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AD9850 based function generator

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ABSTRACT

Function generator consists of the main generator and a modulation generator. The main generator provides sine, square, or triangular wave output with a frequency range of 0.01Hz to 13MHz. The modulation generator generates sine, square, and triangle waveforms with a frequency range of 0.01Hz to 10kHz. The input signal generator can be used as Amplitude Modulation (AM) or Frequency Modulation (FM). The AM envelope can be adjusted from 0% to 100%, while the carrier frequency of FM can be set up to ± 5%. Function generator generally produces frequencies in the range of 0.5Hz to 20MHz or more depending on the manufacturer's design. The resulting frequency can be selected by rotating the frequency range knob. The amplitude signal can be adjusted within a range from 0.1V to 20Vpp (peak-to-peak voltage) at no-load conditions and 0.1V to 10Vpp with a load of 50ohms. The main output is specified by SYNC Output. This research makes a wave generator and its frequency, as well as DDS AD9850 as a wave reader sensor on the oscilloscope using Arduino Uno to generate waves and a rotary encoder as a frequency regulator. Based on the experiment by varying frequency, peak-to-peak voltage and period are produced as follows: if the frequency at 50Hz, then the peak-to-peak voltage is 1.2Vpp and period (T) is 0.006s if the frequency at 100Hz, then the peak-to-peak voltage is 1.2Vpp and period is 0.005s if the frequency at 150Hz then the peak-to-peak voltage is 1.2Vpp and period is 0.034s if the frequency at 1KHz then the peak-to-peak voltage is 1.2Vpp and period is 0.0006s if the frequency at 1.5KHz then the peak-to-peak voltage is 1.2Vpp and period is 0.0004s, and finally if the frequency at 2KHz then 1.2Vpp and period are 0.000225s.

1. Introduction

Basically, a function generator is a part of electronic equipment or software testing that is used to generate electric waves [1][2]. Another type of function generator is a sub-system that provides an output proportional to the input of mathematical functions [3][4][5]. For example, the output is proportional to the square root of the input. Such devices are used in feed control systems and analog computers [6]. An analog function generator generally generates a triangular wave as the basis of all its output [7]. This triangle is generated by a capacitor being repeatedly charged and discharged from a constant current source and resulted in a linear increasing and decreasing voltage ramp. When the output voltage reaches the upper and lower limits, the charging and discharge process is reversed using a comparator, thus produces a linear triangular wave [8]. By varying currents and capacitor sizes, different frequencies can be generated.

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Meanwhile, DDS Signal Generator Module is a wave generator module that uses AD9850 CMOS 125 MHz DDS Synthesizer IC produced by Analog Devices, Inc. [9]. This IC uses the latest high-performance Digital-to-Analog Converter technology to synthesize frequencies (frequency synthesizer) [10]. With an active crystal oscillator with 125 MHz frequency as a very high-precision pulse source, this module generates a pure spectral analog sine wave with programmable frequency/phase [11]. This output wave can be used directly as a frequency source, or it can also be converted to a digital square wave as a responsive high-accuracy timer source [12]. Therefore, this research intends to maximize the 125 MHz frequency output stated in AD9850 specifications and produces more precise and accurate data analysis using 2 sine waves and 2 square waves.

2. The Proposed Function Generator

The goal of this research is to design a function generator to generate sine and square waves using AD9850 [13] and Arduino Uno R3 modules [14][15][16][17]. AD9850 module functions as a wave generator using AD9850 CMOS 125 MHz IC [18][19]. The Block diagram of the proposed function generator is shown in Fig. 1.

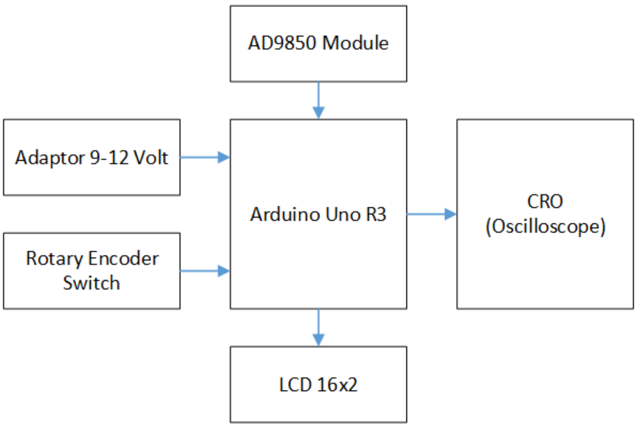

Fig.1. Block diagram of the proposed function generator.

The Block diagram in Fig. 1 represents the flow process of the whole system. Arduino Uno R3 (in the middle position) has a function to control all of the inputs and outputs. This function generator device is supplied using a power supply which is an adapter with a working voltage between 9-12 volts. In addition, this function generator device uses a series of AD9850 modules that function is to generate waves in the function generator. To adjust the amount of frequency input on the function generator device, a rotary encoder switch component is used. The rotary encoder has two output pins that produce a pulse signal which is processed first to get the direction of rotation. The output of this function generator (frequency value) is displayed on a 16x2 LCD display. Setting and selection of the frequency magnitude are also displayed on the 16x2 LCD. The waves generated from the AD9850 module after going through some processing on Arduino Uno R3 will be displayed in the oscilloscope.

A power supply circuit is a circuit that functions as a source of voltage for the circuit system. The voltage source that used in this research is an adapter that has a voltage output range of 3-12 volts DC. The power supply circuit can be seen in Fig. 2.

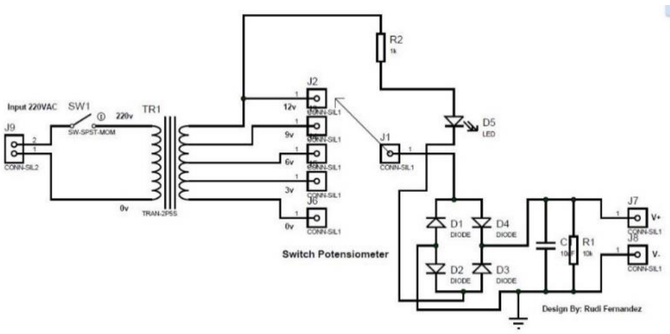

Fig. 2. Power supply adaptor switching 3V-12V schematic diagram.

Based on the schematic diagram shown in Fig. 2, the working principle of the power supply circuit is almost the same as the way the power supply works in general. The input of this power supply is a voltage of 220 VAC, which is connected to the input of the transformer. The transformer used in this power supply is a zero transformer type with a secondary voltage that is quite varied, from 3 volts to 12 volts. The transformer has a current capacity of 500 mA. AC voltage from the transformer is rectified by four H-bridge diodes. However, before the voltage is rectified by the H-bridge diode, it is selected by a potentiometer switch, which is a five-position rotary switch.

Fig. 3 shows the general flowchart of the proposed function generator device. Based on Fig. 3, the device is ready for use when it has been connected to the power supply and is on or active. When the device is turned on, the Arduino Uno microcontroller will make a declaration as well as initialize the library and I/O to the entire system. After carrying out the declaration and initialization of the library and I/O, it will process the data from the AD9850 DDS Signal Generator module. The results of this AD9850 module data processing will be fed to the rotary encoder. The rotary encoder switch will be the only circuit input that will adjust the frequency generated from the AD9850 module. When the rotary encoder button is pressed, the microcontroller will adjust the frequency based on the increment conditions that have been set in the program. After completing the frequency increment setting, this function generator will produce an output in the form of a sine wave signal which can be seen using a Cathode Ray Oscilloscope (CRO) measuring instrument.

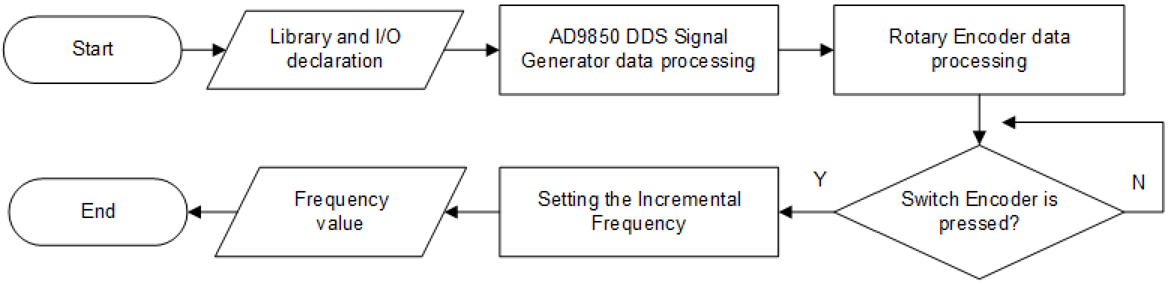

Fig. 3. Flowchart of the proposed function generator.

3. Results and Discussion

The proposed function generator device is evaluated by conducting several experiments such as power supply circuit test, microcontroller Arduino Uno R3 circuit test, rotary switch circuit test, LCD 16x2 circuit test, and finally, function generator test. The detailed experiment of each test is described as follows.

3.1. Power Supply Circuit Test

The first test is the power supply circuit test. Due to the very important function of the power supply in this study, namely as a voltage source that has a function to activate the device, the results of this test are sufficient to determine the device performance. The test is carried out by connecting Arduino voltage input to the power output connector of the power supply. Once connected, the test is carried out using a multi-meter with the red probe (+) mechanism connected to the voltage input pin and the black probe (-) connected to the ground pin on Arduino. The results of power supply circuit testing are presented in Table 1.

Table 1. The result of the power supply circuit test.

No	Adaptor voltage output (volt)	Arduino voltage input (volt)
1	11.56	11.33
2	9.25	9.15
3	7.70	7.30
4	6.00	5.80
5	5.00	4.98

Based on Table 1, the test was carried out five times by adjusting the position of the switch on the potentiometer to change the amount of voltage at the output of the power supply circuit. The result shows that the power supply circuit works or operates normally.

3.2. Arduino Uno R3 Circuit Test

The next experiment is to test the Arduino Uno R3 microcontroller circuit used in the device. The point or essence of this test is to ensure that the microcontroller board used in this device can work normally. The first test phase is to check the connection from the Arduino Uno to the USB connector on a PC or laptop. The successful test result is shown in Fig. 4.

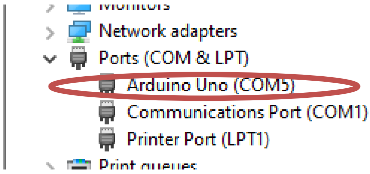

Fig. 4. Notification of port connection (COM and LPT) in device manager.

Based on Fig. 4 from the notification, it can be seen that the Arduino Uno device is detected at the COM ports address 5. The test is carried out five times to test the resilience of the USB cable connector that connects Arduino Uno to the computer. The test results can be seen in Table 2. Based on Table 2, the data retrieval results in a normal connection in all five times trials. With these results, Arduino Uno R3 can be used as the main microcontroller in the device.

Table 2. Ports connection test results

No	Trial number	Port detection result
1	1st connection test	OK
2	2nd connection test	OK
3	3rd connection test	OK
4	4th connection test	OK
5	5th connection test	OK

3.3. Rotary Encoder Switch Circuit Test

A rotary encoder switch circuit test is conducted to test the ability of the rotary encoder switch. The rotary encoder is a component that functions as a frequency value regulator in this function generator device. The rotary encoder switch test requires Arduino Uno R3, rotary encoder switch, and five rows of jumper cables. The rotary encoder testing is carried out using a basic program, as shown in Fig. 5. Based on Fig. 5, the listing program contains variable declarations and also initialization of input/output in the function setup().

```
int encoderPin1 = 2;
int encoderPin2 = 3;
int encoderSwitchPin = 4; //push button switch
volatile int lastEncoded = 0;
volatile long encoderValue = 0;
long lastencoderValue = 0;
int lastMSB = 0;
int lastLSB = 0;
void setup() {
  Serial.begin (9600);
  pinMode(encoderPin1, INPUT);
  pinMode(encoderPin2, INPUT);
  pinMode(encoderSwitchPin, INPUT);
  digitalWrite(encoderPin1, HIGH); //turn pullup resistor on
  digitalWrite(encoderPin2, HIGH); //turn pullup resistor on
  digitalWrite(encoderSwitchPin, HIGH); //turn pullup resistor on

  //on interrupt 0 (pin 2), or interrupt 1 (pin 3)
  attachInterrupt(0, updateEncoder, CHANGE);
  attachInterrupt(1, updateEncoder, CHANGE);
}
```

```
void loop(){
  if(digitalRead(encoderSwitchPin)){
     // program that being ran when the center switch is not pressed
  }
  else {
    // program that being ran when the center switch is pressed
    encoderValue=0;
  }
  Serial.println(encoderValue);
  delay(100);
}

void updateEncoder(){
  int MSB = digitalRead(encoderPin1); //MSB = most significant bit
  int LSB = digitalRead(encoderPin2); //LSB = least significant bit
  int encoded = (MSB << 1) |LSB;
  int sum  = (lastEncoded << 2) | encoded;
  if(sum == 0b1101) encoderValue++;
  if(sum == 0b1110) encoderValue--;
  lastEncoded = encoded; //store this value for next time
}
```

Fig. 5. Listing program to test the rotary encoder switch.

3.4. LCD 16x2 Circuit Test

The 16x2 LCD circuit testing aims to test the ability of the 16x2 LCD to display messages executed from the Arduino Uno microcontroller. The 16x2 LCD on this function generator device is used to display the frequency value generated from the AD9850 DDS Signal Generator module. The test uses a basic program to display messages on the LCD. The results of the 16x2 LCD circuit test and the testing program can be seen in Fig. 6 and Fig. 7. Based on Fig. 7, the program is used to display a message at the address setCursor (0,0).

Fig. 6. 16x2 LCD circuit testing result.

```
#include <LiquidCrystal_I2C.h>
LiquidCrystal lcd(4,5,6,7,12,13);
void setup() {
// put your setup code here, to run once:
lcd.begin();
lcd.clear();

lcd.setCursor(0,0);
```

Fig. 7. A program to test the LCD.

3.5. Function Generator Testing with Frequency Input 50-150 Hz

This test is carried out to see the sine wave generated from the signal processing in the AD9850 DDS Signal Generator module. Sine wave output generated from AD9850 DDS Signal Generator will be measured using a CRO (Cathode Ray Oscilloscope). The steps to take a measurement using CRO are explained as follows.

1. Make sure the ON-OFF switch is in the off position.
2. Position all buttons that have three positions in the middle.
3. Turn the INTENSITY knob to the center or center position.
4. Press the PULL 5X MAG button inward to get the normal position.
5. Connect the AC power line cord to the ACV socket.
6. Turn the ON-OFF switch to the ON position. Wait for twenty seconds. Then a line will appear on the CRT screen. If the line is not visible, please turn the INTENSITY dial clockwise.
7. Set the FOCUS and INTENSITY buttons to clarify the line path.
8. Rearrange the vertical and horizontal positions as needed.
9. Connect the probe to the channel input -A or -A (CH-A) or the channel input B or -B (CH-B) as needed.
10. Connect the probe to the CAL terminal to obtain a 0.5 Vpp calibration.
11. Position the vertical attenuator, the VOLT / DIV switch at the 10 mV position, and turn the VARIABLE knob clockwise. Turn TRIGGERING SOURCE to CH-A.

12. If the rectangular wave that displayed is not perfect, then adjust the trimmer located on the probe so that the perfect waveform will appear.
13. Finally, remove the probe from the 0.5 Vpp CAL terminal. The oscilloscope then can be used.

3.6. Function Generator Test with Frequency Input 50 Hz

The first test is to provide a frequency input of 50 Hz, which shown in Fig. 8a. Setting the CRO with configuration parameters shown in Fig. 8b. Based on the input frequency value of 50 Hz, a sine wave is obtained on the CRO which can be seen in Fig. 8c.

(a) Input frequency of 50 Hz (b) Configuration of the CRO (c) Sinewave result

Fig. 8. Sine wave results on CRO with input frequency 50 Hz.

Based on Fig. 8b, the volt / div setting is at (x 0.5) and the time / div setting is at (x 0.5). From the sine wave result in Fig. 8c, the Volt Peak to Peak and Period (T) are obtained, as follows.

Vpp = Vertical Div × volts / div
Vpp = 2.4 boxes x 0.5 volts / div
Vpp = 1.2 Vpp
T = Div Horizontal × Time / Div
T = 12 x 0.5 ms
T = 0.006 s

Based on the results of the calculations, the voltage value from peak to peak (Volt Peak to Peak) is 1.2 Vpp, and to produce one sine wave cycle, it takes time or a period of 6 ms or 0.006 seconds.

4. Conclusion

Based on the results of the experiment regarding the AD9850-based function generator, it is concluded that this research has successfully designed and applies a function generator prototype using DDS AD9850, which purposed as a sine wave generator, applies the DDS method to the function generator and implements rotary encoder function to adjust the frequency. DDS has many applications. One of them is a function generator. This research also has succeeded in getting a frequency with the range 10Hz - 30MHz. For future development, the AD9850-based Function Generator should optimize the use of DDS AD9850 until it reaches a higher frequency point so that it can be applied to produce larger waves. DDS AD9850 should focus on generating more square waves and triangular waves, and for the development of triangular waves, an inverter can be utilized.

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