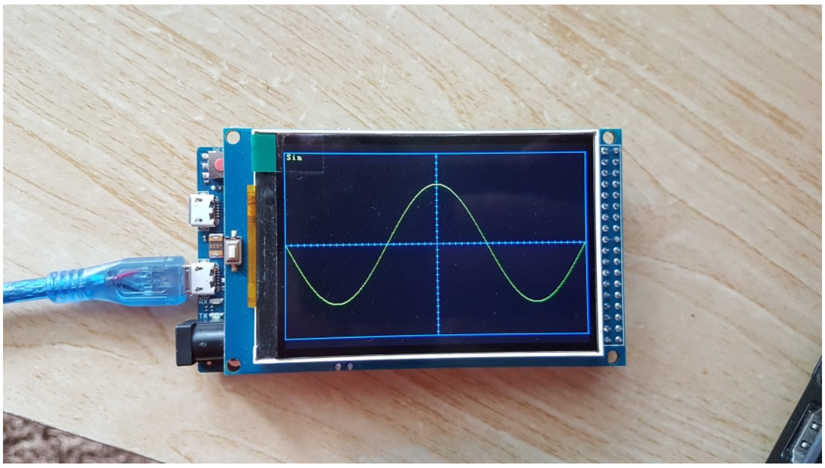

Fig. 9 Oscilloscope.

The picture shows the ready connection and the progress of the sinusoidal signal. In this way I will display all the events that we want to measure. In addition to AC voltage, we can also measure DC voltage. This use is in two channels to compare them to each other. The most important information is that a voltage divider needs to be connected to the input. The voltage range is estimated at 100V.

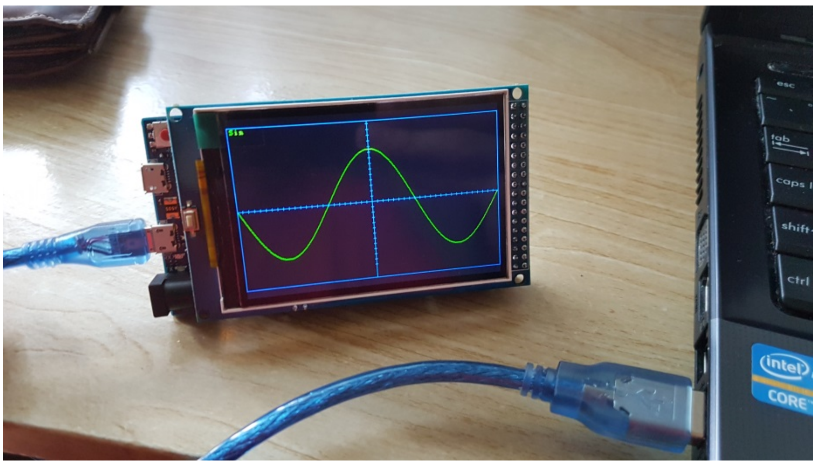

Fig. 3 Oscilloscope.

IV. CONCLUSION

In this work, we have designed and implemented a 2-channel oscilloscope. For optimal functionality and operation of the equipment participated in these 4 parts: Arduino LCD display, micro SD card shield, A/D converter, each of which perform their tasks. All parts suitably connected by functional schemes, we recorded program to the Arduino, and finally, we launched a program to control the oscilloscope. Run complex wiring was operational.

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