Digital Function Generator with Sine-Square-Triangle Output

A DDS-based digital function generator using the AD9833, producing sine, square and triangle waves 0.1 Hz–12.5 MHz with LCD display, rotary-encoder control and an amplitude/offset stage. Delivered built-to-order with the prototype, firmware, wiring docs, calibration procedure and viva kit (report, PPT, Q&A;).

01. Title

Digital Function Generator with Sine-Square-Triangle Output — a student-built bench instrument around direct digital synthesis.

02. Introduction / Background

Every electronics lab needs a function generator, and commercial ones are expensive enough that students often share one unit across a bench — or do without. The core of the instrument is direct digital synthesis: a phase accumulator and lookup table that turn a digital word into a precise, stable waveform, a technique that replaced analog oscillators in real test equipment decades ago.

This project puts that technique in the student's hands: an AD9833 DDS module generates sine, square and triangle waves under Arduino control, a rotary encoder and LCD provide the front panel, and an op-amp stage adds the amplitude and DC-offset control a bare DDS module lacks. The student ends up with a working bench instrument they calibrated themselves, and a report that explains DDS from first principles.

03. Problem Statement

Commercial function generators are expensive enough that students share one unit across a bench or do without, missing hands-on experience with direct digital synthesis — the technique real instruments use. The project addresses this with a student-built DDS generator around the AD9833: rotary-encoder front panel, LCD, amplitude/offset stage and sweep mode, calibrated by the student against a reference — a working bench instrument they built and understand from first principles.

04. Objectives

- Generate sine, square and triangle waves via the AD9833 DDS module — the same principle used in commercial generators.
- Cover 0.1 Hz to 12.5 MHz with fine frequency steps (approximately 0.1 Hz steps at low range, design target).
- Replicate a real instrument front panel: rotary encoder with push-select and 16x2 LCD, digit-by-digit frequency editing.
- Condition the output through an op-amp stage giving adjustable amplitude (approximately 0–5 Vpp, expected) and DC offset (approximately ±2.5 V, expected).
- Store 5 user frequency presets in EEPROM for one-touch recall (design target).

- Provide a sweep mode stepping frequency across a configured span for filter/amplifier response checks.
- Document a buyer-run calibration aligning LCD frequency and output amplitude against a reference instrument.

05. Proposed Methodology

An Arduino Nano programs the AD9833 over SPI with the computed frequency word; the chip's phase accumulator and lookup table produce the waveform. The raw DDS output passes through a TL072/LM358 op-amp conditioning stage where amplitude and DC offset are set from the front-panel controls. The rotary encoder and 16x2 LCD form the menu system; presets persist in EEPROM; sweep mode steps the DDS frequency while the student observes the circuit under test. Frequency follows the AD9833's crystal reference (typically ±20 ppm per the module datasheet); the buyer-run calibration confirms output frequency and amplitude against a reference and trims firmware constants.

06. System Architecture / Working

The student selects waveform type and dials the frequency with the rotary encoder; the LCD shows the exact setting digit by digit. The Arduino programs the AD9833 over SPI with the computed frequency word; the DDS chip's internal phase accumulator and lookup table produce the waveform. The raw DDS output passes through the op-amp conditioning stage, where amplitude and DC offset are set by the front-panel controls. Frequency presets stored in EEPROM are recalled with the encoder push-button for repeat measurements. In sweep mode the firmware steps the DDS frequency across the configured span while the student observes the circuit under test. During calibration the student compares output frequency and amplitude against a reference instrument and trims the firmware constants.

07. Hardware / Software Requirements

- Hardware: Arduino Nano (ATmega328P), AD9833 DDS waveform generator module, 16x2 LCD + rotary encoder front panel, TL072/LM358 op-amp output stage (approximately 50 Ω series output, design target); power 5 V USB / 9 V adapter.
- Software: Arduino IDE (C/C++ firmware) with SPI interfacing.

08. Expected Outcomes

A working bench function generator with DDS waveforms across 0.1 Hz–12.5 MHz and adjustable amplitude/offset.

Buyer-run calibration results recorded in the report (amplitude accuracy approximately ±5% after calibration — a student-built instrument, not a calibrated reference).

A report PDF (DDS theory, SPI, op-amp conditioning, calibration results template), PPT and viva Q&A.;

09. Applications

- Electronics lab bench work: filter response checks, amplifier gain tests, ultrasonic transducer drive, microcontroller clock injection.
- Teaching direct digital synthesis, SPI interfacing and analog signal conditioning.
- A calibrated-by-the-student instrument for their own future projects.

10. Future Scope

- Higher-bit DDS modules for improved waveform purity.
- Frequency-response plotting with an ADC feedback path.
- Arbitrary waveform generation via a DAC extension.
- Dual/triple channel variants.