Design and Implementation of Smart Real Time Bluetooth Controlled Signal Generator

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I. INTRODUCTION

A function generator is usually a piece of electronic test equipment or software used to generate different types of electrical waveforms over a wide range of frequencies. Some of the most common waveforms produced by the function generator are the Sine wave, Square wave, Triangular wave and Sawtooth shapes. These waveforms can be either repetitive or single-shot (which requires an internal or external trigger source). Integrated circuits used to generate waveforms may also be described as function generator ICs. In addition to producing sine waves, function generators may typically produce other repetitive waveforms including Sawtooth and Triangular waveforms, square waves, and pulses. Another feature included on many function generators is the ability to add a DC offset. Although function generators cover both audio and RF frequencies, they are usually not suitable for applications that need low distortion or stable frequency signals. When those traits are required, other signal generators would be more appropriate. Some function generators can be phase-locked to an external signal source (which may be a frequency reference) or another function generator. Function generators are used in the Development, Test and Repair of electronic equipment. For example, they may be used as a signal source to test amplifiers or to introduce an error signal into a control loop. Function generators are primarily used for working with analog circuits, related pulse generators are primarily used for working with digital circuits. The voltage comparator multivibrator changes state at a predetermined maximum level, of the integrator output voltage. This change cuts-off the current supply from supply source 1 and switches to the supply source 2. The current supply source 2 supplies a reverse current to the integrator so that its output drops linearly with time. When the output

Abstract:
Waveform generators (also called function generators) are useful for testing and debugging circuits. In general we often use them to test the frequency response of electronics components like op amp and sensors. This waveform generator is powered by an Arduino with Bluetooth control unit. The system can be controlled by pairing any Bluetooth enabled device with this generator. With the help of Application software in the device we can change the type of wave form, amplitude and brightness also. It outputs four wave shapes: sine, triangle, pulse, and saw, each wave shape ranges in frequency from 1Hz-50kHz. The frequency, pulse width, and overall amplitude (gain) of the waveforms is controlled by three potentiometers. I've also included (optional) indicator LEDs that let you know which type of wave is currently being sent to the output. This type of low cost systems can be used in academic laboratories for the students to generate wave forms, observation and as input to some other system analysis. These low cost portable real time signal generators can replace the old traditional generators with high cost and maintenance.

Keywords — ArduinoNANO, Bluetooth, Function Generator.
attains a predetermined level, the voltage comparator again changes state and switches on to the current supply source. The output of the integrator is a triangular wave whose frequency depends on the current supplied by the constant current supply sources. The comparator output provides a square wave of the same frequency as output. The resistance diode network changes the slope of the triangular wave as its amplitude changes and produces a sinusoidal wave with less than 1% distortion.

II. HARDWARE DESIGN
The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.0) or ATmega168 (Arduino Nano 2.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one. The Nano was designed and is being produced by Gravitech.

The Arduino Nano is very much similar to the Arduino UNO. They use the same Processor (Atmega328p) and hence they both can share the same program. One big difference between both is the size UNO is twice as big as Nano and hence occupies more space on your project. Also Nano is breadboard friendly while Uno is not. To program a Uno you need Regular USB cable where as for Nano you will need a mini USB cable. There is a considerable amount of difference between the Arduino Nano and the Arduino mega as the processor used itself is different. Arduino Mega is more powerful than an Arduino Nano in terms of speed and number of I/O pins. As you might guess the size is also bigger than an Arduino UNO. Arduino Mega is normally used for projects which require a lot of I/O pins and different Communication protocols

A Input and Output
Each of the 14 digital pins on the Nano can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms.

In addition, some pins have specialized functions: Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the FTDI USB-to-TTL Serial chip. External Interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details. PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the AnalogWrite() function. SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language. LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the...
LED is on, when the pin is LOW, it’s off. The Nano has 8 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the analogReference() function. Additionally, some pins have specialized functionality: I2C: 4 (SDA) and 5 (SCL). Support I2C (TWI) communication using the Wire library.

B Communication
The Arduino Nano has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega168 and ATmega328 provide UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An FTDI FT232RL on the board channels this serial communication over USB and the FTDI drivers (included with the Arduino software) provide a virtual com port to software on the computer. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the FTDI chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Nano's digital pins. The ATmega168 and ATmega328 also support I2C (TWI) and SPI communication.

C Programming
The Arduino Nano can be programmed with the Arduino software. Select "Arduino Diecimila, Duemilanove, or Nano w/ATmega168" or "Arduino Duemilanove or Nano w/ ATmega328" from the Tools > Board menu (according to the microcontroller on your board). The ATmega168 or ATmega328 on the Arduino Nano comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files). You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header.

D AD9833 Function Generator Module
The AD9833 is a low power, programmable waveform generator capable of producing sine, triangular, and square wave outputs. Waveform generation is required in various types of sensing, actuation, and time domain reflectometry (TDR) applications. The output frequency and phase are software programmable, allowing easy tuning. No external components are needed. The frequency registers are 28 bits wide: with a 25 MHz clock rate, resolution of 0.1 Hz can be achieved; with a 1 MHz clock rate, the AD9833 can be tuned to 0.004 Hz resolution. The AD9833 is written to via a 3-wire serial interface. This serial interface operates at clock rates up to 40 MHz and is compatible with DSP and microcontroller standards. The device operates with a power supply from 2.3 V to 5.5 V. The AD9833 has a power-down function (SLEEP).
This function allows sections of the device that are not being used to be powered down, thus minimizing the current consumption of the part. For example, the DAC can be powered down when a clock output is being generated. The AD9833 is available in a 10-lead MSOP package.

![Fig 4: AD9833 Module](image)

**E Circuit Description**

The AD9833 is a fully integrated direct digital synthesis (DDS) chip. The chip requires one reference clock, one low precision resistor, and decoupling capacitors to provide digitally created sine waves up to 12.5 MHz. In addition to the generation of this RF signal, the chip is fully capable of a broad range of simple and complex modulation schemes. These modulation schemes are fully implemented in the digital domain, allowing accurate and simple realization of complex modulation algorithms using DSP techniques. The internal circuitry of the AD9833 consists of the following main sections: a numerically controlled oscillator (NCO), frequency and phase modulators, SIN ROM, a DAC, and a regulator. The AD9833 includes a high impedance, current source 10-bit DAC. The DAC receives the digital words from the SIN ROM and converts them into the corresponding analog voltages. The DAC is configured for single-ended operation. An external load resistor is not required because the device has a 200 Ω resistor on-board. The DAC generates an output voltage of typically 0.6 V p-p. VDD provides the power supply required for the analog section and the digital section of the AD9833. This supply can have a value of 2.3 V to 5.5 V. The internal digital section of the AD9833 is operated at 2.5 V. An on-board regulator steps down the voltage applied at VDD to 2.5 V. When the applied voltage at the VDD pin of the AD9833 is less than or equal to 2.7 V, the CAP/2.5V and VDD pins should be tied together, thus bypassing the on-board regulator.

![Fig 5: AD9833 Pin Description](image)

**F Bluetooth HC05 Module**

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication. This serial port bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). Bluetooth module
HC-05 is a MASTER/SLAVE module. By default the factory setting is SLAVE. The Role of the module (Master or Slave) can be configured only by AT COMMANDS. The slave modules cannot initiate a connection to another Bluetooth device, but can accept connections. Master module can initiate a connection to other devices.

**G Pin Description**

The HC-05 Bluetooth Module has 6 pins. They are as follows:

**ENABLE:** When enable is pulled LOW, the module is disabled which means the module will not turn on and it fails to communicate. When enable is left open or connected to 3.3V, the module is enabled i.e., the module remains on and communication also takes place. **Vcc:** Supply Voltage 3.3V to 5V **GND:** Ground pin **TXD & RXD:** These two pins act as an UART interface for communication **STATE:** It acts as a status indicator. When the module is not connected to / paired with any other Bluetooth device, signal goes Low. At this low state, the led flashes continuously which denotes that the module is not paired with other device. When this module is connected to/paired with any other Bluetooth device, the signal goes High. At this high state, the led blinks with a constant delay say for example 2s delay which indicates that the module is paired. **BUTTON SWITCH:** This is used to switch the module into AT command mode. To enable AT command mode, press the button switch for a second. With the help of AT commands, the user can change the parameters of this module but only when the module is not paired with any other Bluetooth device. If the module is connected to any other Bluetooth device, it starts to communicate with that device and fails to work in AT command mode.

JST connectors are electrical connectors manufactured to the design standards originally developed by J.S.T. Mfg. Co. (Japan Solder less Terminal). JST manufactures numerous series (families) and pitches (pin-to-pin distance) of connectors. JST connectors are used in many types of products, and commonly used by electronics hobbyists and consumer products for rechargeable battery packs, battery balancers, battery eliminator circuits, and radio controlled servos. The term "JST" is incorrectly used as a vernacular term meaning any small white electrical connector mounted on PCBs. A majority of JST through-hole headers can't withstand the temperatures required for reflow soldering, because the plastic has a lower melting point since they were designed for wave soldering methods. Some JST surface-mount headers are designed to handle higher temperatures of reflow soldering. A lithium-ion battery or Li-ion battery (abbreviated as LIB) is a type of rechargeable battery in which lithium ions move from the negative electrode to the positive electrode during discharge and back when charging. Li-ion batteries use an intercalated lithium compound as one electrode material, compared to the metallic lithium used in a non-rechargeable lithium battery. Lithium-ion batteries are common rechargeable batteries for portable electronics, with a high energy density, no memory effect (other than LFP cells) and low self-discharge.
LIBs are also growing in popularity for military, battery electric vehicle and aerospace applications. Lithium-ion batteries can be a safety hazard since they contain a flammable electrolyte and may become pressurized if they become damaged. A battery cell charged too quickly could cause a short circuit, leading to explosions and fires. Because of these risks, testing standards are more stringent than those for acid-electrolyte batteries, requiring both a broader range of test conditions and additional battery-specific tests, and there are shipping limitations imposed by safety regulators. There have been battery-related recalls by some companies, including the 2016 Samsung Galaxy Note 7 recall for battery fires.

Another problem can occur if a lithium-ion battery is damaged or crushed, or if a battery without overcharge protection is subjected to a higher electrical load than it can safely handle. Additionally, an external short circuit can trigger the batteries to explode.

Research areas for lithium-ion batteries include life extension, energy density, safety, cost reduction, and charging speed, among others. Research has also been underway for aqueous lithium-ion batteries, which have demonstrated fewer potential safety hazards due to their use of non-flammable electrolytes.

Many times, there is need to step up or step down DC voltages. The circuits for stepping up or stepping down DC voltages are not simple as is the case with AC voltages. The level changing of DC voltages requires complex circuitry. These circuits are called DC to DC converters. The DC – DC converters are the electronic circuits which convert a constant DC voltage to a high voltage level or to a low voltage level. When a circuit increases the DC voltage to a higher level, it is called Boost Converter. When a circuit decreases DC voltage to a lower level, it is called buck converter. Since a boost converter converts the DC voltage to the higher voltage level, it is also known as a step-up converter. For boosting the voltage signal a regulator circuit is required which can step up the input voltage signal.

Most of the electronic gadgets like smart phones, tablets work on 5V DC. However, for general purpose use, 3.7 V batteries are quite common. These batteries can be used to power up 5V devices using a boost converter circuit. In this electronics project, the voltage from 3.7 V Li-ion battery is boosted to 5V DC. The end of discharge voltage of Li-ion battery can be assumed 3.5 V so this circuit will convert the minimum input voltage of 3.5 V to 5V level. A maximum current of 500 mA can be drawn by this boost converter.

- **SRD=05VDC - 5V SPDT RELAY**

The Single Pole Double Throw SPDT relay is quite useful in certain applications because of its internal configuration. It has one common terminal and 2 contacts in 2 different configurations: one can be Normally Closed and the other one is opened or it can be Normally Open and the other one closed. So basically you can see the SPDT relay as a way of switching between 2 circuits: when there is no voltage applied to the coil one circuit “receives” current, the other one doesn’t and when the coil gets energized the opposite is happening.
SP and DP refer to single pole and double pole, ST and DT refer to single throw and double throw. Pole refers to the number of circuits controlled by the switch: SP switches control only one electrical circuit. DP switches control two independent circuits (and act like two identical switches that are mechanically linked). Do not confuse „pole” with „terminal”. The DPST switch, for example, has four terminals, but it is a DP, not a 4P switch. Throw refers to the extreme position of the actuator: ST switches close a circuit at only one position. The other position of the handle is Off. DT switches close a circuit in the Up position, as well as the Down position (On-On). A DT switch can also have a center position (frequently On-Off-On). Single pole/throw and double pole/throw switches are by far the most common switches, but triple and quadruple configurations are also available. They are commonly denoted 3PST, 3PDT, 4PDT, etc.

III SOFTWARE DEVELOPMENT

A Arduino Ide
The first time you run the Arduino software, it will automatically create a directory for your sketchbook. You can view or change the location of the sketchbook location from with the Preferences dialog. The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

B Uploading
Before uploading your sketch, you need to select the correct items from the Tools > Board and Tools > Port menus. The boards are described below. On the Mac, the serial port is probably something like /dev/tty.usbmodem241 (for an Uno or Mega2560 or Leonardo) or /dev/tty.usbserial-1B1 (for a Duemilanove or earlier USB board), or /dev/tty.ASA19QWb1P1.1 (for a serial board connected with a Key span USB-to-Serial adapter). On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows Device Manager. On Linux, it should be /dev/ttyACMx, /dev/ttyUSBx or similar. Once you've selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the Sketch menu. Current Arduino boards will reset automatically and begin the upload. With older boards (pre-Diecimila) that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino Software (IDE) will display a message when the upload is complete, or show an error. When you upload a sketch, you're using the Arduino bootloader, a small program that has been loaded on to the microcontroller on your board. It allows you to upload code without using any additional hardware. The bootloader is active for a few seconds when the board resets; then it starts whichever sketch was
most recently uploaded to the microcontroller. The bootloader will blink the on-board (pin 13) LED when it starts (i.e. when the board resets).

**C Serial Monitor**

This displays serial sent from the Arduino or Genuino board over USB or serial connector. To send data to the board, enter text and click on the "send" button or press enter. Choose the baud rate from the drop-down menu that matches the rate passed to Serial.begin in your sketch. Note that on Windows, Mac or Linux the board will reset (it will rerun your sketch) when you connect with the serial monitor. Please note that the Serial Monitor does not process control characters; if your sketch needs a complete management of the serial communication with control characters, you can use an external terminal program and connect it to the COM port assigned to your Arduino board. You can also talk to the board from Processing, Flash, MaxMSP, etc (see the interfacing page for details).

**D Features of The Project:**

- Fully digital control: No need for passive analog components.
- Modular design: Every sub-circuit is a pre-defined easy to use module.
- Output frequency: Available range from 0Hz to 10MHz.
- Simple control: Single rotary encoder with built-in push button.
- Li-ion battery for portable use, with external charging ability.
- AC and DC coupling for output waveform.
- LCD Brightness control for energy consumption reduction.
- Battery charge indicator.
- Digital amplitude control.
- Three available waveforms: Sine, triangle and square.

**IV RESULT**

Images of different waveforms like Sine waveform, Triangular waveform and Square waveforms are taken. The measures like Amplitude, Frequency, Brightness, Out Coupling is observed.
V CONCLUSION
This low cost Portable Function generator using Arduino is fully digital control. It has Modular design. It operates in output frequency of available range from 0Hz to 10MHz. It has simple control Single rotary encoder with built-in push button. It uses Li-ion battery for portable use, with external charging ability. It has LCD Brightness control for energy consumption reduction. Battery charge indicator, Digital amplitude control. Three available waveforms in this system are Sine, triangle and square wave forms.

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